Where this unit fits in
This unit builds on:
* unit 5F Changing sounds in the key stage 2 scheme of work. This unit could be linked with unit 7 Measuring physical data in the ICT scheme of work, which suggests an investigation of an aspect of sound.

The concepts in this unit are:
* how to measure the pitch and loudness of a sound, that pitch and loudness relate to the characteristics of the vibrations, how humans hear and what sounds they can hear.

This unit leads onto:
* the wave nature of sound is further developed in key stage 4.

To make good progress, pupils starting this unit need to understand:
* that sound is caused by objects vibrating
* that sounds have different pitches and different loudness
* how musical instruments make sounds.

Framework yearly teaching objectives – Energy

- Recognise that when sound travels by vibrations from the source it is transferring energy; use this idea to describe amplitude and frequency and explain the transmission, production and reception of sound.

Expectations from the QCA Scheme of Work

At the end of this unit …

... most pupils will … ... some pupils will not have made so much progress and will … ... some pupils will have progressed further and will …

**In terms of scientific enquiry**

- identify patterns in qualitative data about sound and describe sound qualities
- frame a question about hearing which can be investigated
- identify and control key variables
- identify limitations in their data
- compare sound levels, and report on a loudness enquiry
- describe a current issue related to sound.

**In terms of physical processes**

- relate changes in pitch and loudness of sounds to changes in vibrations
- explain how musical instruments can make these changes and relate these to the oscilloscope representations of waves
- recognise that sound needs a medium to travel through and that it travels at different speeds through different media
- explain simply how the ear works and give examples of hearing ranges
- describe ways in which hearing can be impaired and how noise pollution can be reduced.

Suggested lesson allocation (see individual lesson planning guides)

Direct route

<table>
<thead>
<tr>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good vibrations</td>
<td>Passing through</td>
<td>Hearing the sound</td>
<td>Turn it down!</td>
<td>Detect it - Think about collecting information</td>
</tr>
</tbody>
</table>

Extra lessons (not in pupil book)

<table>
<thead>
<tr>
<th>L3</th>
<th>L5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigate: How well can we tell where sound comes from?</td>
<td>Review and assess progress distributed appropriately</td>
</tr>
</tbody>
</table>

**Additional information**

This unit allows pupils who have some musical ability to come forward and demonstrate their instruments.

**Misconceptions**

Many pupils believe that sound will not travel on the Moon because there is no gravity there (two misconceptions!), rather than the lack of atmosphere.

**Health and safety** (see activity notes to inform risk assessment)

Loud, high pitched (around 3000 Hz) sounds may feel unpleasant, they may also upset some children.
L1 Good vibrations

### Learning objectives

i. Relate the pitch and the loudness of a sound to the pattern on the CRO caused by the vibration.

ii. Revise and develop understanding of how musical instruments make sounds.

### Scientific enquiry

iii. Analyse sounds using a microphone and CRO. (Framework YTO Sc1 8f)

### Suggested alternative starter activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Share learning objectives</th>
<th>Word game</th>
<th>Capture interest (1)</th>
<th>Capture interest (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduce the unit</td>
<td>• Find out how musical instruments make sounds.</td>
<td>Wordsearch of sound vocabulary from KS2.</td>
<td>Show video clips of different musical instruments being played.</td>
<td>Look at different sound-producing devices, and see what vibrates.</td>
</tr>
</tbody>
</table>

### Suggested alternative main activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Learning objective see above</th>
<th>Description</th>
<th>Approx. timing</th>
<th>Target group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook L1</td>
<td>i and ii</td>
<td>Teacher-led explanation and questioning OR pupils work individually, in pairs or in small groups through the in-spread questions and then onto the end-of-spread questions if time allows.</td>
<td>20 min</td>
<td>R/G G R S</td>
</tr>
<tr>
<td>Activity L1a</td>
<td>i, ii and iii</td>
<td>Seeing sounds Making different sounds using different instruments, and displaying them on CRO.</td>
<td>20 min</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>Activity L1b</td>
<td>Practical</td>
<td>Support animation about sound, loudness and pitch and wave shapes.</td>
<td>3 min</td>
<td>✔</td>
</tr>
</tbody>
</table>

### Suggested alternative plenary activities (5–10 minutes)

- **Review learning**: Pupils write questions to elicit given answer.
- **Sharing responses**: Whole-class discussion of answers to questions for Activity L1a.
- **Group feedback**: Pupils draw wave traces that would be seen on CRO for different sounds.
- **Word game**: Pupils match up statements and correct explanations.
- **Looking ahead**: Pupils read the story of Robert Boyle's life.

### Learning outcomes

- **Most pupils will**...
- Some pupils, making less progress will...
- Some pupils, making more progress will...

### Key words

- microphone, cathode ray oscilloscope (CRO), vibrates, pitch, CRO. red only: frequency, hertz, amplitude, kilohertz

### Out-of-lesson learning

- Homework L1 Textbook L1 end-of-spread questions
Passing through

**Learning objectives**

i. Sound needs a material to travel through and can't travel through a vacuum.

ii. Sound travels differently in different materials.

iii. Compare sound and light in the context of thunder and lightning.

**Scientific enquiry**

iv. How a scientist devised an experiment that developed our ideas about sound. (Framework YTO Sc1 8a)

v. Relate the way sound travels to the particle model. (red only) (Framework YTO Sc1 8a)

**Suggested alternative starter activities (5–10 minutes)**

- Recap last lesson
- Question and answer session.
  - Bring telephone demonstration and explanation of how it works.
  - Show an animation of a cowboy with his ear to a railway track, listening for an oncoming train.

**Suggested alternative main activities**

- **Textbook L2**
  - Learning objective: see above i, ii, iv, and v
  - Description: Teacher-led explanation and questioning OR pupils work individually, in pairs or in small groups through the in-text questions and then onto the end-of-spread questions if time allows.
  - Approx. timing: 20 min
  - Target group: C H E S R/G G R S ✔

- **Activity L2a**
  - Learning objective: i and ii
  - Description: Investigating sound: Pupils find out what materials sound can travel through.
  - Approx. timing: 15 min ✔

- **Activity L2b**
  - Learning objective: i and ii
  - Description: Bell in a bell jar: Demo of the electric bell in bell jar with air and vacuum.
  - Approx. timing: 15 min ✔

- **Activity L2c**
  - Learning objective: iii
  - Description: Thunder and lightning: Pupils compare the speed of sound and light in the context of a thunder storm. Optional demonstration.
  - Approx. timing: 5 min or 35 min with demo ✔

- **Activity L2d**
  - Learning objective: iii
  - Description: Comparing light and sound: Pupils use a set of prompt questions to compare sound and light.
  - Approx. timing: 20 min ✔

**Suggested alternative plenary activities (5–10 minutes)**

- **Review learning**
  - Sharing responses: Whole-class discussion of results from Activity L2b.
  - Group feedback: In Core and Extension groups, pupils discuss the answers to questions in Activities L2c and L2d.

- **Problem solving**
  - Pupils act out sound travelling in a solid and a gas, finding out how long it will take for a secret message to get passed on between pupils acting as particles.

- **Looking ahead**
  - Show video clips of animal ears.

**Learning outcomes**

- Most pupils will ...
  - recognise that sound needs a medium to travel through and that it travels at different speeds through different media
  - describe how Robert Boyle showed that sound cannot travel in a vacuum.

- Some pupils, making less progress will ...
  - recognise that sound travels but cannot travel through a vacuum
  - understand that Robert Boyle showed that sound cannot travel in a vacuum.

- Some pupils, making more progress will ...
  - also use particle theory to explain how sound travels through materials
  - also realise that Robert Boyle could not do his experiment until a suitable pump had been invented.

**Key words**

- Material

**Out-of-lesson learning**

- Framework L2
- Textbook L2 end-of-spread questions Activity L2a, c
### Hearing the sound

#### L3

**Learning objectives**

i. A simple model of how the ear works.

ii. Humans can only hear some pitches of sound and not others.

**Scientific enquiry**

iii. Investigate hearing ranges.

**Suggested alternative starter activities (5–10 minutes)**

<table>
<thead>
<tr>
<th>Recap last lesson</th>
<th>Share learning objectives</th>
<th>Problem solving (1)</th>
<th>Problem solving (2)</th>
<th>Capture interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils match observations with correct explanations.</td>
<td>• Find out how the ear works.</td>
<td>Pupils suggest in what ways animal ears are different from ours.</td>
<td>Pupils suggest why people used ear trumpets before hearing aids were invented.</td>
<td>Show an OHT of ear structure or use a model ear.</td>
</tr>
</tbody>
</table>

**Suggested alternative main activities**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Learning objective</th>
<th>Description</th>
<th>Approx. timing</th>
<th>Target group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook L3</td>
<td>i and ii</td>
<td>Teacher-led explanation and questioning OR pupils work individually in pairs or in small groups through the in-text questions and then onto the end-of-spread questions if time allows.</td>
<td>20 min</td>
<td>R/G GR S</td>
</tr>
<tr>
<td>Activity L3a</td>
<td>i</td>
<td>Modelling the eardrum Pupils make a model of an ear drum.</td>
<td>10 min</td>
<td>✔</td>
</tr>
<tr>
<td>Activity L3b</td>
<td>i and iii</td>
<td>Ranges of sound Pupils investigate what range of sound they can hear.</td>
<td>10 min</td>
<td>✔</td>
</tr>
<tr>
<td>Activity L3c</td>
<td></td>
<td>Interactive ear to label and see how sound goes through it to make it work.</td>
<td>10 min</td>
<td>✔</td>
</tr>
</tbody>
</table>

**Suggested alternative plenary activities (5–10 minutes)**

<table>
<thead>
<tr>
<th>Review learning</th>
<th>Sharing responses</th>
<th>Group feedback</th>
<th>Word game</th>
<th>Looking ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display the learning objectives as an OHT and ask pupils to indicate understanding.</td>
<td>Whole-class discussion of how well the model eardrum works in Activity L3a.</td>
<td>In groups, pupils discuss the outcome of Activity L3b.</td>
<td>Pupils sequence statements of how an ear detects sound.</td>
<td>Pupils suggest why animals have their ears positioned in different places on their heads.</td>
</tr>
</tbody>
</table>

**Learning outcomes**

- Most pupils will...
  - explain simply how the ear works and give examples of hearing ranges.
- Some pupils, making less progress will ...
  - explain that sound waves cause our eardrums to vibrate and that this enables us to hear.
- Some pupils, making more progress will ...
  - also use a model of the ear to discuss possible causes of hearing impairment.

**Key words**

- eardrum, kilohertz, red only: transfers, hearing impairment

**Out-of-lesson learning**

- Homework L3
- Textbook L3 end-of-spread questions

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This worksheet may have been altered from the original on the CD-ROM.
L3  Investigate: How well can we tell where sound comes from?

**Learning objectives**

i. Understand why we have two ears, placed as they are.

Scientific enquiry

ii. Collect data, present information as graphs. (Framework Sc1 8d)

iii. Identify and control key variables and explain why these controlled experiments are important. (Framework YTO Sc1 7c, 8e)

iv. Identify limitations in their data. (Framework YTO Sc1g)

**Learning outcomes**

Most pupils will...

- frame a question about hearing which can be investigated
- identify and control key variables
- identify limitations in their data.

Some pupils, making less progress will...

- describe what they found out from an investigation into hearing.

Some pupils, making more progress will...

- select an appropriate approach to investigating a question about hearing
- present a reasoned argument about a current issue in the science of hearing.

---

**Suggested alternative starter activities (5–10 minutes)**

**Setting the context**

Show photos of different kinds of animals and discuss why they all have two ears, and not just one.

Catalyst Interactive Presentations 2

**Introduce the apparatus**

Demonstrate clapping hands near a blindfolded person and ask them to point to the direction they think the sound is coming from.

Pupils work in groups to list the possible hazards and suggest safe working methods to avoid these.

Pupils work in groups to brainstorm what affects how we can tell where sound comes from.

**Learning objective**

i, ii, iii and iv

**Description**

Pupils plan, carry out and evaluate an investigation into how well we can differentiate what direction sound is coming from.

Core: difference in success front/back; left/right

Help: difference in success front/back; left/right

Extension: detection with one/two ears.

**Approx. timing**

30 min

**Target group**

CHES

✔✔✔

---

**Suggested alternative plenary activities (5–10 minutes)**

**Review learning**

Teacher-led review of the planning.

In groups, pupils discuss conclusion and evaluation using post-its and ‘big sheets’, or areas on a whiteboard.

**Analysing**

Teacher-led discussion of the outcome of the investigation.

Teacher-led evaluation of the methods used in the investigation.

**Evaluating**

Teacher-led evaluation of the methods used in the investigation.

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# L4 Turn it down!

## Learning objectives
- **i** Loud sounds can cause hearing impairment.
- **ii** Controlling noise in the environment and using insulation.

## Scientific enquiry
- **iii** Measure the loudness of sounds. (Framework Y6O Sc1 7d)

### Suggested alternative starter activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Learning objectives</th>
<th>Share learning objectives</th>
<th>Brainstorming (1)</th>
<th>Brainstorming (2)</th>
<th>Capture interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils label a diagram of the ear.</td>
<td>Recap last lesson</td>
<td>Pupils list five places where loud noise is a problem.</td>
<td>Pupils list five ways to reduce noise nuisance from an airport.</td>
<td>Set up a sound meter and datalogger to record as the class come into a lesson.</td>
</tr>
</tbody>
</table>

### Suggested alternative main activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Learning objective</th>
<th>Description</th>
<th>Approx. timing</th>
<th>Target group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook L4</td>
<td>See above</td>
<td>Teacher-led explanation and questioning OR pupils work individually, in pairs or in small groups through the in-text questions and then onto the end-of-spread questions if time allows.</td>
<td>20 min</td>
<td>N/G G R S</td>
</tr>
<tr>
<td>Activity L4a</td>
<td>i and ii</td>
<td>Measuring sound levels Pupils measure sound sound school in decibels and produce bar chart.</td>
<td>20 min</td>
<td>✓</td>
</tr>
<tr>
<td>Activity L4b</td>
<td>iii</td>
<td>Sound Insulation Pupils investigate insulation materials using a bleper in a box.</td>
<td>15 min</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Activity L4c</td>
<td>i, ii</td>
<td>At the rock concert Pupils investigate safe exposure time in disco exercise using a graph.</td>
<td>15 min</td>
<td>✓</td>
</tr>
</tbody>
</table>

### Suggested alternative plenary activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Review learning</th>
<th>Sharing responses</th>
<th>Group feedback</th>
<th>Word game</th>
<th>Looking back</th>
</tr>
</thead>
<tbody>
<tr>
<td>Put sounds in order of loudness on the decibel scale.</td>
<td>Whole-class discussion of the outcome of Activity L4a.</td>
<td>In groups, discuss the outcome of Activity L4b.</td>
<td>Check progress with Taboo game.</td>
<td>Pupils revise and consolidate knowledge from the unit.</td>
</tr>
</tbody>
</table>

## Learning outcomes

- **Most pupils will**...
  - describe ways in which hearing can be impaired and how noise pollution can be reduced.
  - compare sound levels, and report on a loudness enquiry.
  - describe a current issue related to sound.

- **Some pupils, making less progress will**...
  - state that loud sounds can damage hearing.
  - compare sound levels, and report on loudness of sound in common situations.

- **Some pupils, making more progress will**...
  - also use a model of the ear to discuss possible causes of hearing impairment related to loud sounds.

### Key words
- noise, decibels, hearing impairment, sound insulation, red only: shock wave

### Out-of-lesson learning
- **Homework L4**
- **Textbook L4 end-of-spread questions**
- **Activity L4c**

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This worksheet may have been altered from the original on the CD-ROM.
### Detect it - Think about collecting information

#### Lesson planning guide

**Learning objectives**
- i. Realise that scientists use instruments to gather information about the environment.
- ii. Think about how these instruments extend our senses.
- iii. Identify energy transfers in some scientific instruments.

The structure of this lesson is based around the CASE approach. The starter activities give concrete preparation. The main activities move away from the concrete towards a challenging situation, where pupils need to think. The extended plenary gives pupils time to discuss what they have learnt, to negotiate a method to commit to paper and express their ideas verbally to the rest of the class.

**Scientific enquiry**
- iv. Draw conclusions based on knowledge acquired over time and across different topics. (Framework YTO Sc1 8f)

#### Suggested alternative starter activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Bridging to the unit</th>
<th>Setting the context</th>
<th>Concrete preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ask pupils to suggest how you can describe a sound.</td>
<td>Ask pupils to make a list of their senses, what is detected and how.</td>
<td>Ask pupils to write down 10 things used for measuring.</td>
</tr>
</tbody>
</table>

#### Suggested main activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Learning objective</th>
<th>Description</th>
<th>Approx. timing</th>
<th>Target group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook L5</td>
<td>i and ii</td>
<td>Teacher-led explanation and questioning. OR pupils work individually, in pairs or in small groups through the in-text questions and then onto the end-of-spread questions if time allows.</td>
<td>20 min</td>
<td>C H E S R/G G R S ✔</td>
</tr>
<tr>
<td>Activity L5a ICT</td>
<td>i</td>
<td>Gathering information. Circus of demonstrations to show different instruments and datalogging detection equipment.</td>
<td>30 min</td>
<td>✔</td>
</tr>
</tbody>
</table>

#### Suggested alternative plenary activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Group feedback</th>
<th>Bridging to other topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>In pairs, pupils share what they have found out about measuring.</td>
<td>What scientific apparatus will we use to help our senses in future science lessons?</td>
</tr>
</tbody>
</table>

**Learning outcomes**

<table>
<thead>
<tr>
<th>Most pupils will ...</th>
<th>Some pupils, making less progress will ...</th>
<th>Some pupils, making more progress will ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>• recall a variety of different scientific instruments and what they measure; • describe how these scientific instruments extend our senses; • think creatively about how we perceive our environment.</td>
<td>• recall some scientific instruments and what they measure • realise that some scientific instruments let us detect things we cannot sense.</td>
<td>• also extend their knowledge of scientific instruments • also realise that data output from scientific instruments needs to be in a form that humans perceive effectively.</td>
</tr>
</tbody>
</table>

**Key words**

none

**Out-of-lesson learning**

Textbook L5 end-of-spread questions.
Sound and hearing

Hearing problems

Making and describing sounds

Detecting sounds

How sound gets to us

Copy the unit map and use these words to help you complete it. You may add words of your own too.

amplitude R
audible
cathode ray oscilloscope (CRO)
deafness
decibel
ear
eardrum
frequency R
hearing impairment
insulation
kilohertz (kHz)

loudness
material
microphone
musical instruments
particles R
pitch
sound meter
speed
ultrasound
vacuum
vibrations
**Good vibrations**

### Suggested alternative starter activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Introduce the unit</th>
<th>Share learning objectives</th>
<th>Word game</th>
<th>Capture interest (1)</th>
<th>Capture interest (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit map for sound and hearing.</td>
<td>• Find out how musical instruments make sounds. • Find out how the pitch and loudness of a note are related to the picture on an oscilloscope screen. • Be able to use a microscope and oscilloscope to look at sounds. (Sc1)</td>
<td>Wordsearch of sound vocabulary from KS2.</td>
<td>Show video clips of different musical instruments being played. Pupils suggest how they make a noise, and how the sound can be changed. Catalyst Interactive Presentations 2</td>
<td>Look at different sound-producing devices, and see what vibrates.</td>
</tr>
</tbody>
</table>

#### Introduce the unit
- **Either** draw the outline of the unit map on the board then ask pupils to give you words to add, saying where to add them. Suggest some words yourself when necessary to keep pupils on the right track.
- **Or** give out the unit map and ask pupils to work in groups deciding how to add the listed words to the diagram. Then go through it on the board as each group gives suggestions.

#### Share learning objectives
- Ask pupils to write a list of FAQs they would put on a website telling people about sound. Collect suggestions as a whole-class activity, steering pupils towards those related to the objectives. Conclude by highlighting the questions you want them to be able to answer at the end of the lesson.

#### Word game
- Ask pupils to complete the wordsearch on the pupil sheet.
- Ring the words on a copy of the pupil sheet and show it as an OHT for them to check their answers. Use the words on it to introduce the lesson.

#### Capture interest (1)
- Show video clips of different musical instruments being played and ask pupils to complete the pupil sheet.
- Take feedback from pupils and discuss their ideas about each instrument.

#### Capture interest (2)
- Demonstrate some or all of the suggestions on the teacher sheet.
- Ask pupils to observe each demonstration closely and say what is vibrating.
- Summarise the observations on the board to reinforce KS2 ideas about vibrations.

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This worksheet may have been altered from the original on the CD-ROM.
**Word game**

All the words below are connected with sound. See how many of them you can find in the wordsearch. Circle each word in the grid and cross it off the list when you find it.

- deaf
- ear
- high
- loudness
- low
- note
- quiet
- microphone
- pitch
- sound
- speed
- tuning
- vibration

Write down the meanings of three of the words you've found:

- deaf
- ear
- high
**L1 Good vibrations**

**Capture interest (1)**

Fill in as much information on the sheet as you can for each of the musical instruments that you see on the video.

<table>
<thead>
<tr>
<th>Name of musical instrument</th>
<th>How it makes a sound</th>
<th>How the player makes the sound louder</th>
<th>How the player makes the sound higher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>
Capture interest (2)

Teacher sheet

1. Strike a tuning fork on a bung and hold it to a pupil’s ear, so that she/he can hear it.
2. Hold the base of the fork on an empty wooden box or wooden bench so that the whole class can hear the sound.
3. Have a Petri dish half-full of water on an overhead projector, touch the tip of the fork to the water and see the ripples – alternatively have a ping-pong ball suspended from a stand with cotton and hold the fork so that one of the tines knocks the ball.
4. Ask the class to sing “Ah …...”, and to feel their vocal cords vibrate by holding their (own) throats.
5. Ask pupils how they know the fork is vibrating (extension – why is the sound louder when you hold the fork on the bench? Because the whole bench vibrates, and that sets much more air vibrating).
**Recap last lesson**
- Read out questions from the teacher sheet for pupils to answer orally or on individual whiteboards. The harder questions are at the end. Discuss their answers afterwards and any misconceptions.

**Share learning objectives**
- Ask pupils to write a list of FAQs they would put on a website telling people about how sound travels. Collect suggestions as a whole-class activity, steering pupils towards those related to the objectives. Conclude by highlighting the questions you want them to be able to answer at the end of the lesson.

**Problem solving**
- Set the question for pupils to consider and suggest answers to. Then ask them to share their responses with other pupils. Make it clear they may not know the answer and need to suggest their ideas and predictions.
- Pupils can summarise the suggestions and record them in their books, to reconsider after further lessons.

**Capture interest (1)**
- Demonstrate the use of a string telephone (two thin plastic cups with a string stretched between them, passed through a hole in the base of each cup and knotted – a pupil puts one cup to their ear and listens, another speaks quietly into the other cup). Ask pupils to suggest how it works.
- Collect ideas and then if necessary explain that the voice produces vibrations in air, which make the bottom of the cup vibrate, vibrations are passed along the string and make the bottom of the other cup vibrate, which makes the air in the other cup vibrate, which then passes into the ear – find out how the ear works in another lesson about sound.

**Capture interest (2)**
- Show a video clip of a cowboy with his ear to a railway track, listening for an oncoming train, and discuss why he does this.

---

**Question and answer session.**
- To find out whether sound can travel through solids, liquids, gases and a vacuum.
- To explain the differences in the way sound travels through different things using the particle model.
- To learn how a scientist did the first experiment to find out how sound travels. (KS1)

**Problem solving**
- Pupils suggest how whales can hear each other when they are miles apart, but on the moon, astronauts without radios must put their helmets together to talk.

**Capture interest (1)**
- String telephone demonstration and explanation of how it works.

**Capture interest (2)**
- Show an animation of a cowboy with his ear to a railway track, listening for an oncoming train. Catalyst Interactive Presentations 2

**Capture interest (1)**
- Question
  How can whales hear each other when they are miles apart, but on the moon, astronauts without radios must put their helmets together to hear each other?

**Equipment**
- two thin plastic cups (or tin cans with holes in base), string
Recap last lesson

Teacher sheet

Read out the questions below for pupils to answer orally or on individual whiteboards, as a recap of the last lesson.

1. What do we call the machine that turns sound signals into electrical signals?
   Answer: Microphone.

2. What do we call the backwards and forwards movement of the ends of a tuning fork?
   Answer: Vibrating (or vibration).

3. On an oscilloscope, how would the graph for a quiet sound be different from that for a loud sound? (If using a whiteboard, draw a trace.)
   Answer: The graph does not go up and down so far for a quiet sound as for a loud one.

4. On an oscilloscope, how would the graph for a low-pitched sound be different from that for a high-pitched sound? (If using a whiteboard, draw a trace.)
   Answer: The graph has fewer ups and downs for a low sound than for a high sound.

5. How would you make the note from a guitar higher?
   Answer: Shorten the string, increase its tension or use thinner string.

6. How would you make the note from a recorder louder?
   Answer: Blow harder.

7. What vibrates in your throat when you speak or sing?
   Answer: Vocal cords.

8. What do we call the number of vibrations per second?
   Answer: Frequency.

9. This tuning fork vibrates with a frequency of 256Hz, and it vibrates backwards and forwards 256 times a second. (Hold up middle C tuning fork.) Write down a possible frequency for a fork with a higher pitch.
   Answer: Any number greater than 256.
Hearing the sound

**Suggested alternative starter activities (5–10 minutes)**

<table>
<thead>
<tr>
<th>Recap last lesson</th>
<th>Share learning objectives</th>
<th>Problem solving (1)</th>
<th>Problem solving (2)</th>
<th>Capture interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recap last lesson</td>
<td>Share learning objectives</td>
<td>Problem solving (1)</td>
<td>Problem solving (2)</td>
<td>Capture interest</td>
</tr>
<tr>
<td>Pupils match each observation with the correct explanation on the pupil sheet.</td>
<td>- Find out how the ear works.</td>
<td>Pupils suggest in what ways animal ears are different from ours.</td>
<td>Pupils suggest why people used ear trumpets before hearing aids were invented</td>
<td>Show an OHT of ear structure or use a model ear.</td>
</tr>
<tr>
<td>Pupils match each observation with the correct explanation on the pupil sheet.</td>
<td>- Find out why different people and other creatures have different hearing ranges.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Be able to measure hearing ranges. (Sc1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Recap last lesson**

- Pupils match each observation with the correct explanation on the pupil sheet.
- Check the answers and correct any misconceptions.

**Share learning objectives**

- Ask pupils to write a list of FAQs they would put on a website telling people about how we hear sound. Collect suggestions as a whole-class activity, steering pupils towards those related to the objectives. Conclude by highlighting the questions you want them to be able to answer at the end of the lesson.

**Problem solving (1)**

- Set the question for pupils to consider and suggest answers to. Then ask them to share their responses with other pupils. Make it clear they may not know the answer and need to suggest their ideas and predictions.
- Pupils can summarise their suggestions and record them in their books, to reconsider after further lessons.
- Some animals have larger ears, e.g. elephants; some animals can prick their ears up and down, e.g. dogs; some animals are sensitive to different ranges, e.g. dogs higher, whales lower.

**Problem solving (2)**

- Set the question for pupils to consider and suggest answers to. Then ask them to share their responses with other pupils. Make it clear they may not know the answer and need to suggest their ideas and predictions.
- Pupils can summarise their suggestions and record them in their books, to reconsider after further lessons.
- The ear trumpet acts like the pinna on an elephant’s ear – it collects a larger volume of vibrating air, so sound vibrations passed down the ear canal are larger.

**Capture interest**

- Show the OHT of the structure of the ear or have a model ear on the front bench. Ask pupils to suggest how it works.
### Recap last lesson

Match each observation with the correct explanation for it.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. You see the lightning before you hear the thunder.</td>
<td>A. Light can travel through a vacuum.</td>
</tr>
<tr>
<td>2. The sound of the bell gets quieter as the air is pumped out.</td>
<td>B. Sound travels faster through metal than it does through air.</td>
</tr>
<tr>
<td>3. Starlight can reach us through empty space.</td>
<td>C. He was the first person (with Robert Hooke) to develop a good vacuum pump.</td>
</tr>
<tr>
<td>4. In films, cowboys sometimes put their ear to a railway track to see if a train is coming.</td>
<td>D. Light travels faster than sound.</td>
</tr>
<tr>
<td>5. It takes 5 seconds for us to hear the thunder from a mile (just over 1500 metres) away.</td>
<td>E. Sound needs air (or something) to travel through.</td>
</tr>
<tr>
<td>6. Robert Boyle was the first person to demonstrate that sound cannot travel through a vacuum.</td>
<td>F. Sound travels at over 300 metres per second.</td>
</tr>
</tbody>
</table>
Hearing the sound

Capture interest

- auditory canal
- ear drum
- auditory nerve to brain
- cochlea
- pinna
- three small bones- hammer, anvil, stirrup
- outer ear
- middle ear
- inner ear

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This worksheet may have been altered from the original on the CD-ROM.
L3  Investigate: How well can we tell where sound comes from?

Suggested alternative starter activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Setting the context</th>
<th>Introduce the apparatus</th>
<th>Safety</th>
<th>Brainstorming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Show photos of different kinds of animals and discuss why they all have two ears, and not just one.</td>
<td>Demonstrate clapping hands near a blindfolded person and ask them to point to the direction they think the sound is coming from.</td>
<td>Pupils work in groups to list the possible hazards and suggest safe working methods to avoid these.</td>
<td>Pupils work in groups to brainstorm what affects how we can tell where sound comes from.</td>
</tr>
</tbody>
</table>

Setting the context

- Show pictures of different animals and discuss why animals have two ears and not just one.

Introduce the apparatus

- Blindfold a volunteer pupil, and either click your fingers or clap softly to the left and right of her/his head. She/he points in the direction they think the sound is coming from.

Safety

- Ask pupils to work in pairs to list the hazards involved in this investigation.
- Pupils then decide how to minimise the danger presented by each hazard.
- Pairs report back to a class discussion during which a final set of safety procedures is listed on the board.

Brainstorming

- Ask pupils to discuss in groups what the variables are in the investigation.
- Ask them to decide which variable should be changed (input variable) and which should be measured during the investigation (outcome variable).
- Ask individual pupils for their ideas. Use class discussion to finalise details of the two dependent variables.
**Suggested alternative starter activities (5–10 minutes)**

<table>
<thead>
<tr>
<th>Recap last lesson</th>
<th>Share learning objectives</th>
<th>Brainstorming (1)</th>
<th>Brainstorming (2)</th>
<th>Capture interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils label a diagram of the ear.</td>
<td>• Find out how loud sounds can damage hearing. • Find out how to reduce noise pollution. (Sc1)</td>
<td>Pupils list five places where loud noise is a problem.</td>
<td>Pupils list five ways to reduce noise nuisance from an airport.</td>
<td>Set up a sound meter and datalogger to record as the class come into a lesson.</td>
</tr>
</tbody>
</table>

**Recap last lesson**
- Pupils label the diagram of an ear on the pupil sheet.
- Label the parts on a copy of the pupil sheet and show it as an OHT for them to check their answers. Use the words on it to recap the last lesson.

**Share learning objectives**
- Ask pupils to write a list of FAQs they would put on a website telling people about how hearing can be damaged by loud sounds. Collect suggestions as a whole-class activity, steering pupils towards those related to the objectives. Conclude by highlighting the questions you want them to be able to answer at the end of the lesson.

**Brainstorming (1)**
- Ask pupils to brainstorm in groups and come up with a list of five places where loud noise is a problem.
- Collect suggestions and list them on the board.

**Brainstorming (2)**
- Ask pupils to brainstorm in groups and come up with a list of five ways to reduce noise nuisance from an airport.
- Collect suggestions and list them on the board.

**Capture interest**
- Set up a sound sensor to monitor loudness and project a graph of the sensor output on to a screen as pupils enter the classroom.
- Ask what is being monitored and ask individual pupils to try to identify different events from the screen image (chairs moving, call for silence, etc.).

Answers:
- Road works; in factories; airport runway; near rock concert speakers; driving tractor; next to a busy road; in a classroom.

Answers:
- Triple glazing; soft furnishings inside buildings; earth banks round runways; site runways away from houses; make planes that use engines on lower power at lift-off; make planes go high quickly after lift-off.
L4  Turn it down!

Recap last lesson

Label the parts of the ear on the diagram.
L5 Detect it - Think about

Suggested alternative starter activities (5-10 minutes)

<table>
<thead>
<tr>
<th>Bridging to the unit</th>
<th>Setting the context</th>
<th>Concrete preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ask pupils to suggest how you can describe a sound.</td>
<td>Ask pupils to make a list of their senses, what is detected and how.</td>
<td>Ask pupils to write down 10 things used for measuring.</td>
</tr>
</tbody>
</table>

Bridging to the unit

- Ask pupils to discuss what characteristics of a sound they would need to measure in order to describe the sound, and how they would measure them.
- Ask for individual contributions and, if necessary, suggest pitch (could be measured with a microphone and CRO, or sound probe and datalogger), loudness (could be measured with noise meter or sound probe), and quality, timbre or waveform (could be measured using a microscope and oscilloscope graph, or sound sensor and datalogger to see the sound pattern).

Setting the context

- Ask pupils to make a list of their senses, what is detected and how.
- Collect suggestions and list them on the board.

Concrete preparation

- Ask pupils to work in groups and list 10 things that are used for measuring.
- Collect suggestions and list them on the board.

Answers

- Metre rules; measuring cylinders; balances; protractors; CRO; sensors of various types; tyre pressure gauges; thermometers; light meters; ammeters; speedometers, etc.
L1a Seeing sounds

### Running the activity

Core/Help: Ask an extrovert pupil to sing into the microphone. Observe the effect of low and high notes, soft and loud notes. This can be demonstrated very clearly by whistling into the microphone but by sucking the air IN rather than blowing it out. Use different musical instruments (ideally brought in by pupils), and look at the 'pictures' of the notes as amplitude and pitch are varied. For transient sounds, e.g. from a plucked guitar string, or drum, a sound sensor and datalogger give a picture that is easier to see. See ICT opportunities below.

While pupils are completing the worksheet, groups of pupils can be asked to come and sing into the microphone, so that all are included in the activity.

Extension: After answering question 5, pupils could be asked to look at the oscilloscope they have used and see what the timebase setting is (the time it takes the pattern to cross one square). N.B. 1 millisecond is 1/1000 of a second. They could then look at one of the patterns they recorded and count how many squares it covered and how much time this represented, in order to work out how many vibrations there were per second.

### Expected outcomes

Core/Help: Pupils learn that loud sounds have large amplitudes and quiet sounds have small amplitudes, the traces for high-pitched notes show more waves on the screen, and sounds from different instruments have different waveforms.

Extension: By counting squares on CRO traces pupils can work out the frequency of a sound to get more quantitative information.

### Pitfalls

Do not refer to the wavelength on the CRO trace – the graph is against TIME, so the distance from peak to peak represents the period of the oscillation.

### Safety notes

Hygiene – pupils should not pass round cups that have been in contact with each other’s mouths.

### ICT opportunities

Use a sound sensor and datalogger rather than microphone and CRO; ideally they should be connected directly to a PC so that pupils can see the waveforms immediately. The voltage gain will have to be adjusted for quiet sounds such as that from a tuning fork.

### Answers

Core:
1. There are more waves on the screen for a higher sound than for a lower sound.
2. The waves are taller for a loud sound than for a quiet sound.
3. and 4. Depends on what pupils have used.

Help:
High loud sound has same height waves, but more of them. Low quiet sound has few, low height waves. High quiet sound has more waves, but still low ones.

1. The low sounds show fewer vibrations than the high sounds.
2. The quiet sounds show shorter vibrations than the loud sounds.

Extension:
3. Four squares take 0.04 seconds.
4. The frequency is 25Hz.

Pupils may count the squares on their CRO for instruments they have measured, the settings will vary. The calculations they need to do are:

- Time taken = number of squares × time for one square
- Frequency = reciprocal of time for one wave, but this time must be expressed in seconds.

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Seeing sounds

**Type** | **Purpose** | **Differentiation**
--- | --- | ---
Practical | Pupils learn to relate different sounds to different images on the CRO screen. | Core (Extension), Help

**Equipment**

Microphone and CRO, which should be adjusted so that a stable trace is seen when you ‘lah’ into the microphone – most of the controls will be on the default value, the voltage gain (y-gain on some models) will need adjustment, and the timebase set on about 1 millisecond per division.

A sound sensor (set on waveform, not loudness) if it is available, datalogger and computer to display the waveforms could be used instead.

Musical instruments, such as recorder, whistle, mouth organ. Pupils could be asked to bring in instruments.

**For your information**

**Running the activity**

Core/Help: Ask an extrovert pupil to sing into the microphone. Observe the effect of low and high notes, soft and loud notes. This can be demonstrated very clearly by whistling into the microphone but by sucking the air IN rather than blowing it out. Use different musical instruments (ideally brought in by pupils), and look at the ‘pictures’ of the notes as amplitude and pitch are varied. For transient sounds, e.g. from a plucked guitar string, or drum, a sound sensor and data logger give a picture that is easier to see. See ICT opportunities below.

While pupils are completing the worksheet, groups of pupils can be asked to come and sing into the microphone, so that all are included in the activity.

Extension: After answering question 5, pupils could be asked to look at the oscilloscope they have used and see what the timebase setting is (the time it takes the pattern to cross one square). N.B. 1 millisecond is 1/1000 of a second. They could then look at one of the patterns they recorded and count how many squares it covered and how much time this represented, in order to work out how many vibrations there were per second.

**Expected outcomes**

Core/Help: Pupils learn that loud sounds have large amplitudes and quiet sounds have small amplitudes, the traces for high-pitched notes show more waves on the screen, and sounds from different instruments have different waveforms.

Extension: By counting squares on CRO traces pupils can work out the frequency of a sound to get more quantitative information.

**Pitfalls**

Do not refer to the wavelength on the CRO trace – the graph is against TIME, so the distance from peak to peak represents the period of the oscillation.

**Safety notes**

Hygiene – pupils should not pass round cups that have been in contact with each other's mouths.

**ICT opportunities**

Use a sound sensor and datalogger rather than microphone and CRO; ideally they should be connected directly to a PC so that pupils can see the waveforms immediately. The voltage gain will have to be adjusted for quiet sounds such as that from a tuning fork.
Seeing sounds

You are going to use the microphone and CRO to observe the electrical signals produced by different sounds and to find out how they depend on the loudness and the pitch of the sound.

Obtaining evidence

1. Sing a low note into the microphone. Look at the pattern.
2. Sing a high note into the microphone. Look at the pattern.
3. Find out how the pattern changes when the sound gets louder.
4. Find out how the pattern changes when different musical instruments are played into the microphone.

Presenting the results

5. Draw neat diagrams to show the pattern for low, high, quiet and loud sounds. Label them carefully.

Considering the evidence

1. Compare the patterns for a high and a low sound.
2. Compare the patterns for a quiet and a loud sound.
3. a. Which instrument had the highest pitch? b. Which instrument had the lowest pitch?
4. a. Which instrument could play most loudly? b. Which instrument could play most softly?

Extension

5. An oscilloscope is set so that the pattern moves across each square in 0.01 seconds (one-hundredth of a second). The wave shape of a certain sound covers four squares.

a. How long does the pattern take to move across it?

b. How many of these vibrations are there per second? (This is the frequency of the sound.)
You are going to use the microphone and CRO to observe the electrical signals produced by different sounds and to find out how they depend on the loudness and the pitch of the sound.

**Obtaining evidence**

1. Sing a low note into the microphone. Look at the pattern.
2. Sing a high note into the microphone. Look at the pattern.
3. Find out how the pattern changes when the sound gets louder.
4. Find out how the pattern changes when different musical instruments are played into the microphone.

**Presenting the results**

5. Fill in the squares to show the wave patterns – the first one has been done for you.

**Considering the evidence**

1. Fill in the sentences by deleting the wrong word.
   - The low sounds show more/fewer vibrations than the high sounds.
   - The quiet sounds show taller/shorter vibrations than the loud sounds.
## Investigating sound

<table>
<thead>
<tr>
<th>Type</th>
<th>Purpose</th>
<th>Differentiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>To reinforce that sound needs a material or substance through which to travel.</td>
<td>Core</td>
</tr>
</tbody>
</table>

### Running the activity

Pupils work in groups, reaching their answers by discussion.

### Answers

1. air
2. water
3. wood

4. Sound needs a material or substance to travel through. We know this because sound can travel through air, water and wood but not through a vacuum (no material/substance).
You are going to find out what materials sound can travel through.

1. Listen to other people in the room talking.
   ① What material is between you and the other people?

2. Whales use sound to communicate with each other over long distances.
   ② What material is between the whales?

3. Tap on the table very softly, while your partner listens with their ear to the table.
   ③ What material is between you and the person tapping the table?

4. What does sound need to travel?
**Bell in a bell jar**

**Running the activity**

Show the bell in the jar, and check that everyone can hear the bell ringing, and see the parts moving. Put the safety shield in place and use the pump to extract as much air as possible, while the bell keeps ringing. As the air is extracted pupils should hear the sound getting fainter, even though they can still see the moving parts. When the pump is switched off and the air allowed to re-enter then the sound should get louder again.

**Expected outcomes**

As the air is extracted the sound gets fainter, but the 'view' is unchanged - sound can't travel through a vacuum, but light can.

**Pitfalls**

The bell needs to have as little contact as possible with the base or jar, because sound vibrations are transmitted through contact points. It is unlikely that you will achieve a good enough vacuum to make the sound inaudible. If you use an electric pump then the sound of the pump may make it difficult to hear the bell.

**Safety notes**

Safety screen for jar when connected to the vacuum pump. All present should wear eye protection. Use only bell jars designed to be evacuated. Check for cracks (which could cause implosive failure) before each use.

**Answers**

**Core:**

1. Light can travel through a vacuum, sound can't.
2. Depends on pupils' predictions.
3. Not really a fair test because we couldn't pump out all the air/some sound came through the connections to the bell, it was difficult to hear the difference in the sound.

**Extension:**

5. Possibilities - going to swimming pool, two friends underwater, one claps; design hydrophones - funnels with membrane across end, tubes to surface to listen through.

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**Table of activities**

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<th>Type</th>
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<th>Differentiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical</td>
<td>Demonstration to show pupils that sound needs a material medium to travel.</td>
<td>Core (Extension)</td>
</tr>
</tbody>
</table>

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This worksheet may have been altered from the original on the CD-ROM.
Bell in a bell jar

Equipment
For the class:
- bell in bell jar apparatus – good seal to base plate is needed
- power supply for bell, unless hand bell
- vacuum pump
- safety screen

For your information
Running the activity
Show the bell in the jar, and check that everyone can hear the bell ringing, and see the parts moving. Put the safety shield in place and use the pump to extract as much air as possible, while the bell keeps ringing. As the air is extracted pupils should hear the sound getting fainter, even though they can still see the moving parts. When the pump is switched off and the air allowed to re-enter then the sound should get louder again.

Expected outcomes
As the air is extracted the sound gets fainter, but the ‘view’ is unchanged – sound can’t travel through a vacuum, but light can.

Pitfalls
The bell needs to have as little contact as possible with the base or jar, because sound vibrations are transmitted through contact points. It is unlikely that you will achieve a good enough vacuum to make the sound inaudible. If you use an electric pump then the sound of the pump may make it difficult to hear the bell.

Safety notes
Safety screen for jar when connected to vacuum pump. All present should wear eye protection. Use only bell jars designed to be evacuated. Check for cracks (which could cause implosive failure) before each use.

Type | Purpose | Differentiation
--- | --- | ---
Practical | Demonstration to show pupils that sound needs a material medium to travel. | Core (extension)
Bell in a bell jar

You are going to find out what happens to the sound a bell makes if the air around the bell is removed.

Planning and predicting

1. Write down how well you think you will hear the sound from the bell as the air is pumped out.
2. Give a reason for your prediction.
3. Write down how well you think you will see the bell as the air is pumped out.
4. Give a reason for your prediction.

Presenting the results

5. Write down what you heard, and what you saw.

Considering the evidence

1. What do your results show about whether light and sound can travel through a vacuum? Write a sentence to explain what you have found out.
2. Does what you have found out agree with your prediction? Have you changed any of your ideas?

Evaluating

3. Was this experiment a fair test? Give reasons for your answer.
4. Suggest how the experiment could be improved.

Extension

5. Design an experiment to find out whether sound can travel through water. What result do you expect? Give reasons for your answer.
**L2c Thunder and lightning**

**Running the activity**

Pupils read and work through the activity sheet.

If possible, take the class outside so they can experience the time lag between seeing and hearing for themselves. Position one pupil – or classroom assistant – at one end of the distance, with two large pieces of wood to clap together. Pupils can have stopwatches to time the difference between seeing and hearing. This can be extended to a full-scale experiment, but for most pupils the key thing is to experience the time lag.

**Pitfalls**

You need a distance of at least 100 metres, preferably more. Stopwatches must be able to record fractions of a second.

**Safety notes**

Usual safety precautions when taking pupils outside.

**Answers**

1. light
2. a. 680 metres  
   b. 3400 metres  
   c. 1700 metres
3. The bang and the flash happen at the same time, but light travels to our eyes faster than sound travels to our ears.
Thunder and lightning

You are going to think about how fast sound and light travel.

The lightning flash and the thunder roll both happen at the same time in a thunderstorm, when the energy from the electrical discharge is released, but we always see the lightning first.

1. Which travels faster – sound or light?
2. Sound travels at about 340 metres per second. Light travels about one million times faster than sound, so we see things almost instantly. The time it takes to travel is almost too short to measure.
   a. How far will sound travel in 2 seconds?
   b. How far will sound travel in 10 seconds?
   c. If you hear the thunder 5 seconds after seeing the lightning, how far has the thunder sound travelled?

3. Write an explanation of why we see the flash of a firework rocket that explodes high above the ground before we hear the bang.
Comparing light and sound

Running the activity
Pupils use the activity sheet to inform a discussion comparing light and sound. A spokesperson for each group feeds back one similarity or one difference to the class.

Other points made on the activity sheet are: sources, echoes, refraction of sound, detection.

Answers
At the end of the feedback session, these points should have been made:
- sound and light travel away from a source in all directions
- sound needs a medium through which to travel but light does not
- sound travels more slowly than light
- both light and sound are reflected
- changing frequency changes the pitch of sound and the colour of light
- changing the amplitude changes the loudness of sound and the brightness of light.

These points may have been made:
- sound travels at different speeds in different media and so does light
- light and sound are refracted.
Comparing light and sound

You are going to compare light and sound.

1. Study each box on this sheet and discuss the questions in your group. Make notes about what you discuss.

Some objects are light sources or sound sources.

- In what direction do the sound and light move away from the source?
- Which travels faster, light or sound?
- Does sound always travel at the same speed?
- Does light always travel at the same speed?
- Can sound and light go through empty space?
- What causes an echo?
- Does light ‘echo’?

Sound bends down towards the ground when the air near the ground is cooler than the air above.

- How do you make light bend?
- What is this bending called?

We hear sound.

- What affects the pitch of the sound?
- What pitches of sound can we hear?
- What affects the loudness of the sound?
- How do we hear sound?

We see light.

- What affects the colour of the light?
- What colours of light can we see?
- What affects the brightness of the light?
- How do we see light?
Modelling the eardrum

Running the activity
Pupils cut the bottom off a plastic cup and cover it with cling film to make a model of the eardrum. They make sounds into the cup and watch in a mirror as the cling film vibrates, showing how the eardrum responds to sound waves. The hole in the base of the cup needs to be large. The cling film needs to be fixed tightly to the base of the cup.

A high-pitched sound will not produce vibrations that can be seen – any vibrations observed are due to pupils blowing air at the film, not sound waves. This, however, does demonstrate the mechanical operation of the eardrum, with the sound wave modelled by a lower-frequency air pressure wave (infra sound).

Expected outcomes
The cling film vibrates, modelling what happens when sounds hit the eardrum and it vibrates. In the ear, the movement is then magnified and passed along by the three small bones in the middle ear.

Pitfalls
If the cling film is not taut it will not work.

Safety notes
Hygiene – pupils should not pass round cups that have been in contact with each other’s mouths.

ICT opportunities
Pupils could research the structure and action of the ear, using the Internet.

Answers
1. The cling film moves/vibrates. The vibrations will be different for sounds a, b and c (the actual form of the vibrations is not important, just that pupils try different sounds).
2. Sound vibrations move the eardrum and cause it to vibrate. The cling film shows how this happens in the ear.
Modelling the eardrum

Equipment

Per group:
- plastic cup
- cling film
- sticky tape
- scissors
- mirror

For your information

Running the activity
Pupils cut the bottom off a plastic cup and cover it with cling film to make a model of the eardrum. They make sounds into the cup and watch in a mirror as the cling film vibrates, showing how the eardrum responds to sound waves. The hole in the base of the cup needs to be large. The cling film needs to be fixed tightly to the base of the cup.

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The cling film vibrates, modelling what happens when sounds hit the eardrum and it vibrates. In the ear, the movement is then magnified and passed along by the three small bones in the middle ear.

Pitfalls
If the cling film is not taut it will not work.

Safety notes
Hygiene – pupils should not pass round cups that have been in contact with each other's mouths.
Modelling the eardrum

You are going to make a model eardrum.

Equipment
- plastic cup
- cling film
- sticky tape
- scissors
- mirror

Obtaining evidence

1. Using the scissors, make a hole in the bottom of the plastic cup. Now cut the bottom out of the cup.
2. Cut a piece of cling film large enough to completely cover the bottom of the cup. Stretch the cling film tightly over the bottom of the cup.
3. Use two or three pieces of sticky tape to stick the cling film to the sides of the cup.
4. Hold the cup over your mouth.
5. Look in the mirror so that you can see what is happening to the cling film as you try making these sounds:
   a. sssssssssssssss
   b. hmmmmmmmm
   c. da da da da da da da

Considering the evidence

1. What happened to the cling film when you made each sound?
2. Use your model to explain how the eardrum works.
Running the activity

Pupils listen to sounds from a signal generator connected to a loudspeaker. Starting with a frequency of about 200–300 Hz, the teacher turns down the frequency to below 20 Hz. Pupils record the frequency at which they and the teacher can no longer hear the sound. The frequency is then increased slowly up to 20 kHz or higher until no one can hear the sound. Pupils note the frequency at which they and the teacher cannot hear the sound. Discuss whether the ability to hear high-pitched sounds is always an advantage, and whether it necessarily means that a person’s hearing is ‘better’. Distinguishing sounds of different frequency is a different skill from hearing quiet sounds. By emphasising your own value for the high-frequency threshold, you will not only show that it decreases with age but also reduce embarrassment for pupils who can’t hear very well.

Expected outcomes

The highest note audible to you will be lower than the highest audible to most of the class. The lowest note is more subjective (see pitfalls).

Pitfalls

Pupils with hearing loss, whether permanent or a result of temporary ear infection, may have problems with this experiment and you will need to handle this appropriately, depending on the circumstances. Consult with form teachers or special needs staff beforehand if you know of pupils with hearing difficulties. It may be appropriate to discuss the lesson with the pupil concerned privately beforehand.

Ensure that the volume is not set to ‘loud’ when the signal generator is switched on. It can be started off quiet and turned up to a comfortable setting.

Pupils will still hear very low-frequency sounds – but as separate pulses. Explain carefully that they are looking for the moment that the sound turns from a single note to separate ‘clicks’.

Safety notes

Be aware that some people experience unpleasant side effects, even nausea, with sounds of certain frequencies.

ICT opportunities

Pupils could research ultrasonic and subsonic signals, e.g. as used by bats, dolphins and whales, on the Internet.

Answers

Most of the class will probably not be able to hear above 20 kHz. Your hearing threshold will almost certainly be lower than theirs as you are older, unless of course they listen to a lot of damaging loud music and you do not!
Ranges of sound

Equipment
For the class:
- signal generator
- loudspeaker
- connecting leads

For your information
Running the activity
Pupils listen to sounds from a signal generator connected to a loudspeaker. Starting with a frequency of about 200–300Hz, the teacher turns down the frequency to below 20Hz. Pupils record the frequency at which they and the teacher can no longer hear the sound.

The frequency is then increased slowly up to 20kHz or higher until no one can hear the sound. Pupils note the frequency at which they and the teacher cannot hear the sound.

Discuss whether the ability to hear high-pitched sounds is always an advantage, and whether it necessarily means that a person's hearing is 'better'. Distinguishing sounds of different frequency is a different skill from hearing quiet sounds. By emphasising your own value for the high-frequency threshold, you will not only show that it decreases with age but also reduce embarrassment for pupils who can't hear very well.

Expected outcomes
The highest note audible to the teacher will be lower than the highest audible to most of the class. The lowest note is more subjective (see pitfalls).

Pitfalls
Pupils with hearing loss, whether permanent or a result of temporary ear infection, may have problems with this experiment and you will need to handle this appropriately, depending on the circumstances. Consult with form teachers or special needs staff beforehand if you know of pupils with hearing difficulties. It may be appropriate to discuss the lesson with the pupil concerned privately beforehand.

Ensure that the volume is not set to 'loud' when the signal generator is switched on. It can be started off quiet and turned up to a comfortable setting.

Pupils will still hear very low-frequency sounds – but as separate pulses. The teacher needs to explain carefully that they are looking for the moment that the sound turns from a single note to separate 'clicks'.

Safety notes
Be aware that some people experience unpleasant side effects, even nausea, with sounds of certain frequencies.

ICT opportunities
Pupils could research ultrasonic and subsonic signals, e.g. as used by bats, dolphins and whales, on the Internet.
In this activity, you will find the highest- and lowest-pitched sounds you can hear.

Obtaining evidence

Your teacher will set up a signal generator with a speaker so that the electrical signal produces a sound that you can hear.

1. Listen carefully as the pitch is made lower. Eventually you will no longer be able to hear the sound. Record the pitch at which you cannot hear the sound any more.
2. Your teacher will tell you the pitch at which he or she cannot hear the sound any more. Record this pitch.
3. Listen carefully as the pitch is made higher, until you can no longer hear it. Record the pitch at which you cannot hear the sound any more.
4. Your teacher will tell you the pitch at which he or she cannot hear the sound any more. Record this pitch.
   (Remember that not everyone in the class will have the same results.)

Considering the evidence

1. Could the teacher hear higher-pitched sounds than most of the class? Or could most of the class hear higher-pitched sounds than the teacher?
2. Who heard the lowest-pitched sounds, most of the class or the teacher?
3. Do your results suggest a link between hearing range and age?
Investigate: How well can we tell where sound comes from?

### Running the activity

Core/Help: Pupils plan how to investigate whether it is easier to detect a sound from left or right, in front or behind. They blindfold a volunteer, and then snap their fingers or clap in different directions at head level around the volunteer, who points in the direction(s) he thinks the sound is coming from. They will need to make sounds of the same loudness, the same distance away, in a random order around the blindfolded volunteer. They will need to test each direction the same number of times.

Extension: Pupils may come up with a more sophisticated method using more different directions determined by using a protractor. The volunteer can stand at the centre of (say) eight axes, like the points of a compass. They may decide to measure success with both ears, then one ear blocked and then the other.

### Other relevant material

- Skill sheet 8: Variables
- Skill sheet 20: Writing frame: Planning an investigation
- Skill sheet 21: Writing frame: Reporting an investigation
- Skill sheet 23: Checklist for investigation

### Expected outcomes

Pupils find it easier to detect left/right than front/back because ears are on sides of head. Pupils find they are better at judging direction with two ears than with one. (This is because the brain measures time difference in receiving the signals from each ear.)

### Pitfalls

Background noise must be controlled – or one group’s experiment will interfere with another’s.

### Safety notes

Blindfolded children should sit still. Good classroom order must be maintained for their safety. Pupils must not poke things into their ears. They should only cover their ears with their hands.

### ICT opportunities

The final account of the experiment may be word-processed, and pupils could use a spreadsheet to prepare a bar chart for insertion.

### Answers

Core:

1. Probably four directions - left/right/front/back but may also do up/down, some may suggest subdividing, and having volunteer point in direction of source of sound.
2. 10–20 times for each direction, random order (perhaps throw dice to decide which direction next!).
3. Prediction – any reasonable point from pupils should be accepted.
Investigate: How well can we tell where sound comes from? (continued)

- Bar chart of total correct identifications for each direction.
- Probably only tested one pupil, and certainly one age group, so could comment on this.
- More varied sample of volunteers, finer division of directions, more tests.

Help:
1. Pupil name, other pupil name, clicking fingers/pressing buzzer, first pupil's name, fair test, ten to twenty.
2. Prediction - any reasonable point from pupils should be accepted.
3. and 4. As Expected outcomes above.
5. Completed evaluation sentences as 6 and 7 in Core answers.

Extension:
1. Possible independent variables: one/two ears, direction of sound, loudness of sound, age/sensitivity of hearer, background noise.
2. The easiest to investigate are number of ears and direction of sound source.
3. Control - same loudness of noise, same distance away, etc.
4. Make results reliable by doing many trials in each direction.
5. Prediction - any reasonable point from pupils.
6. Results table.
7. Bar chart.
8. See Expected outcomes above.
9. See 8 and 9 in Core answers.
10. Comments on hearing defects may need tactful handling.
Investigate: How well can we tell where sound comes from?

Equipment
For each group:
- blindfolds
- metre rules or measuring tapes
- possibly a flipchart or other large sheets of paper to stand on, circular protractors, marker pens
- Skill sheet 23: Checklist for investigation.

For your information

Running the activity
Core/Help: Pupils plan how to investigate whether it is easier to detect a sound from left or right, in front or behind. They blindfold a volunteer, and then snap their fingers or clap in different directions at head level around the volunteer, who points in the direction (s)he thinks the sound is coming from. They will need to make sounds of the same loudness, the same distance away, in a random order around the blindfolded volunteer. They will need to test each direction the same number of times.

Extension: Pupils may come up with a more sophisticated method using more different directions determined by using a protractor. The volunteer can stand at the centre of (say) eight axes, like the points of a compass. They may decide to measure success with both ears, then one ear blocked and then the other.

Expected outcomes
Pupils find it easier to detect left/right than front/back because ears are on sides of head. Pupils find they are better at judging direction with two ears than with one. (This is because the brain measures time difference in receiving the signals from each ear.)

Pitfalls
Background noise must be controlled – or one group’s experiment will interfere with another’s.

Safety notes
Blindfolded children should sit still. Good classroom order must be maintained for their safety. Pupils must not poke things into their ears. They should only cover their ears with their hands.

ICT opportunities
The final account of experiment may be word-processed, and pupils could use a spreadsheet to prepare a bar chart for insertion.
Investigate: How well can we tell where sound comes from?

You are going to investigate whether it is easier to tell if a sound comes from left or right, in front or behind you.

Equipment
- a blindfold
- a metre rule or tape measure
- a sound source - it can be clicking fingers, or a beeper

Planning and predicting
1. Decide which directions you are going to test. How will you make the test fair?
2. Decide how many times you will test each direction. How can you try to make sure that it is impossible to guess which way the sound will come from?
3. Write a prediction about which directions will be easiest to judge. Give a reason for your prediction.

Obtaining evidence
4. Get your plan approved by your teacher before you carry it out.
5. Carry out your plan and record the results in a table like the one below.

Presenting the results

<table>
<thead>
<tr>
<th>Direction of sound</th>
<th>Identified correctly?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>

6. Organise the data in your table so you can draw a bar chart.

Considering the evidence
7. Decide whether your bar chart shows any pattern. Are any directions easier or harder to judge? Try to give a scientific reason for any pattern that you have found.

Evaluating
8. Consider whether you have enough results - for enough people, and in each direction - to be sure that any pattern is reliable.
9. Write down any ways you can think of in which the experiment could be improved, or extended.
Investigate: How well can we tell where sound comes from?

You are going to investigate whether it is easier to tell if a sound comes from left or right, in front or behind you.

**Equipment**
- a blindfold
- a metre rule or tape measure
- a sound source – it can be clicking fingers, or a beeper

**Planning and predicting**
1. Complete the following to make a plan for your experiment:
   - [ ] I will wear a blindfold so that s/he can’t see where the sound is coming from. [ ] will make a noise by [ ] .
   - The noise will always be made 50cm from [ ] ’s head, and will always be the same loudness; this is to make sure we have a [ ] .
   - We will try four directions – left, right, front and back. We will do each direction [ ] times, and we will do them in a random order.

2. Make a prediction for your experiment, with a scientific reason:
   - I think it will be easiest to tell the direction when the sound is [ ] , because [ ]

**Obtaining evidence**
1. Carry out your experiment, and record your results in the table below by putting a tick in the ‘Yes’ or ‘No’ column.

**Presenting the results**

<table>
<thead>
<tr>
<th>Direction of sound</th>
<th>Identified correctly?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Left</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td></td>
</tr>
<tr>
<td>Front</td>
<td></td>
</tr>
<tr>
<td>Behind</td>
<td></td>
</tr>
</tbody>
</table>
Investigate: How well can we tell where sound comes from? (continued)

2. Add up the total number of ticks in the ‘Yes’ column for each row, and write the number in the ‘Total correct’ column.

3. Draw a bar chart on the grid below.

Considering the evidence

Does your chart show that any of the directions are easier to judge?
Investigate: How well can we tell where sound comes from? (continued)

4. Was the result what you expected? If not, can you give any explanation?

................................................................................................................................................
................................................................................................................................................
................................................................................................................................................

Evaluating

5. Complete the sentences below to evaluate this investigation:

This experiment was/was not a fair test because ............................................................
................................................................................................................................................
................................................................................................................................................

The results would have been better if I had ............................................................
................................................................................................................................................
................................................................................................................................................

If I did the experiment again I would also ............................................................
................................................................................................................................................
................................................................................................................................................

because ................................................................................................................................
................................................................................................................................................
................................................................................................................................................
Investigate: How well can we tell where sound comes from?

You are going to investigate what affects how well we can judge the direction a sound is coming from.

**Equipment**
- a blindfold
- a metre rule or tape measure
- a sound source – it can be clicking fingers, or a beeper
- white paper to stand on, on which directions can be marked
- a large protractor

**Planning and predicting**
1. List the independent variables that could affect how well someone can judge where a sound is coming from.
2. Choose a variable from your list that you are going to investigate – what range of values will you allow it to take?
3. Decide how you will control the other independent variables, and write down what values they must have throughout the experiment.
4. Write down how you will make your results reliable.
5. Write a prediction for your experiment, with a scientific reason.

**Obtaining evidence**
6. Check your plan with your teacher. Then carry out your experiment, and record the results in a table. Don’t forget to repeat measurements.

**Presenting the results**
7. Draw a bar chart to summarise your results.

**Considering the evidence**
8. Write down whether your results show any clear pattern. Try to give a scientific reason for your results.

**Evaluating**
9. Do you have enough results to reach a firm conclusion? How would you improve the experiment if you did it again?
10. Are there any anomalous (surprising) results? Can you explain what may have caused these results?
Measuring sound levels

Running the activity

Pupils draw up a table of sounds that they can measure in school. They use a sound meter or sound sensor and datalogger to measure the loudness and record it in their table. They display their results on a bar chart.

The sounds chosen could be linked, such as traffic noise at different times of day. If there is a main road close to the school, do this from inside the school grounds, such as on the other side of a fence. A study could be made of noise made by pupils at break, during lessons, etc. If only one portable sound meter is available, groups of pupils could do the experiment at different times, in parallel with other classroom activities.

Expected outcomes

The sound levels may vary from about 40 dB to over 80 dB.

Pitfalls

Permission must be sought from other teachers before pupils go into their rooms to measure noise levels.

Safety notes

If pupils are outside the school grounds recording traffic noise, supervision must be arranged as for an off-site visit. Pupils should not be exposed to sounds loud enough to require the use of ear protection.

ICT opportunities

It would be possible to set up a spreadsheet for the results and to produce a bar chart.

Answers

This is a guide to the results pupils may get.

<table>
<thead>
<tr>
<th>Decibel level</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>threshold of audibility</td>
</tr>
<tr>
<td>10</td>
<td>rustling paper</td>
</tr>
<tr>
<td>20</td>
<td>recording studio</td>
</tr>
<tr>
<td>30</td>
<td>quiet whisper, eating crisp cereal, quiet library</td>
</tr>
<tr>
<td>40</td>
<td>background noise at home</td>
</tr>
<tr>
<td>50</td>
<td>light traffic, refrigerator, gentle breeze</td>
</tr>
<tr>
<td>60</td>
<td>conversation</td>
</tr>
<tr>
<td>70</td>
<td>busy traffic, e.g. motorway traffic 60 metres away, noisy restaurant</td>
</tr>
<tr>
<td>80</td>
<td>vacuum cleaner</td>
</tr>
<tr>
<td>85</td>
<td>heavy city traffic, need to raise your voice to be heard by someone else</td>
</tr>
<tr>
<td>90</td>
<td>lawn mower, truck traffic, hairdryer</td>
</tr>
<tr>
<td>100</td>
<td>pneumatic road drill at 4 metres, chainsaw</td>
</tr>
<tr>
<td>115</td>
<td>maximum sound from human voice</td>
</tr>
</tbody>
</table>
Measuring sound levels

**Equipment**
Per group or class:
- sound meter or sound sensor and datalogger
- tape measure

**For your information**

**Running the activity**
Pupils draw up a table of sounds that they can measure in school. They use a sound meter or sound sensor and datalogger to measure the loudness and record it in their table. They display their results on a bar chart.

The sounds chosen could be linked, such as traffic noise at different times of day. If there is a main road close to the school, do this from inside the school grounds, such as on the other side of a fence. A study could be made of noise made by pupils at break, during lessons, etc. If only one portable sound meter is available, groups of pupils could do the experiment at different times, in parallel with other classroom activities.

**Expected outcomes**
The sound levels may vary from about 40 dB to over 80 dB.

**Pitfalls**
Permission must be sought from other teachers before pupils go into their rooms to measure noise levels.

**Safety notes**
If pupils are outside the school grounds recording traffic noise, supervision must be arranged as for an off-site visit. Pupils should not be exposed to sounds loud enough to require the use of ear protection.

**ICT opportunities**
It would be possible to set up a spreadsheet for the results and to produce a bar chart.
Measuring sound levels

You are going to measure the loudness of different sounds.

Equipment
- sound meter or sound sensor and datalogger
- tape measure

Obtaining evidence
1. Draw a table ready to record the type of sound you are testing (for example, pupils talking) and the level shown on the meter in decibels (dB).
2. Think of some sounds you can test around your school. List these in your table.
3. Measure and record the noise levels of the sounds listed in your table. Say how far you were away from the sound.

Considering the evidence
4. Draw a bar chart of your results.
   ① What was the loudest sound?

Evaluating
② Noise levels of about 80 dB and higher are dangerous. Was this level reached during your experiment?
③ Did you notice any safety notices or ear protection being used in any areas?
④ Without the help of the meter, would you have put the sounds in the same order of loudness using your ears?
⑤ You may have thought some sounds were louder than others but found that they were not really. Can you explain this?
Sound insulation

Type | Purpose | Differentiation
--- | --- | ---
Practical | Pupils investigate the effectiveness of different sound insulation materials. | Core, Help, Extension

Running the activity

This experiment can be a class experiment, if you have enough sound meters and dataloggers – or you could arrange that groups do the experiment in a circus of other activities. If equipment is limited it could be done as a demonstration.

Core/Help: Pupils place the source of sound in the box, and put the lid on. They place the sound meter 10 cm away and record the sound level. This is a control. Then they wrap the sound source in any of the insulating materials and repeat each measurement twice and calculate the mean.

Extension: Pupils have to decide their own method and may decide to use either single layers of different materials or increasing numbers of layers of just one material.

Expected outcomes

Porous materials with a large number of air holes and surfaces are the best absorbers.

Pitfalls

The class needs to be quiet for the sound level recording.

ICT opportunities

Use of detector and datalogger. Use of spreadsheet to produce graph.

Answers

Core:
1. Always put lid on box, always have meter same distance from beeper, class must be silent when taking results.
2. Depends on pupils' knowledge and experience – a vacuum would be best!
3. Expect one of the porous materials with a large number of air holes and surfaces to be the best absorber, because sound can't travel through air as well as through a solid.
4. Answers could concern more results to check the same materials, or more materials to check; or improvements to the method, e.g. same thickness of material each time, do experiment in soundproof room; or extensions, e.g. use just one type of insulation and find effect of adding layers.

Help:
1. Prediction – any reasonable point from pupils should be accepted.
2. Reason for prediction – reward scientific reasoning more highly than extrapolation from experience.
3. As questions 3 and 4 in Core.

Extension:
1. Bar chart because of discontinuous input variable.
2. and 3. Depends on results.
5. As question 4 in Core.
Sound insulation

For each group:
- beeper, e.g. beeping stopwatch
- box, e.g. small child’s shoebox
- sound insulation materials to compare, e.g. bubble wrap, cotton wool, packing material, corrugated cardboard, another box (so one box fits inside the other), towelling, tissues, aluminium foil, newspaper – about six examples

For your information

Running the activity
This experiment can be a class experiment, if you have enough sound meters and dataloggers – or you could arrange that groups do the experiment in a circus of other activities. If equipment is limited it could be done as a demonstration.

Core/Help: Pupils place the source of sound in the box, and put the lid on. They place the sound meter 10cm away and record the sound level. This is a control. Then they wrap the sound source in any of the insulating materials and repeat each measurement twice and calculate the mean.

Extension: Pupils have to decide their own method and may decide to use either single layers of different materials or increasing numbers of layers of just one material.

Expected outcomes
Porous materials with a large number of air holes and surfaces are the best absorbers.

Pitfalls
The class needs to be quiet for the sound level recording.

ICT opportunities
Use of detector and datalogger. Use of spreadsheet to produce graph.

Type | Purpose | Differentiation
--- | --- | ---
Practical | Pupils investigate the effectiveness of different sound insulation materials. | Core, Help, Extension
Sound insulation

You are going to find out which material is the best sound insulator. You will measure the loudness of the sound when a beeper is surrounded by different kinds of insulation.

Planning and predicting
1. Write down two things that you will need to do to make this a fair test.
2. Predict what you think will be the best insulation. Explain your answer.

Obtaining evidence
1. Set up the equipment as shown in the diagram.
2. Place the sound meter 10cm away from the box.
3. Use a table like this to record your results.

<table>
<thead>
<tr>
<th>Insulation</th>
<th>Meter reading in decibels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First try</td>
</tr>
</tbody>
</table>

4. First record the sound from the beeper with no insulation wrapped around it. Repeat the reading and calculate the mean of the two results and enter it in your table.
5. Wrap the beeper in one kind of insulation and repeat the experiment.
6. Take readings for three different kinds of insulation. Repeat each reading and then calculate the mean of the two readings and enter it in your table.

Presenting the results
7. Draw a bar chart of the mean values for your results.

Considering the evidence and evaluating
3. Which was the best insulator? Why do you think it was the best?

4. How could this experiment be improved?
Sound insulation

Use this sheet to help you record and analyse your results.

Predicting

1. Predict what you think will make the best insulation.

2. Give a scientific reason for your prediction.

Obtaining evidence

1. Use this table to record your results.

<table>
<thead>
<tr>
<th>Insulation</th>
<th>Meter reading in decibels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First try</td>
</tr>
<tr>
<td>No insulation</td>
<td></td>
</tr>
<tr>
<td>crumpled paper</td>
<td></td>
</tr>
<tr>
<td>towels</td>
<td></td>
</tr>
<tr>
<td>bubble wrap</td>
<td></td>
</tr>
<tr>
<td>cotton wool</td>
<td></td>
</tr>
<tr>
<td>sound meter</td>
<td></td>
</tr>
<tr>
<td>beeper</td>
<td></td>
</tr>
<tr>
<td>crumpled paper</td>
<td></td>
</tr>
<tr>
<td>towels</td>
<td></td>
</tr>
</tbody>
</table>

Presenting the results

2. Work out the mean by adding the numbers from the two tries together and then dividing by two.
3 Draw a bar chart of your results.

Considering the evidence and evaluating

3 Complete the following sentences.

The bar chart shows that ........................................ is the best insulator.
I think this is because ........................................................................
This experiment could be improved by ..............................................
........................................................................................................
........................................................................................................
You are going to design an experiment to find out the best way to insulate a sound.

Equipment
- sound meter
- beeper in a box
- tape measure
- layers of different insulating material, e.g. cotton wool, bubble wrap, newspaper, packing material (polystyrene or corn), corrugated cardboard.

Planning and predicting
1. Decide how you will investigate insulation using the materials available.
2. Decide how you will make this experiment a fair test.
3. Decide how you will make the experiment accurate, reliable and precise.
4. Make a prediction about the kind of material you expect to make the best insulation. Give a reason for your answer.

Obtaining evidence
5. Record your results in a table.

Presenting the results
6. Draw a bar chart of your results.

Considering the evidence and evaluating
1. Explain why you must present your results as a bar chart – not a line chart.
2. Which material was the best insulator? Why do you think it was the best?
3. Does the result agree with your prediction?
4. Were there any anomalous (surprising) results? Can you explain them?
5. How could this experiment be improved?
At the rock concert

Running the activity
Pupils use information on worksheet to plot a graph and answer questions about the dangers of noise.

ICT opportunities
Pupils could research the Internet for more examples of readings on the decibel scale, and for information about hearing aids.

Answers

<table>
<thead>
<tr>
<th>Noise level in dB</th>
<th>Safe exposure time in minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>480</td>
</tr>
<tr>
<td>95</td>
<td>240</td>
</tr>
<tr>
<td>100</td>
<td>120</td>
</tr>
<tr>
<td>105</td>
<td>60</td>
</tr>
<tr>
<td>110</td>
<td>30</td>
</tr>
<tr>
<td>115</td>
<td>15</td>
</tr>
<tr>
<td>120</td>
<td>7.5</td>
</tr>
</tbody>
</table>

1. Graph should be a smooth curve.
2. 30 minutes
3. Wear hearing protection/ear defenders.
4. Hardly! It wouldn’t look ‘cool’ – and they want to hear the music.
5. They have lived in a much quieter environment, so their hearing has not been damaged so much.
At the rock concert

Loud sounds can damage your hearing, by damaging the nerves in your cochlea. These nerves can never be repaired.

Any sound louder than 90dB can damage your hearing. The maximum time in a day it is safe to be exposed to 90dB is 8 hours, and the safe time halves for every increase in loudness of 5dB, so at 120dB the safe time is only 7.5 minutes.

Directly in front of (say 1 metre away from) a rock band’s speakers the sound level might be 130dB. At 2 metres away, the noise level would have gone down to 120dB, and 4 metres away it would be 110dB.

1. Draw up a table to show how the safe exposure time (in minutes) varies with noise level, from 90dB to 120dB.
2. Draw a graph to show how this time varies with loudness. It should be a smooth curve.
3. How long would it be safe to stand 4 metres in front of the rock band’s speakers?
4. What should people who have to work in noisy conditions do to protect their hearing?
5. Are people at rock concerts likely to wear hearing protection?
6. Explain why an elderly person from a remote part of the world is likely to have better hearing than someone the same age who has lived all their life in a city.
Gathering information

Running the activity

The activity is designed as an experimental circus, with the pupils moving from one activity to the next, following the instructions on the cards provided on the Resource sheet and completing a record table. If there is not enough equipment, the experiments could be demonstrations.

Suggestions are given for a large number of experiments – six would be ample for one lesson. As an extension, more able pupils could identify the units for each measurement.

Demonstrations
1. Signal generator, connected to speaker and CRO. See, hear and measure.
2. Ammeter in circuit with varying numbers of bulbs/cells.
3. Thermometer and water at three temperatures.
4. Newton meter being stretched.
5. Light meter, filters.
6. Two magnets glued in sealed flat opaque box (e.g. transparency box), plotting compass to find magnetic field and deduce magnet arrangement.
7. Datalogging light levels during lesson next to window – if natural light varies enough.
8. Datalogging loudness during lesson.
9. Datalogging temperature variation with distance away from radiant heater.

Expected outcomes
Pupils get some experience of looking at different devices and deciding what they are measuring or detecting.

Pitfalls
If pupils are performing the experiments as a circus, there is a tendency to rush from one to the next without completing the activities.

Safety notes
No specific problems, but pupils should put bags out of the way to avoid tripping, and beware of hot objects and devices that use mains electricity.

ICT opportunities
Pupils will see the results of datalogging light intensity, sound or heat over a period of time.

Answers

<table>
<thead>
<tr>
<th>Name of device</th>
<th>What it is measuring/detecting?</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRO</td>
<td>Frequency and amplitude of signal</td>
</tr>
<tr>
<td>Ammeter</td>
<td>Electric current</td>
</tr>
<tr>
<td>Thermometer</td>
<td>Temperature at a specific time</td>
</tr>
<tr>
<td>Newton meter</td>
<td>Force</td>
</tr>
<tr>
<td>Light meter</td>
<td>Light intensity at a specific time</td>
</tr>
<tr>
<td>Plotting compass</td>
<td>Direction of magnetic field</td>
</tr>
<tr>
<td>Datalogging: light probe</td>
<td>Light intensity over time</td>
</tr>
<tr>
<td>Datalogging: sound probe</td>
<td>Loudness (decibels) over time</td>
</tr>
<tr>
<td>Datalogging: temperature probe</td>
<td>Temperature as it changes over distance</td>
</tr>
</tbody>
</table>
### Equipment

1. Signal generator, connected to speaker and CRO (adjusted as in L1a).
2. Ammeter in circuit with two cells and two bulbs connected in parallel.
3. Three thermometers clamped in separate beakers of water – one initially very hot, one initially at 50°C, and one in an ice/water mixture.
4. Spring clamped at top, Newton meter that will give reading when it is used to stretch spring by 5cm.
5. Light meter, filters, bulb (e.g. ray box and power supply), black paper.
6. Two magnets glued in sealed flat opaque box (e.g. OHP transparency box), plotting compass, white paper.
7. Light probe, datalogger, with graph of results displayed.
8. Sound probe, datalogger, with graph of results displayed.
9. Temperature probe, datalogger, radiant heater, rule/tape/paper graduated in distances, with graph of results displayed.

### For your information

**Running the activity**

The activity is designed as an experimental circus, with the pupils moving from one activity to the next, following the instructions on the cards provided on the Resource sheet and completing a record table. If there is not enough equipment, the experiments could be demonstrations. Suggestions are given for a large number of experiments – six would be ample for one lesson.

As an extension, more able pupils could identify the units for each measurement.

**Demonstrations**

1. Signal generator, connected to speaker and CRO. See, hear and measure.
2. Ammeter in circuit with varying numbers of bulbs/cells.
3. Thermometer and water at three temperatures.
4. Newton meter being stretched.
5. Light meter, filters.
6. Two magnets glued in sealed flat opaque box (e.g. transparency box), plotting compass to find magnetic field and deduce magnet arrangement.
7. Datalogging light levels during lesson next to window – if natural light varies enough.
8. Datalogging loudness during lesson.
9. Datalogging temperature variation with distance away from radiant heater.

**Expected outcomes**

Pupils get some experience of looking at different devices and deciding what they are measuring or detecting.

**Pitfalls**

If pupils are performing the experiments as a circus, there is a tendency to rush from one to the next without completing the activities.

**Safety notes**

No specific problems, but pupils should put bags out of the way to avoid tripping, and beware of hot objects and devices that use mains electricity.

**ICT opportunities**

Pupils will see the results of datalogging light intensity, sound or heat over a period of time.
You are going to look at different kinds of instruments and decide what they are doing.

**Obtaining evidence**

1. For each experiment, look carefully at what is being measured or detected. Follow the instructions on the card and fill in the table below to record why the device is useful.

**Presenting the results**

<table>
<thead>
<tr>
<th>Name of device</th>
<th>What is it measuring or detecting?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Gathering information

You are going to look at different kinds of instruments and decide what they are doing.

1. Find out what happens when you (a) turn the frequency dial on the signal generator, (b) turn the amplitude dial on the signal generator. What information is the CRO displaying?

2. Find out what happens if you change (a) the number of cells, (b) the number of bulbs in the circuit. What changes is the ammeter measuring?

3. What is the thermometer reacting to? How does it work? How precise is it?

4. Stretch the spring 5cm. What is the Newton meter measuring?

5. Place the light meter 20cm from the bulb, and make a tunnel of black paper so that light from the rest of the room cannot get in. Look at the reading on the meter. Put one of the filters between the bulb and the meter. Look at the reading again. Find out which filter makes the brightness go down the most. What is the meter measuring?

6. There are two magnets inside the box, do NOT try to open it. Use the plotting compass and a sheet of paper to plot the magnetic field, and decide the arrangement of the magnets. What is the plotting compass detecting?

7. Do not move the light probe! It has been measuring during the lesson. What is it measuring? Has this changed much?

8. The sound probe has been measuring during the lesson. Describe what it is measuring. Has this changed much?

9. Move the temperature probe away from the radiant heater in short steps. Describe what it is measuring. Has this changed much?
L1

Good vibrations

Suggested alternative plenary activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Review learning</th>
<th>Sharing responses</th>
<th>Group feedback</th>
<th>Word game</th>
<th>Looking ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils write questions to elicit given answer.</td>
<td>Whole-class discussion of answers to questions for Activity L1a.</td>
<td>Pupils draw wave traces that would be seen on CRO for different sounds.</td>
<td>Pupils match up statements and correct explanations.</td>
<td>Pupils read the story of Robert Boyle’s life.</td>
</tr>
</tbody>
</table>

Review learning

- Give pupils the list of answers. Ask them to work in pairs to devise a question that would result in each of these answers.

Sharing responses

- Pupils explain how they know that sounds are produced by vibrations, from the evidence of Activity L1a.

Group feedback

- Pupils work in groups to sketch the patterns that would be seen on the CRO screen for sounds listed opposite.
- Ask group representatives to draw their sounds on the board to share and discuss.

Word game

- Pupils match up fact statements with explanations from worksheet. Check the answers and correct any misconceptions.

Looking ahead

- Pupils read the pupil sheet and learn about the importance of Robert Boyle’s work. To follow this up ask pupils to discuss the questions.
- If there is time you could also discuss how modern scientists share ideas by methods that were not available to scientists in Hooke’s time (phone, fax, Internet, etc.).

Answers

By vibrating.
- microphone
- frequency
- loudness
- Shorter string.
- Cathode ray oscilloscope.

Sounds

- a loud, high-pitched sound, e.g. a PE teacher’s whistle
- a loud, low-pitched sound, e.g. a lorry driving past
- a quiet, high-pitched sound, e.g. birdsong from a distance
- a quiet, low-pitched sound, e.g. someone humming

Answers

1C; 2E; 3A; 4B; 5D.

Answers

1 Sound caused by vibrations, pitch depends on frequency, loudness on amplitude of signal.
2 Planning and Prediction, Equipment, (Obtaining) Results, Concluding/ Considering Evidence, Evaluating. It is useful so that the people who are writing it up don’t miss anything important out, and the people who are reading about it know where to find the information that they need.
3 To get more ideas, to check each other’s work, to share out tasks, to help/hold apparatus and/or take results.
## L1 Good Vibrations

### Word Game

Match up the statements in the left-hand column with the correct explanation in the right-hand column:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tuning forks make a sound.</td>
<td>C. Because the prongs vibrate.</td>
</tr>
<tr>
<td>2. You need a microphone to send a sound signal to a CRO.</td>
<td>A. Because a child’s voice is higher (it has a higher frequency).</td>
</tr>
<tr>
<td>3. There are more waves on the screen when a child sings into the microphone than when a man does.</td>
<td>B. Because loud noises have more energy, so the waves have a bigger amplitude.</td>
</tr>
<tr>
<td>4. The waves on the screen are taller for a louder noise.</td>
<td>D. Because this makes the vibrating part of the string shorter, giving a higher note.</td>
</tr>
<tr>
<td>5. Guitar players place their fingers on the strings as they play.</td>
<td>E. Because a microphone turns sound into electricity.</td>
</tr>
</tbody>
</table>
Robert Boyle was born in Ireland nearly 400 years ago. He studied lots of different subjects at an advanced level, rather than specialising in just one or two areas of science as people do nowadays.

He went to school in England, and to Oxford University. He moved from Oxford to London, and was one of the first members of the Royal Society.

The Royal Society started in the reign of King Charles II, and ever since has existed to help scientists tell each other about what they are doing, and to advise the British Government about scientific matters. The Royal Society Christmas Lectures are shown on television every year. You might have seen them; they are designed for school pupils.

Robert Boyle was interested in religion as well as science, and wrote many books about theology. He also studied the reactions of acids and alkalis. He had ideas about how particles react. One of his first books was called The Sceptical Chemist. Someone who is sceptical always checks the facts. He believed that scientific ideas had to be tested by experiment, and the experiments had to be described so that other people could check them. Nowadays Boyle is most famous for his experiments in physics about air pressure. These were possible with the new vacuum pump (to suck air out of things) he helped invent.

Like modern scientists, he did not work alone. He invented the first vacuum pump with Robert Hooke. He used the pump for another experiment to learn about how sound travels. We still do this experiment in the laboratory today.

Robert Boyle did three things that are important for modern scientists too:

- he checked the facts
- he started the tradition of writing up experiments in a formal way, so that other people could repeat them
- he co-operated with other scientists.

1. Say which scientific facts you have checked during this lesson.
2. What headings do you use to describe experiments? Why is it useful for everyone to use the same system?
3. Write down three advantages of co-operating with other scientists when you do experiments.
**Suggested alternative plenary activities (5–10 minutes)**

<table>
<thead>
<tr>
<th>Review learning</th>
<th>Sharing responses</th>
<th>Group feedback</th>
<th>Problem solving</th>
<th>Looking ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils complete statements about how sound travels.</td>
<td>Whole-class discussion of results from Activity L2b.</td>
<td>In Core and Extension groups, pupils discuss the answers to questions in Activities L2c and L2d.</td>
<td>Pupils act out sound travelling in a solid and a gas, finding out how long it will take for a secret message to get passed on between pupils acting as particles.</td>
<td>Show video clips of animal ears. Catalyst Interactive Presentations 2</td>
</tr>
</tbody>
</table>

### Review learning
- Pupils fill in worksheet, or use individual whiteboards to suggest missing words if sheet is projected. If you use an interactive board, the ‘correct’ statements can be revealed if typed in, coloured white, and then the colour is changed after pupils suggest answer.

### Sharing responses
- Pupils answer these questions:
  - What was in the jar at the beginning of the experiment?
  - Could you hear the bell?
  - Could you see the bell?
  - What was in the jar at the end of the experiment?
  - Could you still hear the bell (as clearly)?
  - Could you still see the bell (as clearly)?
  - What does sound need to travel?
  - Does light need particles to travel?

### Group feedback
- In Core and Extension groups, pupils discuss the answers to questions in Activity L2c (Core) and Activity L2d (Extension).

### Problem solving
- Tell pupils to stand close together, touching, to model solid. Give a ‘secret message’ to one pupil and tell them to pass it on to any pupil they are touching and time how long it takes to get from one side of solid to other.
- Tell pupils to act as a gas, walking around slowly. They can only pass the secret message on when pupils collide. Again, time how long it takes.
- To sum up, discuss how well the model works.

### Looking ahead
- Show video clips of animals listening, as an introduction to finding out how ears work in the next lesson.
- Ask pupils to identify any patterns they can see in the way animals respond to noise.
- Emphasise the fact that animals of similar size, e.g. mice and bats, have different sizes of ears and discuss why this might be.
Review learning

1. For sound to travel there must be __________ to carry it.
2. Sound cannot travel through a __________.
3. The first scientist to show this was __________.
4. Sound travels faster through __________ than through gases.
5. __________ travels faster than sound.
6. If sound travels at 340 m/s, then in 3 seconds it will travel __________ metres.
# L3 Hearing the Sound

## Suggested alternative plenary activities (5-10 minutes)

<table>
<thead>
<tr>
<th>Review learning</th>
<th>Sharing responses</th>
<th>Group feedback</th>
<th>Word game</th>
<th>Looking ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display the learning objectives as an OHT and ask pupils to indicate understanding.</td>
<td>Whole-class discussion of how well the model eardrum works in Activity L3a.</td>
<td>In groups, pupils discuss the outcome of Activity L3b.</td>
<td>Pupils sequence statements of how an ear detects sound.</td>
<td>Pupils suggest why animals have their ears positioned in different places on their heads.</td>
</tr>
</tbody>
</table>

### Review learning
- Pupils show either traffic light cards (red, amber, green) to indicate understanding of each lesson objective, or use thumb up, horizontal, down.
- Ask a pupil who indicated that the objective has been understood (a) to state the objective in different words, (b) to give an example.

### Sharing responses
- Ask individual pupils to read out their explanation of how the eardrum works, using the model from Activity L3a.
- Make sure pupils are aware of what each part in the model represents in the ear.

### Group feedback
- In groups, pupils compare what they could hear and what the teacher can hear. They discuss if they think there is a link between the hearing range and age.
- Pupils could also suggest what else can affect hearing range – exposure to loud sounds, inherited ability, illness (be sensitive here), injury.

### Word game
- Pupils place the cards in the correct order to summarise how the ear works.

### Looking ahead
- Set the question for individuals to consider and suggest answers to. Then ask them to share their responses with other pupils. Make it clear they may not know the answer and need to suggest their ideas and predictions.
- Pupils can summarise the suggestions and record them in their books, to reconsider after further lessons.

---

Answers: D; A; C; E; F; B.

Question: Why do different animals have their ears positioned in different places on their heads?
**Hearing the sound**

**Word game**

Put the sentences in the correct order:

A. Sound travels along the ear canal and makes the eardrum vibrate.

B. The electrical signals travel along the nerves to the brain.

C. Eardrum vibrations are passed on, and magnified by three small bones.

D. The ear catches sound and funnels it into the ear canal.

E. The three bones touch one another and pass on the vibration.

F. The vibrations turn into electrical signals in the inner ear.
**L3 Investigate: How well can we tell where sound comes from?**

**Suggested alternative plenary activities (3–10 minutes)**

<table>
<thead>
<tr>
<th>Review learning</th>
<th>Group feedback</th>
<th>Analysing</th>
<th>Evaluating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-led review of the planning.</td>
<td>In groups, pupils discuss conclusion and evaluation using post-it notes and 'big sheets', or area on a whiteboard.</td>
<td>Teacher-led discussion of the outcome of the investigation.</td>
<td>Teacher-led evaluation of the methods used in the investigation.</td>
</tr>
</tbody>
</table>

**Review learning**
- Ask pupils to list independent variables in the investigation (direction, one/two ears, loudness, type of sound, background noise).
- Ask which of these could be controlled – and which were, in the experiment (depends on what pupils did).

**Group feedback**
- In their groups, pupils write down what their evidence shows on post-it notes and stick them on to either a big poster, or an area of the whiteboard.
- Summarise the results for the class.
- Pupils then do an evaluation of the method they used in the same way.
- Summarise the suggestions for the class.

**Analysing**
- Pupils discuss what they have learnt from this experiment.
- If pupils have all done similar investigations, it may be possible to total all the class results (how many got direction correct when sound was from right, etc.). Pupils can then discuss whether this makes pattern clearer.

**Evaluating**
- Pupils evaluate their experimental methods by answering the questions opposite.
- Go through the answers and summarise for the class.

**Questions**
- What was difficult to do?
- Was their testing fair? Were their results reliable?
- Would they get the same results next time?
- How could the experiment be improved?
Suggested alternative plenary activities (5–10 minutes)

<table>
<thead>
<tr>
<th>Review learning</th>
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<th>Group feedback</th>
<th>Word game</th>
<th>Looking back</th>
</tr>
</thead>
<tbody>
<tr>
<td>Put sounds in order of loudness on the decibel scale.</td>
<td>Whole-class discussion of the outcome of Activity L4a.</td>
<td>In groups, discuss the outcome of Activity L4b.</td>
<td>Check progress with Taboo game.</td>
<td>Pupils revise and consolidate knowledge from the unit.</td>
</tr>
</tbody>
</table>

Review learning

- Pupils use worksheet to put listed sounds in order of loudness.

Sharing responses

- Teacher leads class discussion of answers on activity sheet.
- If there is time, the discussion could broaden to whether some sounds appear louder/more annoying (ears are more sensitive to some frequencies, but dBA meters are adjusted to allow for this), and which sounds annoy pupils most.

Group feedback

- Pupils compare their answers to the questions in Activity L4b with those of another group.
- Pupils suggest to each other how the activity could be improved/extended.

Word game

- Pupils play Taboo using cards cut out from the pupil sheet.
- Give one pupil a card with a mystery word on it. The pupil offers clues to the class to allow them to identify the mystery word, but is not allowed to use the given ‘taboo’ words in their clues.
- You can adjust the level of challenge by banning the use of just the first, or first and second words in the taboo list, and then increasing the number later.

Looking back

- Pupils revise and consolidate knowledge from the unit. They can use the Unit map, Pupil checklist or the Test yourself questions.

Answers:
C 10 dB; E 20 dB; F 50 dB; G 60 dB; B 90 dB; A 100 dB; H 115 dB; I 120 dB; D 140 dB.
Turn it down!

Review learning

Arrange the different noises in order of loudness, and suggest a noise rating in decibels for each one.

A. Pneumatic road drill 4 metres away
B. Hair dryer
C. Rustling paper
D. Gunshot blast
E. Recording studio
F. Refrigerator
G. Conversation
H. Maximum human voice
I. Jumbo jet taking off 65 metres away
J. Quiet whisper
L4 Turn it down!

Word game

**Audible**
- hear
- sound
- ear

**Eardrum**
- ear
- canal
- hear

**Pitch**
- high
- low
- frequency

**Decibel**
- loudness
- measure
- sound

**Vacuum**
- nothing
- sound
- travel

**Oscilloscope**
- microphone
- television
- CRO
Detect it - Think about

Group feedback
- Pupils work in pairs to discuss what they found out about measuring.
- Then the pairs join into groups to discuss their findings.
- Summarise the discussion as a class, taking ideas from each group in turn.

Bridging to other topics
- Ask pupils to think about the question opposite.
- Broaden the discussion to suggest what else could usefully be measured, and how; extension activity could be to research whether equipment they have suggested actually exists.

Question
What scientific apparatus will we use to help our senses in future science lessons?
1. Use some of these words to fill the gaps.

   a. Sound is made when something ______________.

   b. Fast vibrations make a ______________ pitched sound.

   c. ______________ vibrations make a low pitched sound.

   d. Big vibrations make a ______________ sound.

   e. ______________ vibrations make a soft sound.

   f. A ______________ shows the pattern of a sound on a screen.

2. Look at these three sounds.

   a. Wave ______________ has the lowest pitch. This is because it has ...
      ..the most vibrations in the same time  
      ..the least vibrations in the same time.

   b. Wave ______________ has the highest pitch. This is because it has ...
      ..the most vibrations in the same time  
      ..the least vibrations in the same time.
3 Look at these three sounds.

A

B

C

Fill in the gaps in the sentences and then tick the correct answer.

a Wave __________ is the softest sound. This is because it has ...
   ... the biggest vibrations  □
   ... the smallest vibrations. □

b Wave __________ is the loudest sound. This is because it has ...
   ... the biggest vibrations  □
   ... the smallest vibrations. □

4 Look at these four sounds.

A

B

C

D

Fill in the gaps.

a Which wave has a higher pitch than A? __________

b Which wave is louder than A? __________

c Which wave has a lower pitch than A? __________
L2  Passing through

1 Use these words to fill in the gaps.

- Sound can travel through _______________, _______________ and _______________.
- Sound cannot travel through a totally empty space called a _______________.
- Sound travels _______________ through solids and liquids than through gases.
- Sound travels much _______________ than light.
- I see lightning _______________ I hear the thunder.

2 At a cricket match, you see the ball being hit before you hear the sound of it hitting the ball. This is because ...

- sound travels faster than light
- light travels faster than sound
- the ball travels faster than sound.
3 A rocket explodes on fireworks night. You see the flash of light before you hear the bang of the explosion. This is because ...

... the sound of the bang travels slower than the light of the explosion

... the light of the explosion travels slower than the sound of the bang

... the rocket moves quickly through the air.

4 Look at these materials.

- air
- oil
- water
- helium
- steel
- wood

a Sound would travel the slowest through

______________________ and ____________________ because they are solids / liquids / gases.

b Sound would travel the quickest through

______________________ and ____________________ because they are solids / liquids / gases.
Look at this drawing of the ear.

a Use these words to label the drawing.

three small bones | nerves to brain | eardrum | inner ear

b These sentences explain how your ear works. They’re all mixed up. Write numbers in the boxes to put the sentences in order.

- The inner ear turns the vibrations into electrical signals.
- The vibrating three small bones make the inner ear vibrate.
- The sound makes the eardrum vibrate.
- The nerves carry the electrical signals to the brain.
- The vibrating eardrum makes the three small bones vibrate.
L3  Hearing the sound (continued)

2  Tick the correct answers.
   a  If my eardrum breaks ...
      ... it will not vibrate and I won’t be able to hear ☐
      ... it will vibrate and I’ll be able to hear ☐
      ... it will not vibrate and I will be able to hear ☐
   b  My ear drum can be broken by ...
      ... talking ☐
      ... the wind ☐
      ... being hit very hard. ☐

3  Write true or false for each sentence.
   a  Sound does not make the eardrum vibrate. ................
   b  Some sounds are too low-pitched or too high-pitched for humans to hear. ............... 
   c  Dogs can hear higher pitched sounds than humans. ................
   d  As people get older, they can’t hear high-pitched sounds. ................
1. Look at this table of information about the loudness of sounds.

   a. Show this information as a bar graph on the graph grid. Make sure you fill in the missing numbers and words!

   b. Which sound is the quietest?

   c. Which sounds are the loudest?

   d. Sounds above 90 decibels can cause hearing impairment. Which sounds in the table will cause hearing impairment?

   e. Sounds above 120 decibels can break the eardrum. Will any of these sounds break the eardrum?
2 Draw lines to match the words to their descriptions.

- **Eardrum**  
  This can be broken by sounds louder than 120 decibels.

- **Hearing Impairment**  
  This soaks up the sound vibrations and stops the sound.

- **Sound Insulation**  
  This is sound that no-one wants.

- **90 Decibels**  
  Sound is measured in these.

- **Noise**  
  This is damage done to your ears. Loud noises make your ears numb. If the loud noises go on too long then the damage can be permanent.

- **Decibels**  
  Above this, the sound can cause hearing impairment.
Humans have five senses. Here is a list of the five senses. The letters in each one have been jumbled up. You need to sort the letters out.

1. m l s l e  t a s e t  c o u t h  g t h e  r g h e i a n

2. Match the scientific instruments to the jobs scientists use them for.

- **Telescope**
  - For seeing things that are very far away.
  - To see sounds.

- **Microscope**
  - To measure an electric current.

- **Ammeter**
  - For finding the direction of a magnetic field.

- **Thermometer**
  - For measuring temperature.

- **Compass**
  - To find the pH of a liquid.
L Sound and hearing

L1 Good vibrations
1 a vibrates  d loud
   b high   e small
   c slow   f CRO
2 a C ... the least vibrations in the same time.
   b B ... the most vibrations in the same time.
3 a C ... the smallest vibrations.
   b B ... the biggest vibrations.
4 a C
   b B
   c D

L2 Passing through
1 a solids, liquids, gases
   b vacuum
   c faster
   d slower
   e before
2 ... light travels faster than sound.
3 ... the sound of the bang travels slower than the light of the explosion.
4 a air, helium, gases
   b steel, wood, solids

L3 Hearing the sound
1 a Clockwise from top – three small bones, nerves to brain, inner ear, eardrum
   b Top to bottom – 4, 3, 1, 5, 2
2 a ... it will not vibrate and I won't be able to hear.
   b ... being hit very hard.
3 a false
   b true
   c true
   d true

L4 Turn it down!
1  

L5 Detect it
1 From left to right – smell, taste, touch, sight, hearing
2 telescope – For seeing things that are very far away.
   microscope – For seeing things that are very small.
   ammeter – To measure an electric current.
   thermometer – For measuring temperature.
   compass – For finding the direction of a magnetic field.
   universal indicator paper – To find the PH of a liquid.
   CRO – To see sounds.

b whisper
   c club music, thunder
   d jet plane, club music, thunder
   e no
2 eardrum – This can be broken by sounds louder than 120 decibels.
   hearing impairment – This is damage done to your ears. Loud noises can make your ears numb. If the loud noises go on too long then the damage can be permanent.
   sound insulation – This soaks up the sound vibrations and stops the sound.
   90 decibels – Above this, the sound can cause hearing impairment.
   noise – This is sound that no-one wants.
   decibels – Sound is measured in these.
Good vibrations

HELP

1. Look at the diagrams. Each object shown can make a sound.

   A. piano
   B. violin
   C. xylophone
   D. trumpet
   E. guitar
   F. bee flying
   G. saxophone
   H. gong

   a. Make a list of the objects. Next to each one, write down what is vibrating when it makes a sound.
   b. Why does hitting a drum harder make a louder sound?
   c. Jenny plays a high-pitched note and a low-pitched note on her piano. Write a sentence to explain how the vibrations that make the two notes are different.
   d. Copy and complete the following sentence:
      A cathode ray oscilloscope is used to ..........................................

CORE

2. A loudspeaker makes sounds by vibrating a cardboard cone. What happens to the vibrations of the cone?
   a. as the sound gets quieter?
   b. as the sound becomes lower-pitched?
Homework

L1  Good vibrations (continued)

3 Look at the diagrams. They show sound patterns on an oscilloscope.

\[
\begin{align*}
A & \quad B & \quad C \\
\end{align*}
\]

a i Which pattern is most likely to have been made by a very low-pitched note?
   ii Explain your choice.

b i Which pattern came from the loudest sound?
   ii Explain your choice.

c i How would the sound that made patterns A and B be similar?
   ii How would the sound that made patterns A and B be different?

EXTENSION

4 You will need some graph paper for this question.

The table gives the frequencies of some notes on a keyboard. The notes begin with the A three notes below middle C and continue to the A an octave higher (six notes above middle C).

<table>
<thead>
<tr>
<th>Notes below Middle C</th>
<th>Middle</th>
<th>Notes above Middle C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Frequency (Hz)</td>
<td>220</td>
<td>256</td>
</tr>
</tbody>
</table>

a Plot a graph of the data, putting the notes of the scale on the x-axis and the frequency on the y-axis. Draw a line graph, even though the x-axis does not contain numbers.

b Use the graph to estimate the two missing frequencies. Show, on the graph, how you reached your answers.

c i What is the relationship between the A below Middle C and the A six notes above Middle C?
   ii Using your relationship, suggest what the frequency for the C, an octave above middle C, would be.

d Which of the notes, given in the table, has the highest pitch?

e i Jools and Sandy both played Middle C. Jools played it much louder than Sandy. Sketch the two CRO patterns that the sounds would make.
   ii On your sketch of Sandy’s pattern, add a label to show the amplitude of the sound and another to show the frequency of the sound.
1. Look at this diagram of Neil and Buzz exploring the Moon in 1969. There is no atmosphere around the Moon. There is only empty space.

   a. Neil is talking to Buzz. Neil’s radio is not working. Why can’t Buzz hear what Neil is saying?

   b. Buzz leans towards Neil so that their helmets are touching. Why can Buzz hear Neil now?

   c. Imagine that Buzz had an alarm clock. He sets it ringing on the Moon’s surface.
       i. Would Buzz be able to hear the bell?
       ii. How would he know that the bell was ringing?
       iii. What could he do with the bell so that he could hear it?

2. North American Indians were very good at hunting buffalo. They would lie down with one ear to the ground. They did this to tell them where the buffalo were. How would lying down help them to find the buffalo?

3. The diagram shows Jennifer standing 330 metres away from a big cliff. She has a powerful torch that she is pointing at the cliff and a starting pistol that fires blanks.

   Jennifer presses the ‘on’ switch on the torch. At exactly the same moment she fires the starting pistol. Jennifer hears the sound echoing back from the cliff. She also sees the torchlight reflecting back from the cliff.
Passing through (continued)

a i Which gets back to Jennifer first, the light or the sound?  
   ii Explain why this happens.

b i Sound travels at 330 m/s. How long does it take for the  
   sound to get from the pistol to the cliff?  
   ii How long after firing the pistol does Jennifer hear the  
   sound?  
   iii Explain why it takes this amount of time.

4 Leo hears a fast jet plane approaching from behind a row of  
   trees. It was travelling at 250 m/s. He looks up to where he thinks  
   the plane will be from the sound he hears, but it is not there. His  
   friend says that it has already passed overhead.

   Explain why Leo did not see the plane where he thought it  
   should be.

EXTENSION

5 a Using ideas about particles, write two or three sentences to  
   explain how sound travels through materials.

b Submarines use sonar to detect other ships that are near  
   them. Sonar sends out a sound wave from the submarine.  
   The sound wave hits things and bounces back.

   i Suggest why submarines can use sound waves to locate  
      other ships when aircraft cannot use sound to track other  
      aircraft. (This is hard: think about the speeds of sound,  
      ships and aircraft.)  
   ii Some carnivorous sea mammals, like dolphins, also use a  
      sort of sonar. Suggest why sonar might be useful to  
      dolphins.

c Explain why sonar systems could never be used in space.

d Evelyn Glennie is a famous percussion player. She is totally  
   deaf. She plays standing up and barefoot. Suggest how she  
   can keep in time with a pianist when she cannot hear what  
   they are playing.
Hearing the sound

1. Look at this picture of the human ear.

a. Phillip labelled the parts but he got them wrong. Here are Phillip’s labels.

   A – cochlea  B – eardrum  C – small bones  D – nerve

Write the list again, putting the labels with the correct letters.

b. Write a list of each of the parts above. Next to each one, write down what it does when you are hearing a sound.

c. Copy and complete the sentences below:
   i. It is important that small mammals can hear well because ____________________.
   ii. As mammals get older their hearing gets ____________________.

CORE

2. Pablo is a dolphin trainer in a theme park. He uses a high-pitched whistle to tell his dolphins what to do. This is better for the audience watching the dolphin shows than a normal whistle.

a. Why is the high-pitched whistle better for the audience?

b. Explain why the high-pitched whistle is fine for the dolphins.

c. Using ideas about vibrations, explain what a dolphin’s eardrum can do better than a human eardrum.

d. Bats have eardrums that can do the same thing. Explain why bats need excellent hearing?
3 Draw a flow diagram to explain the order in which things happen when we hear something. Start with a firework as it explodes.

EXTENSION

4 Read the information below, which is taken from a health information booklet for teenagers.

Knowing about your hearing

Many young people enjoy socialising by going to clubs and discos. The music in these places is often very loud. You can see the speakers vibrating and feel the floor shaking. Some people like to be really close to the speakers. They say you get a better effect than you get from further away. Researchers have questioned people who stand close to very loud music. They often described some or all of the following symptoms after they left the event:

- ringing in their ears for several hours afterwards
- temporary deafness for several hours
- headaches
- sharp pain inside the ears that can last for several days.

Surveys of the hearing of young adults in their 20s to early 30s have shown that nearly a third of them have a 20-30% hearing loss, compared with the hearing levels in the same age group over the last fifty years. Many of these people admitted going to clubs regularly, in their late teens and early 20s, and standing close to the speakers.

One result of these surveys is that some doctors are campaigning for a reduction in the maximum sound levels allowed at discos, concerts and nightclubs.

a How would the movement of your eardrum be different in a disco where the music was at a reasonable loudness, compared with one where you were standing next to a very loud speaker?

b How would the loudness of the music be linked to the movement of the small bones inside your ear?

c Why might the people described suffer from the following, after visiting a club:
   i sharp pain inside the ear
   ii temporary deafness for several hours?

d i Suggest why our ability to hear decreases naturally as we get older.
   ii Why would visiting loud discos make it more likely that we would lose our hearing at an earlier age?

e Suggest a job where hearing could be damaged if precautions are not taken.
HELP

1. Gerry drives a digger. His employer tells him to wear ear protectors.
   a. What do ear protectors actually do to the sound?
   b. What might happen to Gerry, if he does not wear the protectors?
   c. The noise from a road drill is about 110 decibels. Some discos play music at 110 decibels.
      i. What advice would you give to a man operating a road drill?
      ii. What advice would you give to a friend who often goes to discos?

CORE

2. Look carefully at this picture.
   a. Make a list of all the objects that would create sounds that could damage your ears.
   b. Make another list of the sounds that are unlikely to damage your ears.
L4  Turn it down! (continued)

Imagine you live in a house beneath the flight path of the jet aircraft.

i List two things you could do to reduce the effect of the engine noise as the planes take off and land.

ii Suggest one thing that the airport could do to try to reduce the nuisance that the aircraft create.

Barry runs a pub in a residential area. Bands play there three nights a week. The local residents have complained.

i Suggest two specific reasons why the residents have complained. You need to say more than just “it is too noisy”.

ii Suggest two things Barry could do to keep the bands while making the residents happier.

EXTENSION

3 Salmon is an expensive fish. In Scotland, poachers sometimes use explosive charges, which they put into the water to kill the salmon. The explosion kills all the salmon over quite a long stretch of the river. It is even more effective if the fish are kept in large cages on a salmon farm.

a Roughly how many decibels might be produced by an explosive charge?

b In naval warfare, submariners worry about special explosives called depth charges. Suggest what depth charges might be and why they worry submariners.

c Malcolm is trying to outwit the poachers on his salmon farm. He has surrounded the salmon cages with thick rubber sheets. The sheets have a pattern of holes in them.

i Explain why rubber sheets might reduce the number of fish that are killed, in a poaching attack using explosive charges.

ii Why must the sheet contain holes?

4 Brian is a tank commander in the ‘Desert Rats’. He always wears ear protectors when he is in the tank.

a Suggest two sources of noise that Brian should be protected from, when he is in the tank.

b Brian must talk to the tank driver, who has very restricted vision. Suggest how they can talk to each other when they are both wearing ear protectors.
### HELP

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 a</td>
<td>Piano – string; violin – string; xylophone – wooden keys; trumpet – air inside the trumpet; guitar – strings; a bee – its wings; a saxophone – air inside the saxophone; a gong – the metal</td>
<td>8</td>
</tr>
<tr>
<td>b</td>
<td>It makes bigger vibrations/the skin goes up and down further.</td>
<td>1</td>
</tr>
<tr>
<td>c</td>
<td>High-pitched note vibrates faster/more times per second than the low-pitched note.</td>
<td>1</td>
</tr>
<tr>
<td>d</td>
<td>A cathode ray oscilloscope is used to make sounds visible. Accept equivalent answers. Underscore shows the pupil's answer.</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total for Help 11**

### CORE

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 a</td>
<td>They get smaller/the vibrations are not as large.</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>They get slower/less vibrations per second.</td>
<td>1</td>
</tr>
<tr>
<td>3 a i</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>b i</td>
<td>Because it shows the least vibrations per second.</td>
<td>1</td>
</tr>
<tr>
<td>c i</td>
<td>Both have the same loudness.</td>
<td>1</td>
</tr>
<tr>
<td>d i</td>
<td>A is a lower pitch than B.</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total for Core 8**

### EXTENSION

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 a</td>
<td>Sensible scales. Accurate plots. (Deduct 1 mark for each error to a maximum of 2.) Best fit curve drawn in.</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>Missing frequencies are: B – 236 and E – 312 (Accept near misses from pupil graph, if method shown.) Method clearly shown at least once on the graph.</td>
<td>2</td>
</tr>
<tr>
<td>c i</td>
<td>The frequency of the higher note is double the frequency of the lower note.</td>
<td>1</td>
</tr>
<tr>
<td>d</td>
<td>The A above Middle C.</td>
<td>1</td>
</tr>
<tr>
<td>e i</td>
<td>Sketch shows that: Jools' wave is taller than Sandy's. The frequencies are the same.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>Amplitude label refers to the distance between the crest/trough of a wave and its centre point. Frequency label refers to the distance between two crest/troughs.</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total for Extension 15**
## HELP

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 a</td>
<td>There is no air/a vacuum between Neil and Buzz.</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>The sound goes through their helmets to the air inside them.</td>
<td>1</td>
</tr>
<tr>
<td>c i</td>
<td>No</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>He would see the hammer hitting the bell.</td>
<td>1</td>
</tr>
<tr>
<td>iii</td>
<td>Hold it so it touched his helmet.</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>They could hear the sound of their hooves through the ground and work out where it was coming from.</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total for Help**: 8

## CORE

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 a i</td>
<td>The light.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>Light travels faster than sound.</td>
<td>1</td>
</tr>
<tr>
<td>3 b i</td>
<td>1 second</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>2 seconds</td>
<td>1</td>
</tr>
<tr>
<td>iii</td>
<td>The sound has to go to the cliff and back again/the sound has to travel 660 metres in total.</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>By the time the sound reaches Leo’s ears the plane has already travelled a long way.</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total for Core**: 6

## EXTENSION

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 a</td>
<td>Pupil must mention the following ideas:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sound transfers energy.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sound energy is transferred when particles touch each other.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>The closer together particles are, the easier it is to transfer the sound energy.</td>
<td>1</td>
</tr>
<tr>
<td>b i</td>
<td>Sound reflects/bounces back from another ship.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Ships move quite slowly so the other ship has not gone far when the sound returns to the submarine.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Planes travel much faster than ships so the other plane would have moved a long way by the time the sound returned to the first plane.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>It can show where their food/fish is/are.</td>
<td>1</td>
</tr>
<tr>
<td>c</td>
<td>Space is a vacuum/contains no air so sound will not travel through it.</td>
<td>1</td>
</tr>
<tr>
<td>d</td>
<td>She can feel the vibrations through the floor.</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total for Extension**: 11
## Hearing the sound

### HELP

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Correct order is: A - ear drum; B - cochlea; C - nerve; D - small bones.</td>
<td>4</td>
</tr>
<tr>
<td>1b</td>
<td>Ear drum - vibrates as the sound reaches it. Cochlea - changes the vibrations into electrical signals. Nerve - carries the electrical signal to the brain. Small bones - vibrate and carry the movement of the eardrum to the cochlea. Accept answers given in terms of energy transfers.</td>
<td>1</td>
</tr>
<tr>
<td>1ci</td>
<td>It is important that small mammals can hear well because it helps them to avoid being eaten by predators. (or equivalent answer)</td>
<td>1</td>
</tr>
<tr>
<td>1ii</td>
<td>As mammals get older their hearing gets worse/less effective.</td>
<td>1</td>
</tr>
</tbody>
</table>

### CORE

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a</td>
<td>Humans cannot hear it.</td>
<td>1</td>
</tr>
<tr>
<td>2b</td>
<td>They have a wider hearing range than humans so they can hear it.</td>
<td>1</td>
</tr>
<tr>
<td>2c</td>
<td>It can vibrate very much faster than a human eardrum.</td>
<td>1</td>
</tr>
<tr>
<td>2d</td>
<td>They use sound to navigate/locate food when they are flying at night.</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Flow diagram should contain the following sequence: sound of explosion; vibrations/transfer of energy through the air particles; vibration/movement of the eardrum; vibrations/movement of the small bones; vibration of the cochlea; generation of electrical signals in the nerve; transfer of electrical signal to the brain; brain decodes the signal. Award 1 mark for every correct link, or link in an incorrect position, to a maximum of 8.</td>
<td>8</td>
</tr>
</tbody>
</table>

### EXTENSION

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>4a</td>
<td>It would vibrate further (do not accept 'vibrate more') in the louder music.</td>
<td>1</td>
</tr>
<tr>
<td>4b</td>
<td>The louder the music the further (not more) they will move/the larger the movement.</td>
<td>1</td>
</tr>
<tr>
<td>4ci</td>
<td>The eardrum has burst.</td>
<td>1</td>
</tr>
<tr>
<td>4ii</td>
<td>The small bones have become paralysed/the nerve has stopped working.</td>
<td>1</td>
</tr>
<tr>
<td>4di</td>
<td>The bones move less easily. Accept other similar or equivalent answers.</td>
<td>1</td>
</tr>
<tr>
<td>4e</td>
<td>Accept any job that involves loud noise, e.g. tractor driver/road drill operator etc.</td>
<td>1</td>
</tr>
</tbody>
</table>

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**HELP**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>They make it quieter/absorb it.</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>He might go deaf/his hearing might get worse.</td>
<td>1</td>
</tr>
<tr>
<td>c i</td>
<td>Wear ear protectors.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>Stand away from the speakers.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Total for Help</strong></td>
<td><strong>4</strong></td>
</tr>
</tbody>
</table>

**CORE**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a</td>
<td>Aircraft taking off.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Pneumatic drill.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Loudspeaker</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>Engines in stationary plane.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Vehicles</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Police siren</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Baby crying</td>
<td>1</td>
</tr>
<tr>
<td>c i</td>
<td>Fit double glazing.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Line your walls with sound-insulating material (or give example).</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>Any one from:</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Stop flights at night.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Reduce the frequency of flights.</td>
<td>1</td>
</tr>
<tr>
<td>d i</td>
<td>Children cannot get to sleep.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Interferes with their TV/radio enjoyment.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Cannot have a quiet time at home after a busy day at work.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Look for two sensible specific suggestions.</td>
<td>2</td>
</tr>
<tr>
<td>ii</td>
<td>Reduce the length of time they play.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Add soundproofing to the room they play in.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Keep doors and windows shut.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Ask them to play earlier in the evening.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Reduce the number of days they play.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Look for two sensible specific suggestions.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>Total for Core</strong></td>
<td><strong>14</strong></td>
</tr>
</tbody>
</table>

**EXTENSION**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a</td>
<td>120Db (Accept 110–150Db.)</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>Charges that explode deep underwater.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>The shock wave could damage/sink the submarine.</td>
<td>1</td>
</tr>
<tr>
<td>c i</td>
<td>Rubber would absorb some of the sound/energy.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>So that fresh water can circulate</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>to get oxygen to the fish/wash away fish waste.</td>
<td>1</td>
</tr>
<tr>
<td>4a</td>
<td>The engine noise.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>The sound of shells being fired from the tank.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>The sound of shells exploding around the tank.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Look for two points.</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>Each has a microphone with a small speaker in the ear protector.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Total for Extension</strong></td>
<td><strong>9</strong></td>
</tr>
</tbody>
</table>

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This worksheet may have been altered from the original on the CD-ROM.
Sound and hearing

1. Nadine has made a musical instrument with three stretched strings on a metal tin. She wants to improve it.
   a. What can she do to the strings to make the sound louder?
   b. All the strings make a similar-pitched note when plucked. How can she change a string to make it higher pitched?

2. Jack is investigating sound with a microphone and a cathode ray oscilloscope (CRO).
   Look at patterns A, B and C below.
   Which pattern shows:
   a. the lowest-pitched note?
   b. the highest-pitched note?
   c. the loudest note?
   d. the softest note?

3. Complete these sentences using the words below.
   Sound is caused by _________________. These can pass through ________________, ________________ and ________________, but not through a ________________ because there are no ________________.
Sound and hearing (continued)

4 These statements describe how the ear hears sounds. Put them in order by writing numbers in the boxes.

- Electrical signals travel along the nerve to the brain.
- The tiny ear bones vibrate too.
- The eardrum vibrates.
- The vibrations enter the ear.

5 Amy is seven years old. She tells her family that the television has been left on. There is no picture or sound, but she can hear the high-pitched whistle that televisions give out.

a Why can Amy hear the television whistle when her parents can’t?

b Amy’s great-grandma is 90 years old. Her granddad is 62 and used to work in a steelworks. She has a friend at school who uses a hearing aid. All these people have hearing loss for different reasons. Suggest a reason for each one.

great-grandma
granddad
friend

c Amy has an older brother who goes to rock concerts. Afterwards he says it feels as if his ears are full of water – he can’t hear clearly. Why is this?

d He says it doesn’t matter because he can hear the next day. Is he right? Explain your answer.

6 There are lots of examples of noise pollution in our modern world. Suggest a way of reducing the noise in each of these situations.

a inside a house close to a runway where a jet aircraft is taking off

b for the operator of a pneumatic drill

c inside a noisy primary school classroom
Sound and hearing

1. Nadine has made a musical instrument with three stretched strings on a metal tin. She wants to improve it.
   a. What can she do to the strings to make the sound louder?
      
      Pluck them harder.
   b. All the strings make a similar-pitched note when plucked. How can she change a string to make it higher pitched?
      
      Use a thinner or tighter string.

2. Jack is investigating sound with a microphone and a cathode ray oscilloscope (CRO).

   Look at patterns A, B and C below. Which pattern shows:
   a. the lowest-pitched note?
      
      B
   b. the highest-pitched note?
      
      C
   c. the loudest note?
      
      B
   d. the softest note?
      
      A

3. Complete these sentences using the words below.

   Sound is caused by vibrations. These can pass through solids, liquids and gases but not through a vacuum because there are no particles.

---

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This worksheet may have been altered from the original on the CD-ROM.
Sound and hearing 

4 These statements describe how the ear hears sounds. Put them in order by writing numbers in the boxes.

1. The vibrations enter the ear.
2. The eardrum vibrates.
3. The tiny ear bones vibrate too.
4. Electrical signals travel along the nerve to the brain.

5 Amy is seven years old. She tells her family that the television has been left on. There is no picture or sound, but she can hear the high-pitched whistle that televisions give out.

a Why can Amy hear the television whistle when her parents can’t? She is younger so can hear higher-pitched sounds.

b Amy’s great-grandma is 90 years old. Her granddad is 62 and used to work in a steelworks. She has a friend at school who uses a hearing aid. All these people have hearing loss for different reasons. Suggest a reason for each one.

great-grandma: loss due to age
granddad: loss due to damage from noise at work
friend: loss due to infection

C Amy has an older brother who goes to rock concerts. Afterwards he says it feels as if his ears are full of water – he can’t hear clearly. Why is this?

The loud sounds have caused damage to his ears

D He says it doesn’t matter because he can hear the next day. Is he right? Explain your answer. No, gradual loss from damage may not be noticed until later in life.

6 There are lots of examples of noise pollution in our modern world. Suggest a way of reducing the noise in each of these situations.

a inside a house close to a runway where a jet aircraft is taking off

b for the operator of a pneumatic drill
c inside a noisy primary school classroom

Double glazing
Ear defenders
Carpet and/or curtains
1. Megan has connected this microphone to a cathode ray oscilloscope (CRO) so that she can see traces of the sounds on the screen.

a. Megan strikes a tuning fork and holds it close to the microphone. This is the trace she sees.

She chooses a tuning fork with a lower pitch and repeats the experiment. Which screen shows the trace now?

1 mark

b. A whistle from the next lab is being picked up on the screen:

If Megan shuts the door, the whistle is much fainter. Which screen shows the trace now?

1 mark
2. This bar chart shows the highest pitch that these four animals can hear.

   - a. Write the correct animal for label C and for label D. 1 mark
   - b. What is the highest pitch that the dog can hear? 1 mark
   - c. Sound travels through the air and down the ear canal. Explain what happens to the eardrum when the sound reaches it. 1 mark

3. Peter has made a musical instrument out of some metal tubing. He has cut different lengths and hung them from string. He hits them with a stick to make a sound.

   - a. When a tube is struck, what vibrates so that you hear the note? 1 mark
   - b. What is meant by the frequency of the note? Write the correct letter. 1 mark
     - A. the number of times the tube is struck each second
     - B. the number of vibrations of the air each second
     - C. the number of swings the tube makes each second
     - D. the number of vibrations of the striker each second

4. In this experiment a small radio is playing inside a bell jar. The air is pumped out so that there is a vacuum inside the bell jar.

   - a. What will happen to the sound from the radio as the air is pumped out? 1 mark
   - b. Why does this happen? 1 mark
Sound and hearing (continued)

**c.** These astronauts are on the Moon. Tom claps his hands. Why doesn’t Louise hear him clap his hands? 1 mark

**d.** Tom flashes his torch at Louise. Will Louise be able to see the light from the torch? 1 mark

**e.** Explain your answer to **d.** 1 mark

**f.** Their radios suddenly stop working. Louise holds a metal hammer between her helmet and Tom’s. How does this help them to communicate? 1 mark

---

**5.** Look at the cartoon.

Scott has been to a loud rock concert. When there is a lot of rain, a pump is used to pump away the water. This pump is next to the brick wall by Jack’s bedroom. Some of the sound reaches him through the brick and some travels through the air.

**a.** Explain why Scott couldn’t hear properly. 1 mark

**b.** What should Scott have done to protect his hearing at the concert? 1 mark

**c.** Will the sound travel faster through the brick or the air? 1 mark

**d.** Will the vibrations sound louder through the brick or through the air? 1 mark

**e.** Describe what could be done to reduce the amount of noise reaching Jack’s ears. Remember to say what you would do, and how this would help. 2 marks
Sound and hearing (continued)

f Jack says that your solution has helped because:

A he fell asleep in less time
B one pillow over his head stopped the noise whereas before he needed three
C he couldn’t hear the pump when he listened to his personal stereo
D his mum’s voice sounded louder than usual when she shouted at him to put out the light.

Which one reason above shows most scientifically that the solution worked? Write the correct letter. 1 mark

6 Emma and Charlie are investigating the effect of insulation on sound. They put an electric buzzer inside a large cardboard box. Emma surrounded the buzzer with different materials. Charlie used a sound sensor to measure the sound from the buzzer.

Here are their results:

<table>
<thead>
<tr>
<th>Insulation material used</th>
<th>Sound (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton wool</td>
<td>44</td>
</tr>
<tr>
<td>Screwed up newspaper</td>
<td>38</td>
</tr>
</tbody>
</table>

a Emma said they should make sure the buzzer made the same amount of sound for each experiment. Why was this important? 1 mark

b Charlie said they could save time by doing the experiment in two boxes, one with cotton wool, the other with screwed up newspaper. If they did this what should they be very careful to check? 1 mark

c Emma said it was important not to let the buzzer touch the side of the box. Why was this? 1 mark

d Charlie had a second box they wanted to use as a control to measure sound with just the box. How should they change the experiment for this box? 1 mark

e Charlie said afterwards that screwed up newspaper was the better insulator. What did he use as the basis for his conclusion? 1 mark
Megan has connected this microphone to a cathode ray oscilloscope (CRO) so that she can see traces of the sounds on the screen.

a. Megan strikes a tuning fork and holds it close to the microphone. This is the trace she sees:

![Waveform A]

She chooses a tuning fork with a lower pitch and repeats the experiment. Which screen shows the trace now? 1 mark

- [A]
- [B]
- [C]
- [D]

b. A whistle from the next lab is being picked up on the screen:

![Waveform B]

If Megan shuts the door, the whistle is much fainter. Which screen shows the trace now? 1 mark

- [A]
- [B]
- [C]
- [D]
2 This bar chart shows the highest pitch that different animals can hear. Some of the bars have not been labelled.

![Bar chart showing highest pitch (Hz) for different animals with unlabelled bars A, B, C, D, E, F, and G.]

a What is the highest pitch that the child can hear? 1 mark

b One of the unlabelled bars represents the highest pitch an elderly person can hear. Is it A, C, E or G? 1 mark

3 Scott goes to a rock concert. As sound enters his ear, describe what happens to each of these parts:

a the eardrum 1 mark

b small hairs inside the cochlea 2 marks

c the auditory nerve 1 mark

d After the concert Scott's hearing is not good – it feels as though his ears are full of water. Next day his hearing has recovered. Describe what happened inside Scott's ears during the concert 1 mark

e Scott is going to another concert next month, but outdoors this time. What could he do to make sure his hearing isn't damaged this time? 1 mark

When there is a lot of rain, a pump is used to pump away the water. This pump is next to the brick wall by Jack's bedroom. Some of the sound reaches him though the brick and some travels through the air.

f Will the sound travel faster through the brick or the air? 1 mark

g Will the vibrations sound louder through the brick or through the air? 1 mark

h Describe what could be done to reduce the amount of noise reaching Jack's ears. Remember to say what you would do, and how this would help. 2 marks
Sound and hearing (continued)

Jack says that your solution has helped because:

A he fell asleep in less time
B one pillow over his head stopped the noise whereas before he needed three
C he couldn’t hear the pump when he listened to his personal stereo
D his mum’s voice sounded louder than usual when she shouted at him to put out the light.

Which one reason above shows most scientifically that the solution worked? Write the correct letter. 1 mark

4 This diagram shows sound vibration travelling through a liquid.

a Use the diagram to explain how sound vibrations travel through a liquid. 2 marks

b Jan says that the particles in gases are further apart than the particles in liquids. Use what Jan says to explain why sound travels faster in liquids than in gases. 1 mark

5 A bird scarer consists of a wheel with spokes, and a plastic sheet which is hit by the spokes as the wheel rotates in the wind.

The wheel rotates so that the plastic hits the spokes 200 times a second, a frequency of 200 Hz. This gives out a sound.
Sound and hearing (continued)

When the wind changes, the speed of the wheel alters so that the frequency is now 270 Hz.
What will happen to the sound given out by the bird scarer? 1 mark

b The farmer decides to increase the amplitude of the sound.
What difference will this make to the sound you hear? 1 mark

Emma and Charlie are investigating the effect of insulation on sound. They put an electric buzzer inside a large cardboard box. Emma surrounded the buzzer with different materials. Charlie used a sound sensor to measure the sound from the buzzer.

Here are their results:

<table>
<thead>
<tr>
<th>Insulation material used</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Cotton wool</td>
<td>44</td>
</tr>
<tr>
<td>Screwed up newspaper</td>
<td>38</td>
</tr>
</tbody>
</table>

a Emma said it was important not to let the buzzer touch the side of the box. Why was this? 1 mark

b Charlie had a second box they wanted to use as a control to measure sound with just the box. How should they change the experiment for this box? 1 mark

c Charlie said afterwards that screwed up newspaper was the better insulator. What did he use as the basis for his conclusion? 1 mark

d Why should Emma make sure the sound sensor is the same distance from the box each time? 1 mark

e What could Emma and Charlie do to make sure that their results are reliable? 1 mark
### Question Answer Mark Level

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Mark</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>C</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>1b</td>
<td>D</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2a</td>
<td>C child, D elderly person</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2b</td>
<td>50 000 Hz</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2c</td>
<td>It vibrates.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3a</td>
<td>The air.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3b</td>
<td>B</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>4a</td>
<td>It will get fainter or quieter or you can't hear it.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>4b</td>
<td>Sound can't travel (through a vacuum).</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>4c</td>
<td>There is no air on the Moon or sound can't travel through a vacuum.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>4d</td>
<td>Yes</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>4e</td>
<td>Light can travel through vacuum or doesn't need air.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>4f</td>
<td>Sound will travel through solids or the hammer.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>5a</td>
<td>The loud sound had damaged his hearing or ears.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>5b</td>
<td>Accept any sensible suggestion, e.g. stayed further from the speakers, put cotton wool in his ears, not attended, left early.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>5c</td>
<td>Through the brick.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>5d</td>
<td>Through the brick.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>5e</td>
<td>Accept any sensible suggestion, e.g. stand the pump on noise-reducing material, put noise-reducing material on the wall, enclose the pump in a box. Accept any explanation that involves stopping sound vibrations travelling to the ears.</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>5f</td>
<td>B</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>6a</td>
<td>Make sure the test was fair/only one factor being varied.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>6b</td>
<td>That the boxes were identical.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>6c</td>
<td>The vibrations would travel through the cardboard giving a false reading.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>6d</td>
<td>No insulation in box.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>6e</td>
<td>Evidence from his results.</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

### Scores in the range of: NC Level

<table>
<thead>
<tr>
<th>Range</th>
<th>NC Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-7</td>
<td>3</td>
</tr>
<tr>
<td>8-13</td>
<td>4</td>
</tr>
<tr>
<td>14-17</td>
<td>5</td>
</tr>
<tr>
<td>18-25</td>
<td>6</td>
</tr>
</tbody>
</table>

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# Sound and hearing

## Red (NC Tier 4-7)

### Question | Answer | Mark | Level
---|---|---|---
1 a | C | 1 | 4
| b | D | 1 | 4
2 a | 20,000 Hz | 1 | 5
| b | G | 1 | 5
3 a | It vibrates. | 1 | 5
| b | Small hairs move or vibrate and produce electrical signals. | 1 | 5
| c | It transmits electrical signals (to the brain). | 1 | 5
| d | The hair cells are flattened or damaged or cannot move. | 1 | 6
| e | Accept any sensible suggestion, e.g. stay further from the speakers, put cotton wool in his ears, leave early. | 1 | 5
| f | Through the brick. | 1 | 5
| g | Through the brick. | 1 | 5
| h | Accept any sensible suggestion, e.g. stand the pump on noise-reducing material, put noise-reducing material on the wall, enclose the pump in a box, move the pump away from the wall. Accept any explanation that involves stopping sound vibrations travelling to the ears. | 1 | 6
| i | B | 1 | 5
4 a | Particles collide passing on vibrations. | 1 | 6
| b | Particles in liquids collide more or more often. | 1 | 6
5 a | The pitch will get higher. | 1 | 7
| b | It will be louder. | 1 | 7
6 a | The vibrations would travel through the cardboard giving a false reading. | 1 | 5
| b | No insulation in box. | 1 | 5
| c | Evidence from his results. | 1 | 5
| d | Otherwise the sound levels may be different. | 1 | 6
| e | Repeat each experiment and average the results. | 1 | 6

### Scores in the range of: | NC Level
---|---
4-9 | 4
10-14 | 5
15-18 | 6
19-25 | 7
## Sound and hearing

<table>
<thead>
<tr>
<th>Learning outcomes</th>
<th>I can do this very well</th>
<th>I can do this quite well</th>
<th>I need to do more work on this</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can suggest how to make sounds louder/softer or higher/lower on musical instruments.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can match the pitch and loudness of a sound to a pattern of the vibration on a CRO.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can describe how sounds travel through different materials.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can use particles to explain why sounds travel differently through different materials.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can explain why sound needs a material to travel through.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can compare the speed of sound and light.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can describe how the ear works to hear sound.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can give some examples of how different people have different hearing ranges.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can plan and carry out an investigation into how well we can hear sounds from different directions.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can describe how loud sounds can cause hearing impairments.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can describe ways of stopping noise causing damage, including insulation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can describe how scientific instruments can gather information about our surroundings by measuring or detecting things we can’t detect with our senses.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Word</td>
<td>Definition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>amplitude R</td>
<td>Moves rapidly to and fro. Sound is made when something vibrates.</td>
<td></td>
<td></td>
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<tr>
<td>cathode ray oscilloscope (CRO)</td>
<td>Equipment that turns sound into an electrical signal.</td>
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<tr>
<td>CRO</td>
<td>Machine that shows the pattern of sound on a screen.</td>
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<tr>
<td>decibels</td>
<td>The number of vibrations per second measured in hertz. Higher-pitched</td>
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<tr>
<td></td>
<td>sounds have a higher frequency.</td>
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<tr>
<td>hearing impairment</td>
<td>A measurement for pitch or frequency.</td>
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<tr>
<td>hertz R</td>
<td>A measure of the size of a vibration. The distance on a graph between</td>
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<tr>
<td></td>
<td>the midpoint and the furthest point of the vibration.</td>
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<tr>
<td>kilohertz</td>
<td>A solid, liquid or a gas, not empty space. Sound needs matter to travel</td>
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<tr>
<td></td>
<td>through.</td>
<td></td>
<td></td>
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<tr>
<td>material</td>
<td>Part of the ear that vibrates when sound reaches it.</td>
<td></td>
<td></td>
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<tr>
<td>microphone</td>
<td>Moves from one place to another.</td>
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<tr>
<td>noise</td>
<td>A measurement for pitch or frequency. 1000 hertz.</td>
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<tr>
<td>pitch</td>
<td>Sound.</td>
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<tr>
<td>shock wave R</td>
<td>A measurement for the loudness of sound.</td>
<td></td>
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<tr>
<td>sound insulation</td>
<td>Damaged hearing.</td>
<td></td>
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<tr>
<td>transfers R</td>
<td>Vibrations that travel away from an explosion.</td>
<td></td>
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<tr>
<td>vibrates</td>
<td>Material that ‘soaks up’ sound vibrations and stops sound, e.g. rubber and</td>
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<td></td>
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<tr>
<td></td>
<td>foam.</td>
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</tbody>
</table>
Sound and hearing

- amplitude
- cathode ray oscilloscope (CRO)
- CRO
- decibels
- eardrum
- frequency
- hearing impairment
- hertz
- kilohertz
- material
- microphone
- noise
- pitch
- shock wave
- sound insulation
- transfers
- vibrates
L1 Good vibrations

Green
a. The skin which covers the top of the drum.
b. The microphone turns the sound into an electrical signal.
c. The CRO shows the electrical signal on the screen.
d. The lower-pitched sound shows two vibrations. The higher-pitched sound shows four vibrations.
e. They have the same number of vibrations. They have the same pitch.
f. They have different loudness.
1. Sounds are made by things that vibrate. Pitch is how high (or low) a sound is. More vibrations give higher-pitched sounds. Loudness is how soft (or loud) a sound is. Bigger vibrations give louder sounds.
2. a. i. B
   ii. E
   iii. C, D and F.
   b. i. D and F.
   ii. B, C and E.

Red
a. The skin which covers the top of the drum.
b. The vibrations have the same size. So that the number of vibrations for each sound could be compared more easily.
c. A lower pitch.
d. They have the same pitch.
1. a. The microphone turns the sound into an electrical signal.
   b. The CRO shows the electrical signal on the screen.
2. a. i. B
   ii. E
   iii. C, D and F.
   b. i. D and F.
   ii. B, C and E.
   c. i. D
   ii. It has the highest pitch.
   d. i. B
   ii. It is the loudest.

L2 Passing through

Green
a. Sound passes along the string. The Native American can hear distant horses' hoof-beats by putting his ear on the ground.
b. They could hear the bell ringing again.
c. He should check the speed of sound in more gases.
d. Iron railway tracks carry sound much faster than the air. So the sound of the approaching train can be heard first from the rails 'singing', before the sound of the train in the air.
e. Light travels much faster than sound.
1. Sound can travel through ... solids, liquids and gases. Sound travels much slower than light. Sound cannot travel through ... a vacuum.
2. a. i. 330 m/s
   ii. 1326 m/s
   b. Slower
   c. It is much faster. It means the pipeline doesn’t have to be closed. It is much less expensive than it would be opening up each section of the pipeline.

Red
a. Whales through water; kangaroo rats through the earth; robins through the air.
b. They could hear the bell ringing again.
c. Light travels much faster than sound.
1. a. Slower.
   b. It is much faster. It means the pipeline doesn’t have to be closed. It is much less expensive than it would be opening up each section of the pipeline.
   c. The sound would not pass through the vacuum.
2. Individual answers.

L3 Hearing the sound

Green
a. The eardrum vibrates.
b. The electric signals go through nerves to the brain.
c. No vibrations will be made.
d. Porpoise

Red
a. As we get older our hearing gets worse. We especially lose the ability to hear high pitches.
1. B, D, A, C
2. a. Pitch
   b. Bat
   c. Elephants hear a narrower range of sounds than humans who are young or middle aged. They hear a wider range than 70-year-old humans. The width of the bar charts shows this.
L Sound and hearing (continued)

Red

a When a sound reaches our ears, the eardrum vibrates. It makes some small bones vibrate. The inner ear changes the vibrations into electrical signals. These electrical signals go down the nerves to the brain.

b i A broken eardrum will not vibrate and no electrical signals will reach the brain.
   ii When the small bones become rigid they cannot move, so no electrical signals are produced.

c Porpoises

d i All can hear low-pitch sounds.
   ii The ability to hear high-pitched sounds gradually decreases with age.

e 70

1a i kilohertz
   ii hertz

b The table. An exact number is given whereas in the graph only an estimate can be made.

2 Individual answers. A reasonable range would be about 5 to 10 kilohertz.

L4 Turn it down!

Green

a No vibrations are produced if the eardrum is broken.

b i Their ears become numb.
   ii For the DJ who works there every night, the constant loudness of the music could easily cause his eardrums to be injured and his hearing damaged.

c They could line the room with sound insulation.

1a i Over 120 decibels.
   b 90 to 110 decibels.

2 Rubber or foam.

3 Loud thunderclap – 110, busy street – 70, chatting – 60, whispering – 3

Red

a i The speed of a shock wave is much greater in water than in the air.
   ii The energy carried by a shock wave is much greater in water than in the air.

b Clubbers only visit the clubs occasionally, so although their ears might become numb after a night's music, their ears will return to normal by the next day. People who work at the club will be subjected to longer periods of loud music that are repeated daily. This can cause permanent damage to their eardrums and damage their hearing.

1. Loud sounds can break the eardrum, and damage the inner ear or the nerves that carry the signals from the inner ear to the brain. All of these can cause some or total loss of hearing.

2. Loud thunderclap – 110, busy street – 70, chatting – 60, whispering – 3

3. She could line the room with sound insulation. Bare walls reflect the sound that hits them. The insulation absorbs the energy in the sound and transmits very little through the walls.

L5 Detect it

Green

a i They use microscopes.
   ii They use telescopes.

b i five
   ii fewer

vi The pattern with only one wave.

v The sizes of the vibrations are the same.

c Individual answers relying on detection of heat. Locating injured people in rubble after an earthquake would be one example.

d This enables us to be aware of things which we would otherwise not know about.

1 Finding the direction of a magnetic field – compass.

Seeing things that are far away – telescope.

Detecting a sound that is too high-pitched to hear – CRO.

2 Measuring an electric current – ammeter.

Detecting chemicals we cannot smell or taste – chromatography machine.

Measuring acidity – universal indicator paper.

Detecting heat energy at a distance – infrared camera.

Measuring temperature – thermometer.

Seeing things which are very small – microscope.

2 Individual answers.

3 a, b, c Individual answers. Either yes or no is acceptable for each answer, provided a reasonable explanation is given.
Sound and hearing (continued)

Red

a i microscopes
   ii telescopes
   iii X-ray machines.

b 0.1 and 0.01 decibels.

c 100 and 1000 kilohertz.

d 1 and 10 hertz.

e i five
   ii 50
   iii 500
   iv 5000
   v 5000 hertz or 5 kilohertz.
   vi yes

f Individual answers relying on detection of heat.

  Locating injured people in rubble after an earthquake would be one example.

g This enables us to be aware of things which we would otherwise not know about.

1 a microscope, telescope, X-ray machine, microphone, CRO, infrared camera, chromatography machine


<table>
<thead>
<tr>
<th>Instrument</th>
<th>Detects</th>
<th>Produces information as</th>
</tr>
</thead>
<tbody>
<tr>
<td>ammeter</td>
<td>electric current</td>
<td>Movement of needle on dial or digital display.</td>
</tr>
<tr>
<td>pH meter</td>
<td>acids and alkalis</td>
<td>Movement of needle on dial or digital display.</td>
</tr>
<tr>
<td>voltmeter</td>
<td>voltage</td>
<td>Movement of needle on dial or digital display.</td>
</tr>
<tr>
<td>thermometer</td>
<td>temperature</td>
<td>Column of mercury on scale or digital display.</td>
</tr>
</tbody>
</table>

2 Individual answers.
3 a, b Individual answers.