Sound control – Student sheet

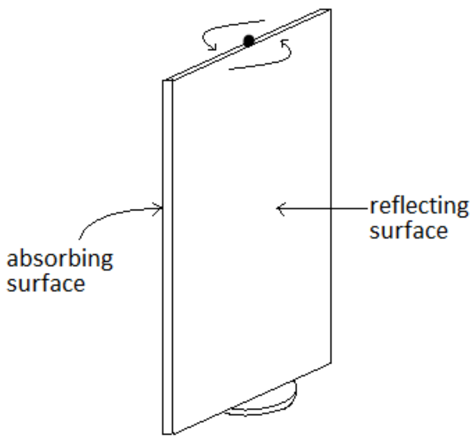
Sound engineers often have to work quickly and in difficult circumstances. They may have to set up a temporary concert venue in a warehouse or in an open space such as a park. They want to be sure that everyone in the audience has a good experience.

A sound engineer needs to be able to reflect sound where it is needed and absorb sound where it is not.

One way to do this is to use boards which have a different surface on each side – one side will reflect sound while the other will absorb sound.

The boards can be rotated to choose between reflecting and absorbing, and to change the direction of the reflected sound.

Rotating sound board



Your task is to suggest suitable materials for the two sides of one of these boards.

You will need to compare several different materials to find out:

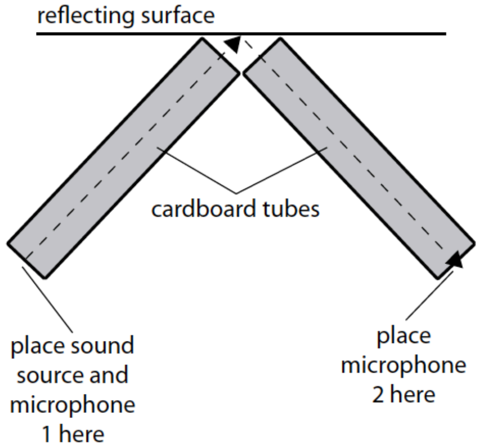
- Which materials are best at reflecting sound?
- Which are best at absorbing sound?

Follow the procedure below to compare samples of different materials.

To do

1 Stand a wooden board upright on the bench.

2 Clamp the two cardboard tubes so that each makes an angle of 45° with the board, as shown in the diagram.



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3 Position the two sound sensors/microphones at the ends of the tubes, as shown in the diagram. Make sure that you can detect sounds with each microphone.

4 Make a sound next to microphone 1.

5 Record the maximum sound level at each microphone in a table.

6 Cover the wooden board with a piece of fabric or carpet. Repeat steps 4 and 5.

7 Try covering the board with other materials and repeat the measurements.

To report

1 Use your results to put the different materials in order, from best reflector to best absorber.

2 Comment on how reliable you think your results are. How could you make your results more reliable?

3 If you are designing sound boards for use at a concert venue, you may need to take other factors into consideration. For example, the boards must be easy to move around.

Make a list of the other desirable features which the boards should have.

4 Of the materials you have investigated, which two would you choose and why?

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Assessing learning

Jo is an acoustic engineer. She is working on the design of a concert hall.

Jo has to choose suitable materials for the ceiling, walls and seating. She needs to know which materials absorb sound and which reflect it.

If the materials in the hall absorb too much sound, the music will be faint and muffled. If the materials reflect too much sound, the music will be loud and echo-y.

Jo uses information about the **sound absorption coefficient** of different materials. This gives the fraction of the sound which is absorbed by a particular material. A high value (close to 1.0) means that the material is a good absorber of sound.

The table shows the values of sound absorption coefficient for some materials which Jo might choose for concert hall.

Material	Sound absorption coefficient
plaster walls	0.02
unpainted brickwork	0.04
3 mm plywood panel	0.02
12 mm fibreboard on battens	0.35
hardwood	0.30
100 mm mineral wool	0.65
carpet	0.15
wooden seating	0.07
wooden seating with spectator	0.76
flat curtains	0.48
pleated curtains	0.75
glass	0.03
steel	0.03

To answer

1 The concert hall has glass windows. The interior designer suggests that curtains are hung in front of the windows. Jo says that more sound will be absorbed. Is she right?

2 The hall has wooden seating. Jo knows that when the audience is present more sound will be absorbed and the music will be more muffled. Explain why this is.

3 To take account of this, Jo wants to hang panels close to the ceiling to reflect sound down towards the audience. Would plywood be a suitable material?

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4 She does not want the sound to echo (reflect) from the plaster wall at the back of the hall as this will make the music sound blurred. Suggest how this problem could be overcome.

5 Jo knows that hard, flat surfaces reflect more sound than soft, rough surfaces. Give examples from the table to support this statement.

6 Use what you know about how sound is reflected to explain why pleated curtains absorb more sound than flat curtains.

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Learning structure of the lesson

The big picture

This lesson sequence is designed to exemplify a careers-linked approach to practical work, using careers-related information to provide a context for practical work.

There are many occupations in which people work with sound. For example, environmental officers may need to measure sound levels (or noise), and concert hall designers may need to control the absorption and reflection of sound.

Age range: 11–14

Timing: 50 minutes

Learning episodes	Learning outcomes	Equipment and materials
Learning episode 1 (teacher-led) 10 mins Review prior learning about sound and ask students ‘How can sound be a nuisance?’. Share learning outcomes for the lesson.	Students will be able to:	Teacher guidance Practical guidance Slide presentation Video Student sheet
Learning episode 2 (teacher-led) 15 mins Demonstrate how to measure the loudness of sounds. Show video about an acoustic engineer whose job involves ensuring that a room has the right acoustic properties for its intended use.	• explain how an understanding of how sound is reflected or absorbed is important in a workplace context	***Per class*** Sources of sound of different loudnesses Sound sensor or meter Wooden board ***Per group*** Sound sensors or meters, 1 or 2 Wooden board, approx. 60 cm × 40 cm, with stand
Learning episode 3 (student-led) 15 mins Students carry out the practical investigation to find out which materials are good absorbers of sound and which are good reflectors of sound.	• give examples of surfaces which are good reflectors of sound, and surfaces which are good absorbers of sound	Pieces of material similar in size to the board, e.g. metal, fabric, carpet, cushion foam (about 5 cm thick), plastic sheeting, expanded polystyrene, bubble wrap, egg boxes. Adhesive putty or tape (to hold materials in place)
Learning episode 4 (student-led) 10 mins Students work in pairs to analyse their results and draw conclusions. They report back their findings and discuss as a class.	• describe how sound is reflected or absorbed when it strikes a surface, depending on the nature of the surface	Cardboard tubes, 2, approx. 50 cm in length Clamps and stands, 2 Source of sound Refer to the health and safety advice and practical guidance

Key words

Amplitude, reflection, absorption, noise

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Prior knowledge

It is assumed that students know the following.

- Sounds are produced by vibrating sources.
- Sound needs a material medium to propagate through.

Background information

When sound waves strike a surface, they may be absorbed, reflected or scattered (or a combination of these), according to the nature of the surface.

An understanding of the behaviour of sound is used in the design of buildings, concert halls etc., and in noise reduction in outdoor environments.

Absorbing surfaces are not just used to stop sound being transmitted from one room to the next. They are used to control the quality of the sound in the room itself. Reflecting (echo-y) surfaces are good for musical performances because music needs a certain amount of reverberation to bring it to life. Absorbing surfaces are better for speaking voices, because voices sound clearer in a 'dead space'.

Terminology

The terms which students need to understand and use in this lesson are:
amplitude – the maximum height of a waveform, or electronic trace such as an oscilloscope reading

reflection – the bouncing of a sound off a surface

absorption – when a sound is absorbed by a surface; the surface becomes slightly warmer

noise – unwanted sound

Differentiation

Challenge students to test the idea that sound has a law of reflection similar to that of light.

Older or more able students could try calculating the reverberation time using the formula:

Reverberation time (s) =
0.16 x volume of room (m^3) /{surface area of room (m^2) x average absorption coefficient}

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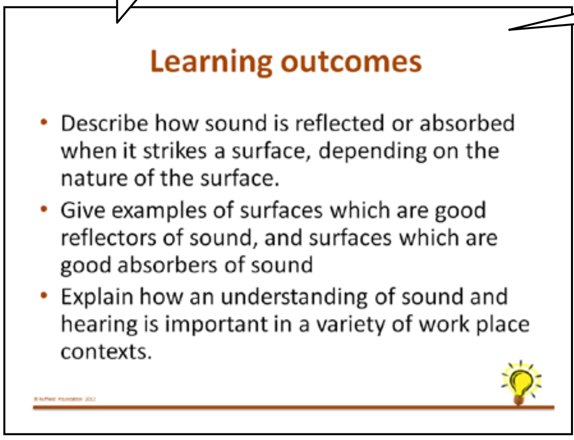
Lesson details

Task: Review prior learning about sound: how sounds are produced, the need for a material medium to carry sound waves, and, if they have already met it, how loudness and pitch are related to amplitude and frequency.

Task: Ask students: 'How can sound be a nuisance?'
Accept answers such as noise, loud music etc.

Slide 2



Task: Use **slide 2** to share learning outcomes for the lesson.

Demonstration

Explain: People who work in concert halls, or workplaces with noisy machinery, need to know exactly how loud some sounds are.

Task: Demonstrate how to measure sound by showing how to use a sound meter, suitable mobile app. or microphone and computer, to compare loudnesses (see **Practical guidance**).

Use the same equipment and technique that students will use in their class experiment.

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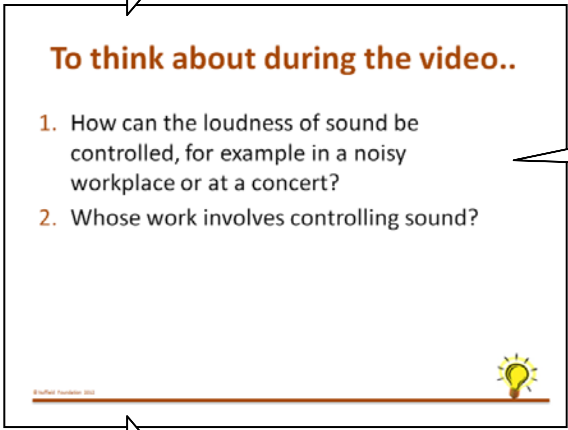
Slide 3

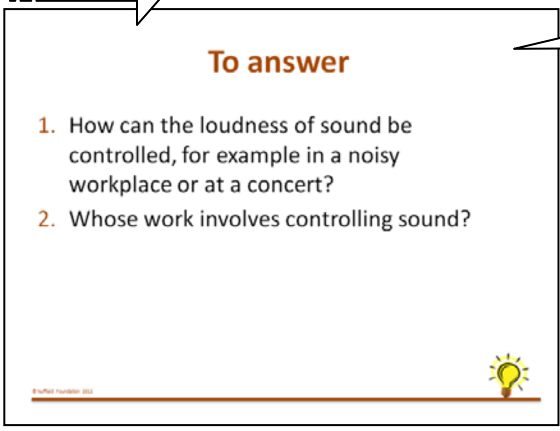


Explain: You are about to show a video about an acoustic engineer. Acoustic engineers control and measure sound for their job.

Task: Show the questions on **slide 3**, which students will need to answer after having watched the video, then show the **video**.

Video

Slide 4



Task: Return to the questions (**slide 4**) which students discuss in pairs then feed back to a class discussion.

Students should recognise the importance of knowing sound can be absorbed or reflected.

Explain: Absorbing surfaces are not just used to stop sound being transmitted from one room to the next. They are used to control the quality of the sound in the room itself. Reflecting (echo-y) surfaces are good for musical performances whereas absorbing surfaces are better for speaking voices, because voices sound clearer in a 'dead space'.

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Student sheet → **Practical**

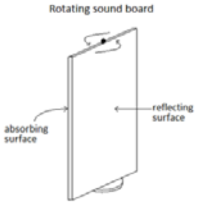
Sound Control – Student sheet

Sound engineers often have to work quickly and in difficult circumstances. They may have to set up a temporary concert venue in a warehouse or in an open space such as a park. They want to be sure that everyone in the audience has a good experience.

A sound engineer needs to be able to reflect sound where it is needed and absorb sound where it is not.

One way to do this is to use boards which have a different surface on each side – one side will reflect sound while the other will absorb sound.

The boards can be rotated to choose between reflecting and absorbing, and to change the direction of the reflected sound.



Your task is to suggest suitable materials for the two sides of one of these boards.

You will need to compare several different materials to find out:

- Which materials are best at reflecting sound?
- Which are best at absorbing sound?

Follow the procedure below to compare samples of different materials.

From the preceding demonstration, students should understand how to use the sound level meter, or microphone and computer, to determine the relative loudnesses of sounds.

Task: Students follow the directions on the **Student sheet** to investigate the reflection and absorption of sound (see **Practical guidance**).

If equipment is limited, you may wish to carry this out as a second demonstration. In either case, it will be necessary for students to keep background noise to a minimum. You could use this to point out the prevalence of random noise in our environment (which can make life very difficult for deaf people), and the need for professionals to make sound measurements, such as hearing tests, in well-insulated environments.

Differentiation: The experimental arrangement assumes that sound is reflected in a similar way to light. With more time, more able students could try adapting the arrangement to see if this is true.

Student sheet

Sound Control – Student sheet

3 Position the two sound sensors / microphones at the ends of the tubes, as shown in the diagram. Make sure that you can detect sounds with each microphone.
4 Make a sound next to microphone 1.
5 Record the maximum sound level at each microphone in a table.
6 Cover the wooden board with a piece of fabric or carpet. Repeat steps 4 and 5.
7 Try covering the board with other materials and repeat the measurements.

To report

1 Use your results to put the different materials in order, from best reflector to best absorber.
2 Comment on how reliable you think your results are. How could you make your results more reliable?
3 If you are designing sound boards for use at a concert venue, you may need to take other factors into consideration. For example, the boards must be easy to move around.
Make a list of the other desirable features which the boards should have.

Task: Students work in pairs to discuss and answer the questions on **Student sheet** page 2. In their pairs they should agree which materials they would use on the board and why. Other factors they might consider include cost of material, thickness of material, look (aesthetics) etc.

Task: Ask students to report back on their findings and discuss as a class:

- Which materials are good reflectors, which are good absorbers of sound?
- How reliable were the results?
- Can you explain your design of the sound board, including other important factors?

Student sheet

Sound Control – Student sheet

Assessing learning

Jo is an acoustic engineer. She is working on the design of a concert hall.

Jo has to choose suitable materials for the ceiling, walls and seating. She needs to know which materials absorb sound and which reflect it.

If the materials in the hall absorb too much sound, the music will be faint and muffled. If the materials reflect too much sound, the music will be loud and echo-y.

Jo uses information about the **sound absorption coefficient** of different materials. This gives the fraction of the sound which is absorbed by a particular material. A high value (close to 1.0) means that the material is a good absorber of sound.

Homework: Students complete the 'assessing learning' questions on the **Student sheet**.

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Assessing learning: Answers

1 Glass (coefficient 0.03) reflects more sound than curtains (0.48).

2 Wooden seating has a lower sound absorption coefficient (0.07) than seating with spectators (0.76).

3 Yes; plywood is a good reflector of sound. It has a very low sound absorption coefficient (0.02).

4 Hang pleated curtains (0.75) in front of the back walls (0.02), (or cover the wall with mineral wool (0.65)).

5 Hard, flat surfaces include steel (0.03), glass (0.03), plaster (0.02). These values are lower than for soft, rough surfaces such as fibreboard (0.35), mineral wool (0.65), flat curtains (0.48) etc.

6 Flat curtains (coefficient 0.48) reflect about half of the sound. With pleated curtains, the reflected sound has a chance of striking another surface of the curtain and so more will be absorbed.

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There are two practical activities in this piece of work, an introductory demonstration and a class experiment.

Equipment and materials

For demonstration

Sources of sound of different loudnesses

Sound sensor or meter (see note 1)

Wooden board

For class practical

Per group

Sound sensors or meters, 1 or 2 (see notes 1 and 4)

Wooden board, approx. 60 cm × 40 cm with stand

Pieces of card, metal, fabric, carpet, cushion foam (about 5 cm thick), plastic sheeting, expanded polystyrene, bubble wrap, egg boxes etc. similar in size to the board (see note 2)

Adhesive putty or tape (to hold the materials above in place)

Cardboard tubes, 2, approx. 50 cm in length (see note 3)

Clamps and stands, 2

Source of sound (see note 4)

Health and safety and technical notes

Before carrying out this practical, users are reminded that it is their responsibility to carry out a risk assessment in accordance with their employer's requirements, making use of up-to-date information.

Read our standard health & safety guidance.

1 The sound sensor or meter could be a sound level meter, or a sound sensor (sensor-meter) and datalogger, or a microphone connected to a computer with sound analysis software such as *Audacity*. Smartphone apps are also available.

A sound level meter will have a display which shows the loudness of sound on a scale which is likely to be in decibels (dB). It is not necessary to discuss this scale; students should simply be aware that a higher reading indicates a louder sound.

If you are using a microphone and computer, students should understand that the amplitude (height) of the trace on the screen is an indication of the loudness of the sound.

If you are using a microphone and computer or a sound sensor and datalogger you will need to be familiar with the appropriate settings which will show loud and soft noises over the range which will be encountered in this demonstration and in the class practical.

2 To give a good range of results it is best to use a selection of materials with a wide variation in acoustic properties; for example, cushion foam (very absorbent), carpet (fairly absorbent) and metal (very reflective).

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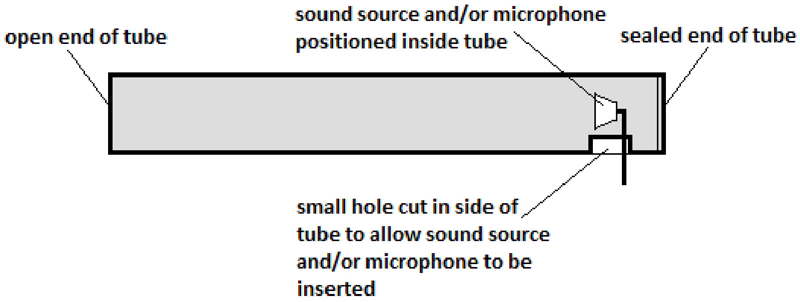
3 Poster tubes would work well. Thick walls will reduce the transmission of sound in unwanted directions.

To reduce the transmission of sound directly from the sound source to microphone 2, a small hole could be cut close to the end of each tube so that the sound source and/or microphones can be positioned inside:



4 A source of sound of consistent and repeatable loudness is ideal but not essential. A higher frequency sound will give a better range of results across the different materials. Smartphone applications which can generate white noise or tones are available. Alternatively the beep of a stopwatch or a buzzer connected in a simple electric circuit could be used.

If a source of sound of consistent and repeatable loudness is used, only one microphone is needed per group. Only the reflected sound needs to be measured and the Student sheet should be amended. If the loudness of the sound is not consistent and repeatable two microphones will be needed.

5 You will find more practical details in the SEP publication *Sound*, in particular in *Activity A7: Managing sounds in buildings*. This booklet can be downloaded freely from the National STEM Centre elibrary: www.nationalstemcentre.org.uk/elibrary/resource/2359/sound

Procedure

Demonstration

1 Show that louder sounds produce higher readings or traces with greater amplitudes. You can do this by banging two pieces of wood together next to the microphone, or by whistling or talking.

Ensure that the class can see the reading or trace at the same time that they hear the noise.

2 Move the source away from the detector and show that the sound detected is quieter. Emphasise the need for a standard sound level; you could appoint one student to speak at a normal, conversational level as you move the detector.

3 Place a wooden board between the source and the detector. Show that the loudness of the sound decreases.

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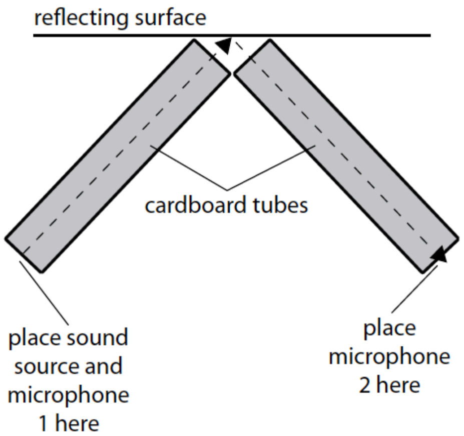
Class practical

1 Stand a wooden board upright on the bench.

2 Clamp the tubes so that they are each at 45° with the board, as shown in the diagram.



3 Position the two sound sensors/microphones at the ends of the tubes, as shown in the diagram. Make sure that you can detect sounds with each microphone.

4 Make a sound next to microphone 1.

5 Record the maximum sound level at each microphone in a table.

6 Cover the wooden board with a piece of fabric or carpet. Repeat the steps 4 and 5.

7 Cover the board with other materials and repeat the measurements.

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