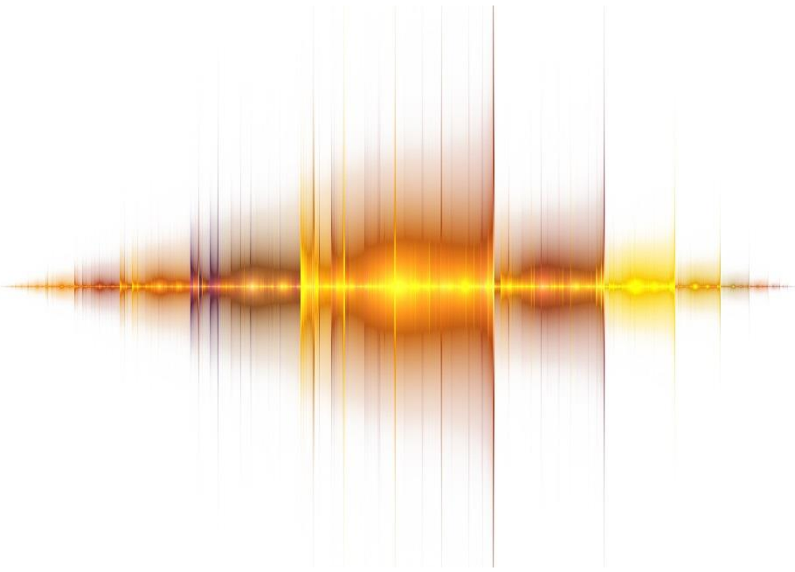
Cambridge Assessment International Education

Teaching Pack

Use of a cathode ray oscilloscope (CRO) to visualise sound waves

Cambridge O Level

Physics 5054



Version 2.0

Cambridge Pathway

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Icons used in this pack:

Briefing lesson

Lab lesson: Option 1 – run the experiment

Lab lesson: Option 2 – virtual experiment

Debriefing lesson

Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note

Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

Lab lesson (1 hour*)	
Option 1: run the experiment	**Option 2: virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases, it will also provide the opportunity to practise extended writing skills.

**the timings given here are guides; you may need to adapt the lessons to suit your circumstances.*

In this *Teaching Pack* you will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: Use of a CRO to visualise sound waves

This *Teaching Pack* focuses on an experiment to visualise sound waves using a cathode ray oscilloscope (CRO).

A microphone can be used to convert sound waves into electrical signals. Alternatively, a signal generator can be used to produce a sound of a constant amplitude and frequency. A CRO can be used to view these signals and visualise the sound waves.

This experiment has links to the following syllabus content (see syllabus for detail):

- 16.1 Sound waves

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations** (see syllabus for assessment objectives):

- demonstrate knowledge of how to safely use techniques, apparatus and materials
- interpretation of experimental observations and data
- evaluate methods and suggest possible improvements.

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- 13.1 Describing wave motion
- 16.1 Sound

Going forward

The knowledge of sound waves that is developed in this experiment is applicable to other areas of the topic of sound. The understanding of how to use a CRO will be useful when you teach learners about sketching graphs of voltage output against time for a simple a.c. generator.

Briefing lesson: Making observations

Resources	• Worksheets A and B

Learning objectives	By the end of the lesson: • ***all*** learners should be able to describe the importance of making careful observations • ***most*** learners should be able to explain the importance of accurate data readings • ***some*** learners will be able to explain how observational errors may affect later interpretations.

Timings	Activity
10 min	**Starter/introduction** Show your learners the picture of the seismic trace on Worksheet A. Give them two minutes to work in pairs to discuss what it shows and its purpose. Ask for their suggestions and then lead a discussion about the purpose of monitoring ground vibration in areas that may be affected by volcanoes or earthquakes.
20 min 20 min	**Main lesson** Use questioning to briefly revise the terms amplitude and frequency. Now your learners need to complete the questions on Worksheet A. You should encourage them to work independently, but as they progress through the worksheet they may benefit from discussing answers with a partner. Once they have finished they should self-assess their work. To do this, select individual learners to share their answer to different questions with the class and allow a discussion to develop where appropriate. By the end of this, the importance of making careful observations should be clear to your learners. Provide your learners with Worksheet B. Give them one minute to discuss what the picture on the worksheet shows and how readings from the oscilloscope may be used. Develop their ideas during a classroom discussion. They should understand that a patients' heart beats are shown on the y-axis and time is shown on the x-axis. Learners should work through the worksheet independently for the first five minutes. They can then use the following five minutes to discuss with a partner and improve their ideas before you go through the answers as a class.
10 min	**Plenary** Learners should work in groups to identify as many scenarios as possible where failure to take accurate data readings may lead to serious problems. Ask groups to take turns to explain one of their examples.

Lab lesson: Option 1 – run the experiment

Resources	• Teacher notes • Teacher walkthrough video • Worksheets C and D • Equipment outlined in the Teacher notes

Learning objectives	By the end of the lesson: • ***all*** learners should be able to describe how sound waves appear on a CRO • ***most*** learners should be able to interpret wave forms on a CRO • ***some*** learners will be able to use measurements to predict how other sound waves may appear.

Timings	Activity
10 min	**Starter/Introduction** Show a picture of a singer with a microphone. Explain that they can vary the volume of their voice coming through the speakers by moving towards or away from the microphone. Ask your learners to discuss how energy is transferred by the microphone to the speakers, and why the volume of the singer's voice varies as they move closer or further away from the microphone.
20 min 20 min	**Main lesson** Use questioning to briefly revise the concept of longitudinal and transverse waves. Use the CRO and microphone to demonstrate that longitudinal sound waves can be visualised using a CRO. Invite your learners to speak or sing through the microphone. Ensure that they see examples of low and high pitch sounds as well as high and low volume sounds. Provide learners with Worksheet C. Once they have completed this, discuss the answers as a group while learners check, and, if necessary, correct their work. Connect the signal generator to the CRO and demonstrate that it produces a sound of constant amplitude and frequency. Reduce the frequency to below 20 Hz. Increase the frequency gradually while asking learners to indicate the points when they begin to hear the sound and when they no longer hear the sound (≈ 20 to 20 000 Hz). Show a constant wave form on the CRO. Ask your learners to count the number of boxes from the equilibrium point to the crest or trough and the boxes between crests. Ask them to predict how the number of boxes will change as you double or halve the amplitude or frequency. Learners should understand that sound waves can be measured and that these measurements can be used to make accurate predictions. Provide learners with Worksheet D. Once they have completed this, discuss the answers as a group while learners check, and, if necessary, correct their work.
10 min	**Plenary** Ask one of your learners how the sound wave of a mouse squeaking may appear on a CRO. Once they have answered, ask them to give an example of another sound. Choose a second learner to describe the sound wave and then provide a different example of a sound. Continue this activity to confirm your learners' understanding.

Teacher notes

Watch the *Teacher walkthrough* video and read these notes.

This experiment should be completed as a live demonstration. You will require:

- A cathode ray oscilloscope
- A microphone
- A signal generator
- A loudspeaker
- Connecting cables/leads

Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

It is your responsibility to carry out an appropriate risk assessment for this experiment.

Substance	Hazard	First aid
—	Electrocution	**If in casualty is in contact with live electricity supply:** break contact by switching off or removing the plug. If this is not possible, use a wooden broom handle or wear rubber gloves to pull the casualty clear. See a doctor. If the casualty is unconscious, check that airways are clear and that the casualty is breathing and has a pulse. If so, place the casualty in the 'recovery position'. If a pulse is found but the casualty is not breathing, artificial ventilation is necessary. If no pulse is found and the casualty is not breathing, cardio-pulmonary resuscitation is necessary.

Experiment set-up

Teacher method

This is your version of the method for this experiment that accompanies the *Teacher walkthrough* video.

Do not share this method with learners.

Before you begin
This experiment is recommended as a demonstration.

The settings on signal generators and CROs can vary greatly. Ensure that you are familiar with the equipment you will be using during the demonstration.

Some of your learners may have hearing impairments or use hearing aids. Although they will be able to access all activities, care must be taken to ensure that they feel included.

Demonstration: Part 1

Steps	Notes
1. Turn on the CRO.	*Some CROs may take up to 10 minutes to warm up.*
2. Connect the output wires from the microphone to the input of the CRO.	
3. Set the TIME/DIV setting to 5 ms/cm.	*This setting should provide a trace at normal speech frequencies.*
4. Set the VOLTS/DIV setting to 5 mV/cm.	
5. Speak into the microphone. Adjust the TIME/DIV and VOLTS/DIV settings if required until a trace is clearly displayed and fills most of the screen.	*The y-axis of the trace is adjusted by the VOLTS/DIV control. The x-axis is adjusted using the TIME/DIV selector*
6. Use the Y-position (Y-POS) control to centre the trace in the middle of the CRO screen.	
7. Invite learners to speak or sing into the microphone.	*Ensure that sounds with a range of pitch and volume are demonstrated*

Demonstration: Part 2

Steps	Notes
1. Disconnect the microphone and connect the high impedance output of the signal generator to the input of the CRO.	*Ensure that the output wave form is sinusoidal. Signal generators usually have a selector to switch between waveforms.*
2. Connect a loudspeaker to the low impedance output of the signal generator.	
3. Adjust the frequency on the signal generator to a value of 50–100 Hz. Demonstrate a constant trace on the CRO.	*You will need to adjust two controls: the frequency dial and the frequency range selector.*
4. Adjust the frequency to demonstrate the range of human hearing (20 Hz to 20 000 Hz).	
5. Select a frequency and amplitude setting where the amplitude and period fit an exact number of boxes.	*Learners need to be able to accurately count the boxes and the trace should be centred.*
6. Demonstrate the effect of doubling and halving the amplitude and frequency.	*Do not change VOLTS/DIV or TIME/DIV settings while traces are being compared.*

Lab lesson: Option 2 – virtual experiment

Resources	• Virtual experiment video • Worksheets C and D

Learning objectives	By the end of the lesson: • ***all*** learners should be able to describe how sound waves appear on a CRO • ***most*** learners should be able to interpret wave forms on a CRO • ***some*** learners will be able to use measurements to predict how other sound waves may appear.

Timings	Activity
10 min	**Starter/Introduction** Show a picture of a singer with a microphone. Explain that the singer can vary the volume of their voice coming through the speakers by moving towards or away from the microphone. Ask your learners to discuss how energy is transferred by the microphone and speakers, and why the volume of the singer's voice varies as they move closer to or further from the microphone.
20 min 20 min	**Main lesson** Use questioning to briefly revise the concept of longitudinal and transverse waves. Ensure that your learners remember that sound waves are longitudinal waves. Provide learners with Worksheet C. They can work through this as they watch the video. Once they have completed this, discuss the answers as a group while learners check, and if necessary, correct their work. Watch the first part of the virtual experiment video. Learners should work in groups for three minutes to discuss and compare the still images on the video. Select groups in turn to describe each image, then select groups to compare similarities and differences between images. They should note that the top images have the same amplitude (volume) but different frequencies (pitch). Watch the second part of the virtual experiment video. You can pause the video to show the still image of a wave form. Ask your learners to count the number of boxes representing the amplitude and the boxes between crests. Note that the equilibrium point is not centred on the video. Give your learners two minutes to predict how the number of boxes will change if amplitude or frequency is doubled or halved. Discuss answers as a class. Learners should understand that sound waves can be measured and that these measurements can be used to make accurate predictions. Provide learners with Worksheet D. Once they have completed this, discuss the answers as a group while learners check, and if necessary, correct their work.
10 min	**Plenary** Ask one of your learners how the sound wave of a mouse squeaking may appear on a CRO. Once they have answered, ask them to give an example of another sound. Choose a second learner to describe how that sound wave might appear. They should then provide a different example of a sound. Continue this activity to confirm your learners' understanding.

Debriefing lesson: Improving the CRO investigation

Resources	• Access to the Internet and speakers • Worksheets E, F and G

Learning objectives	By the end of the lesson: • ***all*** learners should be able to evaluate a method • ***most*** learners should be able to suggest improvements to a method • ***some*** learners will be able to explain the importance of evaluation and improvements to experiments.

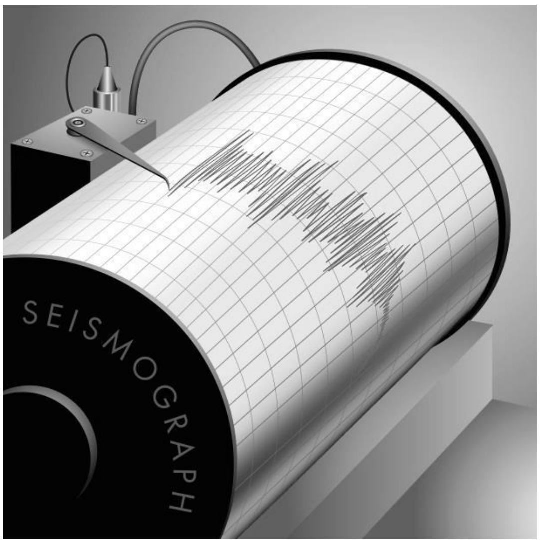
Timings	Activity
10 min	**Starter/Introduction** Show a picture of an orchestra and describe the following scenario to your learners: The conductor is interested in comparing the sound waves produced by different instruments in the orchestra. They plan to ask each musician to play a note in turn and to use a CRO to compare the traces produced. Ask your learners to discuss whether this idea will work and what factors the conductor should consider. Develop their ideas during a classroom discussion. Your learners should realise that if the conductor wishes to compare the trace produced by different instruments, they must keep other things constant during the investigation. These are the control variables, and good examples would include the pitch and amplitude of the note being played. Your learners may also suggest factors such as the distance of the microphone to the instruments, and the importance of keeping background noise to a minimum.
15 min 25 min	**Main lesson** Play some brief examples of birdsong. Ask your learners to focus on the variations in pitch (frequency). **http://www.bbc.co.uk/radio4/science/birdsong.shtml** Provide your learners with Worksheet E. They should work through the task independently for five minutes before sharing their thoughts with a partner for a further minute. You can then select one of your learners to say whether they agree or disagree with Learner 1's statement on the worksheet. Invite further opinions before repeating for the second and third statements. Provide your learners with Worksheet F. Note that they do not need to understand how an oscilloscope is used to calculate frequency. Learners should work in groups to discuss the method for five minutes before completing the worksheet independently. More able learners may progress onto Worksheet G.
10 min	**Plenary** Ask your learners to compare ideas and evaluate the improvements that others have suggested.

Worksheets and answers

	Worksheets	Suggested answers
For use in the *Briefing lesson*:		
A: Making careful observations	**14**	**21**
B: Accurate data readings	**15**	**22**
For use in *Lab lesson: Option 1*:		
C: Sound waves on a CRO	**16**	**23**
D: Measuring sound waves	**17**	**24**
For use in *Lab lesson: Option 2*:		
C: Sound waves on a CRO	**16**	**23**
D: Measuring sound waves	**17**	**24**
For use in the *Debriefing lesson*:		
E: Comparing ideas	**18**	**25**
F: Evaluating a method	**19**	**26**
G: Improving a method	**20**	**27**

Worksheet A: Making careful observations

Look at the picture of the seismic trace and answer the following questions:



1. What does the amplitude of the seismic trace show?

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2. In what way do you think a normal seismic trace would change during a very powerful earthquake?

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3. What actions might be taken if a scientist observed unusual activity on the seismic trace?

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4. What problems might occur if a scientist reads the seismic trace incorrectly?

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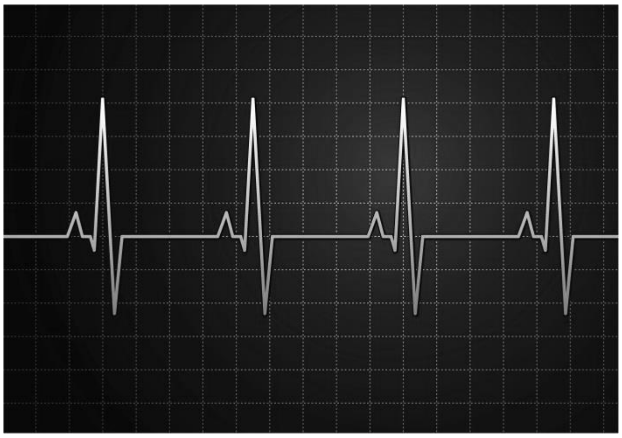
Worksheet B: Accurate data readings

The picture below shows an image from an oscilloscope that is being used as a heart rate monitor.



1. Describe how doctors use the data provided on the oscilloscope.

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2. Explain the problems that may occur if a doctor makes inaccurate data readings from the oscilloscope.

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3. Sketch a diagram to show what would be seen on the display of the oscilloscope if the patient's heart was beating with twice the frequency shown in the picture above.

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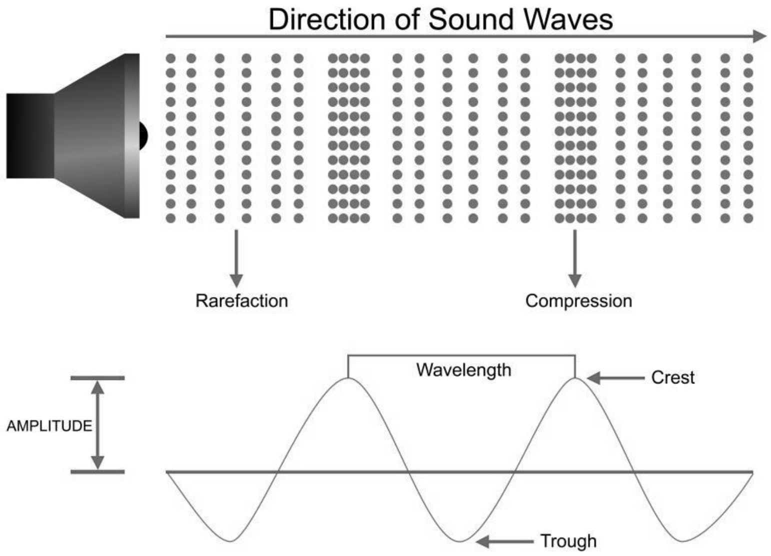
Worksheet C: Sound waves on a CRO



1. Using the diagram above, describe how the waves seen on the screen of a CRO match the properties of a sound wave.

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2. Match the following terms with their correct description:

high pitch	small amplitude	waves spread apart (long wavelength)
low pitch	high frequency	waves appear tall
loud	low frequency	waves bunched up (short wavelength)
quiet	large amplitude	waves appear short

3. Sketch a diagram for each of the following sound waves on a CRO.

high volume	low volume	high pitch	low pitch

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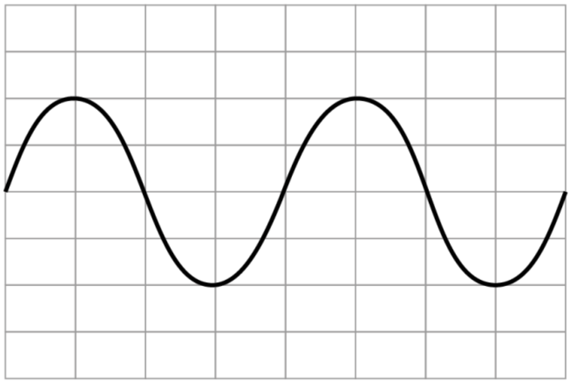
Worksheet D: Measuring sound waves



The picture above shows the screen of a CRO connected to a signal generator.

1. Explain why accurate measurements can be made more easily using a signal generator than a microphone.

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2. Describe how the wave form above would change if the amplitude was doubled.

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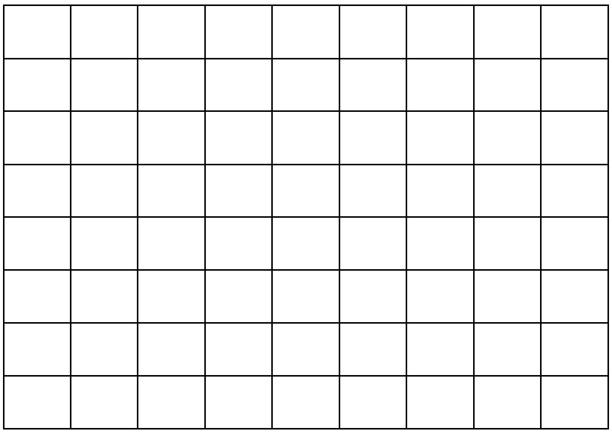
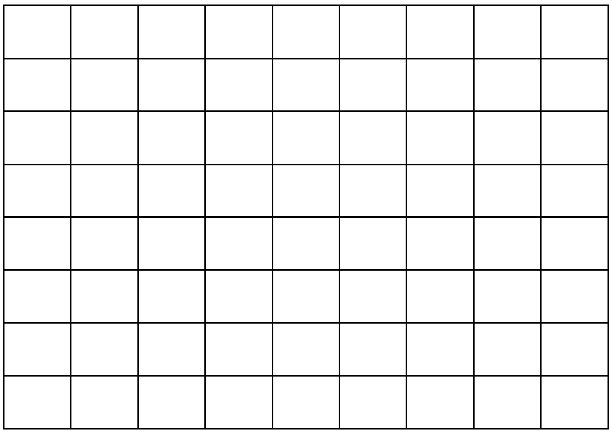
3. Draw the wave forms produced if the sound was changed in the following ways:



The same amplitude but twice the frequency.



Twice the amplitude and half the frequency.

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Worksheet E: Comparing ideas

Three learners are planning to record different kinds of birdsong and then analyse their frequencies.

Read the following statements:

Learner 1 'We must make sure that the distance from the microphone to each bird is the same. Otherwise this will affect our measurements of frequency.'

Learner 2 'It does not matter how close the microphone is to the birds, since the frequency and amplitude of the birdsong will not be affected.'

Learner 3 'The volume of the birdsong is not important so it does not matter where we position the microphone.'

Explain whether you agree or disagree with each of the statements.

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Worksheet F: Evaluating a method

A group of learners plans to investigate the frequency of different sounds using the method below:

Method:

1. Connect a microphone to a hand-held oscilloscope.
2. Remove any other sources of background noise.
3. Position the microphone 2 cm from the source of the first sound.
4. Use the oscilloscope to calculate the frequency in seconds.
5. Repeat steps 2-4 for the other sounds.

Results table:

Noise	Pitch
Guitar	
Hand clap	
Television	
Baby crying	
Tuning fork	
Barking dog	
Train engine	

Evaluate the method and identify any potential problems:

Method: ....

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Choice of sounds: ....

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Results table: ....

....

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Worksheet G: Improving a method

Consider the method outlined on Worksheet F.

1. Add more suitable headings to the table and choose a more appropriate selection of sounds to investigate.

2 Choose two of the sounds and draw the sound waves you may expect them to produce.

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3. Imagine you are going to complete an alternative investigation into sound waves. Write your method below.

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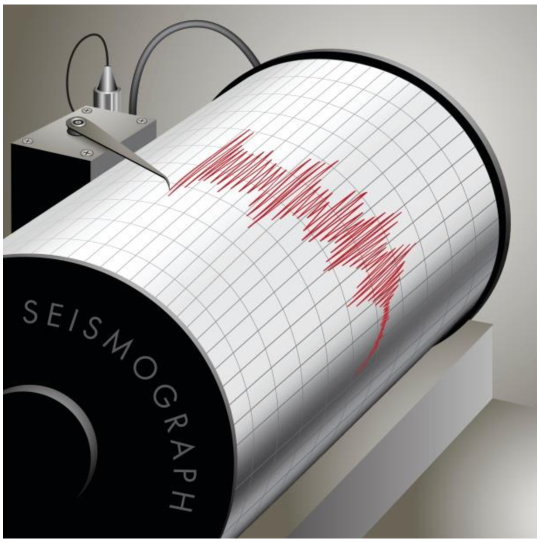
Worksheet A: Answers

Look at the picture of the seismic trace and answer the following questions:



1. What does the amplitude of the seismic trace show?

The amplitude of the seismic trace shows how large the vibrations are that are being measured by the seismograph; the greater the amplitude, the larger the vibrations.

2. In what way do you a normal seismic trace would change during a very powerful earthquake?

Normally the seismic trace would show no vibrations or extremely small vibrations.

During a very powerful earthquake the vibrations would be much greater.

The amplitude of the seismic trace would increase greatly.

3. What actions might be taken if a scientist observed unusual activity on the seismic trace?

A scientist might warn the authorities.

This could lead to warnings being issued to people in the local area.

Local areas might be evacuated.

4. What problems might occur if a scientist reads the seismic trace incorrectly?

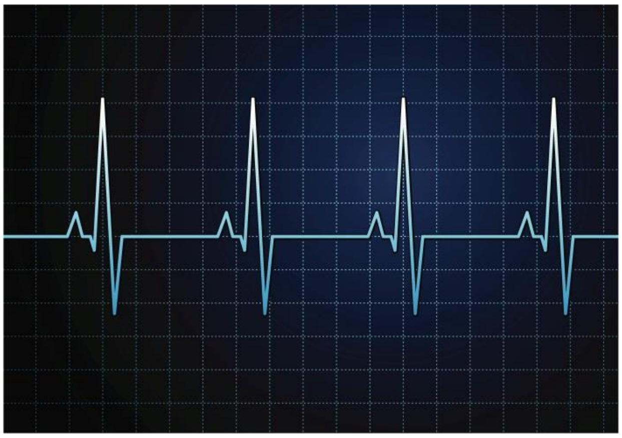
A scientist relies on making accurate observations and readings so they can provide suitable advice.

If the scientist makes incorrect readings, they may overestimate the risk and give warnings unnecessarily.

Alternatively, they may underestimate the risk and fail to give important warnings.

Worksheet B: Answers

The picture below shows an image from an oscilloscope that is being used as a heart rate monitor.



1. Describe how doctors use the data provided on the oscilloscope.

Doctors use the data to check a patient's health by monitoring their heart rate.

Immediate medical assistance can be provided if a patient's heart beats at an unusual rate.

2. Explain the problems that may occur if a doctor makes inaccurate data readings from the oscilloscope.

A doctor makes medical decisions based on the data.

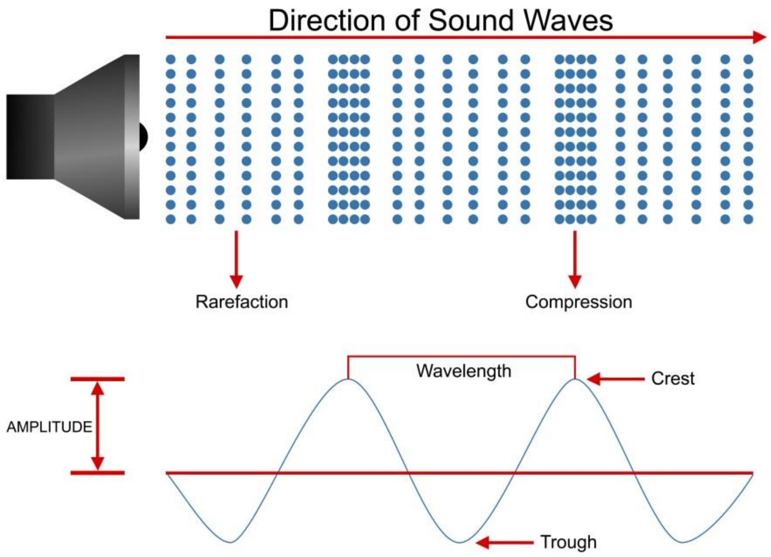
If they make inaccurate data readings, they might make incorrect decisions.

The patient might not receive the medical care they require.

3. Sketch a diagram to show what would be seen on the display of the oscilloscope if the patient's heart was beating with twice the frequency shown in the picture above.

The sketch should show 8 wave forms equally spaced.

Worksheet C: Answers



1. Using the diagram above, describe how the waves seen on the screen of a CRO match the properties of a sound wave.

Compressions match the crests on the oscilloscope trace.

Rarefactions match the troughs on the oscilloscope trace.

2. Match the following terms with their correct description:

high pitch	high frequency	waves bunched up (short wavelength)
low pitch	low frequency	waves spread apart (long wavelength)
loud	large amplitude	waves appear tall
quiet	small amplitude	waves appear short

3. Sketch a diagram for each of the following sound waves on a CRO.

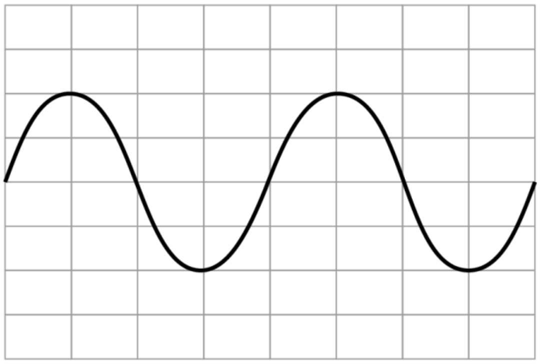
High volume sound waves should have a large amplitude. Ignore frequency.

Low volume sound waves should have a small amplitude. Ignore frequency.

High pitch sound waves should be bunched up (short wavelength). Ignore amplitude.

Low pitch sound waves should be spread apart (long wavelength). Ignore amplitude.

Worksheet D: Answers



The picture above shows the screen of a CRO connected to a signal generator.

1. Explain why accurate measurements can be made more easily using a signal generator than a microphone.

A signal generator produces a sound of a constant (single) amplitude and frequency.

The amplitude and frequency of a microphone signal do not remain constant.

2. Describe how the wave form above would change if the amplitude was doubled.

The height of the wave form would double.

The height/amplitude of the wave form would be four boxes rather than two.

3. Draw the wave forms produced if the sound was changed in the following ways:

The sound wave of the same amplitude but twice the frequency should have an amplitude of 2 boxes and a wavelength of 2 boxes.

The sound wave of twice the amplitude and half the frequency should have an amplitude of 4 boxes and a wavelength of 8 boxes.

Worksheet E: Answers

Three learners are planning to record different kinds of birdsong and then analyse their frequencies.

Read the following statements:

Learner 1 'We must make sure that the distance from the microphone to each bird is the same. Otherwise this will affect our measurements of frequency.'

Learner 2 'It does not matter how close the microphone is to the birds, since the frequency and amplitude of the birdsong will not be affected.'

Learner 3 'The volume of the birdsong is not important so it does not matter where we position the microphone.'

Explain whether you agree or disagree with each of the statements.

The distance from the microphone to the bird will affect the volume (amplitude) but not the pitch (frequency) of its song.

Learner 1 is incorrect. The frequency will not be affected.

Learner 2 is partly correct. The position of the microphone will not affect the measurements of frequency. However, the amplitude will be affected.

Learner 3 is correct. The volume of the birdsong will not affect the frequency. However, some of your learners may realise that a better signal will be received and it will be less affected by background noise if the microphone is positioned close to the bird.

Worksheet F: Answers

A group of learners plans to investigate the frequency of different sounds using the method below:

Method:

1. Connect a microphone to a hand-held oscilloscope.
2. Remove any other sources of background noise.
3. Position the microphone 2cm from the source of the first sound.
4. Use the oscilloscope to calculate the frequency in seconds.
5. Repeat steps 2–4 for the other sounds.

Results table:

Noise	Pitch
Guitar	
Hand clap	
Television	
Baby crying	
Tuning fork	
Barking dog	
Train engine	

Evaluate the method and identify any potential problems:

Method: *(Learners may suggest alternative ideas that may also be correct)*

- *No way of removing other sources of background noise is suggested.*
- *Positioning the microphone 2 cm from these sounds may not be possible.*
- *Frequency is measured in Hertz, not seconds.*

Choice of sounds: *(Learners may suggest alternative ideas that may also be correct)*

- *The frequency of some of the sounds is highly variable (e.g. television, baby crying).*
- *Some of the sounds would be difficult to predict and measure*
- *Some of the sounds only last for a very brief period of time making measurement difficult.*

Results table:

- *'Sound' or 'Source of Sound' would be a more appropriate heading than 'Noise'.*
- *'Frequency' is a more appropriate heading than 'Pitch'.*
- *Frequency is measured in Hertz (Hz)*

Worksheet G: Answers

Consider the method outlined on Worksheet F.

1. Add more suitable headings to the table and choose a more appropriate selection of sounds to investigate.

Source of Sound	Frequency (Hz)
Any appropriate suggestions	

2 Choose two of the sounds and draw the sound waves you may expect them to produce.

Differences in the frequency and amplitude of the two sounds should be correct on the diagrams.

3. Imagine you are going to complete an alternative investigation into sound waves. Write your method below.

Learners may suggest any appropriate investigation. See below for suggestions:

- *Measuring the amplitude of a range of different sounds, rather than the frequency*
- *Investigating the amplitude/frequency of a range of sounds of similar frequency/amplitude*
- *Varying the distance from the microphone to the source of a sound and measuring how the amplitude changes.*
- *Investigating the range of different amplitudes or frequencies that can be produced by the same source.*

Other suggestions may include the following:

- *Using a recording studio to minimise background noise*
- *Positioning the microphone at varying distances from sources to keep amplitude constant*
- *Repeating measurements and taking mean values of frequency*
- *Comparing results with those of other learners to increase the size of the data set*

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