Science KS3:

Year 8

Blended Learning Booklet

Unit 1: Waves

Stewards Academy

Name:

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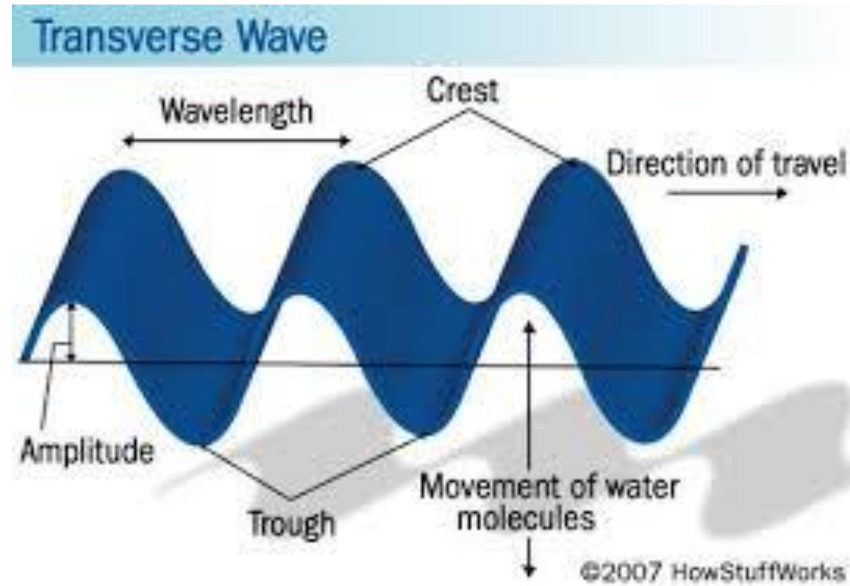

- *Aim to complete three lessons each week.*
- *Make a note of the title, date and just the 1st learning objective.*
- *Answer the in text question A, B, C….*
- *Also answer the summary questions (1 flask questions are easy, 2 flask question are medium and 3 flask question are challenging)*
- At the end of sections 1 & 2 please complete the revision questions
- Please use the mark schemes provided to self assess your work and make corrections in blue pen.

Big Picture – Year 8 Overview

Science

Year 8

The Enquiry Process

UNIT 1

I will be able to explain why controlling variables is important, evaluate and interrogate investigations, be able to communicate scientific ideas appropriately. **I will be able to** critically evaluate scientific claims and weigh up the risks and benefits of new inventions/discoveries

- Identifying variables
- Analysisng and evaluating data
- Scientific communication
- Evaluating scientific sources
- Critique claims and justify opinion

End of Unit Test

Genes

UNIT 2

I will be able to describe all stages of the human lifecycle, including how humans reproduce and how our features are inherited from our parents through our DNA. That all organisms show variation and this can help them survive. **I will be able to** explain how organisms have evolved and understand that this occurs though inheritance and natural selection.

- Variation
- Adaptation
- Reproduction
- Human lifecycle
- Natural selection
- DNA , genes and inheritance

End of Unit Test

Waves

UNIT 3

I will be able to explain what sound is and how we are able to hear. I will be able to explain how sound can vary in loudness and pitch. **I will be able to** explain the difference between sound and light waves and how our eyes enable us to see. **I will be able to** explain different properties of waves and name some other types of wave.

- Sound waves
- The ear and hearing
- Light waves
- The eye and colour vision
- Waves, energy and radiation
- Modelling waves

End of Unit Test

Reactions

UNIT 4

I will be able to explain how useful chemical reactions can be in making medicines, fabrics and building materials. Specifically, **I will be able to** describe the reactions of acids and metals in detail. **I will be able to** explain exactly what happens to atoms in chemical reactions and how energy changes are observed during a chemical reaction.

- Acids and alkalis
- Neutralisation
- Metals and non-metals
- Chemical reactions of metals
- Combustion
- Thermal decomposition
- Law of conservation of mass
- Exo- and endo-thermic

End of Unit Test

Earth

UNIT 5

I will be able to explain how everything we have has been created from materials from the Earth. **I will be able to** describe the Earth's structure, how rocks are formed and explain our Earths position in the Solar System and how this influences life on Earth. **I will be able to** explain how metals are extracted from rocks and are a finite resource that we should make sure we recycle so they don't run out. Finally, **I will be able to** state the composition of the atmosphere and the causes and effects of global warming

- Structure of the Earth
- Rock types,
- The rock cycle
- The solar system
- Global warming and climate change
- The carbon cycle
- Metal extraction and recycling

End of Unit Test

Electromagnets

UNIT 6

I will be able to use models to explain how an electric circuits work. I will be able to identify different circuit components and make circuits designed to do different jobs. **I will be able to** explain how static charge accumulates on an object and ho this can cause lightening or r electric shocks. **I will be able to** explain how permanent and temporary magnets are made and how they are both surrounded by a magnetic field. **I will be able to** make an electromagnet, explain how to alter its strength and be able to describe several uses for electromagnets.

- Voltage, resistance and current
- Series and Parallel circuits
- Models of electrical circuits
- Electrostatic charge
- Magnets and magnetic fields
- Electromagnets and their uses

End of Unit Test

End of Year Assess-ment

Next Year

ZOOM IN...

MY LEARNING JOURNEY:

Subject: Waves Year: 8 Unit: 3

In this unit students will investigate sound waves in terms of amplitude and frequency. They will be able to explain how the ear is adapted to detect sound waves. Student will also investigate light waves, be able to explain reflection and refraction as well as explain how the eye is adapted for vision. In addition, students will learn about the electromagnetic spectrum and how wave radiate energy. Students will be able to describe wave properties using models.

DEVELOPING COURAGE

C Understating how out eyes and ears work
O To carry out practical investigations
U Work safely with others during practicals
R To determine the angles of refraction and total internal reflection
A How Biology and Pyhsis work together for sight and hearing
G Share our knowledge
E Investigating the effect of prisms on light

UP NEXT

Genes

- Evolution
- Biodiversity
- Inheritance
- Genetic modifcation
- Variation
- Adaptation
- Puberty
- Reproduction
- Foetal development

CAREERS

- Seismologist
- Optician
- Audiologist
- Sound and lighting engineer

PREVIOUS LEARNING

Pupils will need to have some experience of the sun being a luminous object, light travelling in straight lines and how shadows are formed. That different sounds are made by vibrating objects in different ways and these vibrations travel through the air to our ears. They will know that light from the sun is dangerous and that it is important to protect their eyes.

WHAT WE KNOW/ REMEMBER

- ....
- ....
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- ....

PERSONAL OBJECTIVES

- ....
- ....
- ....
- ....
- ....
- ....
- ....
- ....
- ....
- ....
- ....

RECOMMENDED READING

1. Spectacular Light and Sound by Rob Colson & Jon Richards,
2. Exploring Heat Light Sound Energy by Shweta Sinha,
3. Light Sound and Electricity by Kirsteen Rogers, P. Clarke, Alastair Smith

Part 1 - Lessons

4 Waves

In a thunderstorm you see a flash of lightning and hear thunder. Your eyes and ears detect light and sound. In this Big Idea you learn about sound and hearing, and what changes when you make sounds of different pitch and loudness. You will learn how we see objects and how light behaves when it hits different materials. You will find out why you see the lightning before you hear the thunder.

You already know

- Light travels in straight lines and is reflected from surfaces. We see things when light is reflected from an object into our eyes. Dark is the absence of light.
- Light from the Sun can be dangerous, and you need to protect your eyes.
- Shadows are formed when light from a source is blocked by an opaque object.
- Sounds are made by vibrating objects.
- Vibrations travel through a medium to the ear.
- You can change the pitch and loudness of a sound by making an object vibrate in different ways.

Q

How do you make a high-pitched sound with a rubber band?

Part 1 – Summary (Check List)

4 Waves: Summary

Key Points

Sound

- Sound travels at 330 m/s in air, which is a million times slower than light.
- Sound travels fastest in solids and slowest in gases and cannot travel through a vacuum. The speed depends on the density of the material.
- In longitudinal waves, the vibration is parallel to the wave direction.
- The loudness of a sound depends on its amplitude, and the pitch depends on its frequency. Frequency is measured in hertz (Hz).
- You can use an oscilloscope to measure the amplitude or to calculate the frequency.
- A human's auditory range is from 20–20 000 Hz. Your ear converts a sound wave to an electrical signal.

Light

- Objects are transparent, translucent, or opaque.
- Light travels through a vacuum at 300 000 000 m/s.
- During an eclipse, what you see depends on where you are.
- The law of reflection says that the angle of incidence equals the angle of reflection.
- When light goes into glass or water, it is refracted towards the normal. When it leaves, it is refracted away from the normal.
- A convex (converging) lens focuses light to a focal point. Lenses correct short and long sight.
- Prisms disperse white light to produce a continuous spectrum.
- Filters and coloured objects subtract colours from white light by transmitting or reflecting the colour that they are and absorbing the rest.

Key Words

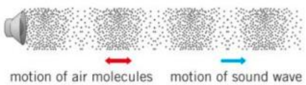
vibration, medium, vacuum, speed of sound, speed of light, amplitude, frequency, wavelength, longitudinal wave, oscilloscope, absorption, echo, pitch, hertz, kilohertz, auditory range, infrasound, ultrasound, ear, pinna, auditory canal, eardrum, outer ear, ossicle, middle ear, amplify, oval window, cochlea, auditory nerve, inner ear, volume, decibel, reflects, absorbed, lumnous, non-luminous, transparent, translucent, opaque, eclipse, image, virtual, plane, incident ray, reflected ray, normal line, angle of incidence, angle of reflection, law of reflection, scattered, specular reflection, diffuse reflection, refraction, medium, lens, convex, converging, focus, focal point, real, virtual, concave, diverging, retina, pupil, iris, cornea, inverted, photoreceptor, optic nerve, brain, prism, spectrum, dispersion, continuous, frequency, primary colour, secondary colour, filter

4.1.1 Sound waves and speed

Learning objectives

After this section you will be able to:

- state the speed of sound and what it can and cannot travel through
- describe how sound is produced and travels
- explain observations where sound is transmitted.



▲ Air molecules move backwards and forwards.

▲ The ends of a tuning fork are vibrating.

▲ Dolphins communicate underwater.

If you very gently press the front of your throat while you are talking, you will feel a vibration. This is your vocal chords vibrating. The vibration produces the sound waves that travel through the air from your mouth.

What is a sound wave?

A **vibration** produces a sound wave. All speakers, like the ones in your headphones, have something that moves backwards and forwards, or vibrates. This makes the air molecules move backwards and forwards, which produces a sound wave. Sound waves are longitudinal. The oscillations are in the same direction as the wave.

Some people think that sound just 'dies away'. It doesn't. It spreads out as it moves away from the source.

A State what produces a sound wave.

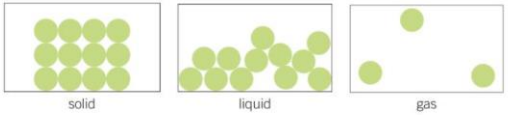
What does sound travel through?

Dolphins and whales use sound waves to communicate underwater. Elephants stamp their feet when a predator comes near – the warning travels through the ground to other elephants. Sound needs a **medium** like a solid, liquid, or gas to travel through. It cannot travel through empty space, a **vacuum**, because there are no air molecules to vibrate.

B Name the three types of medium that sound can travel through.

How fast does sound travel?

Sound travels at 330 m/s in air. Sound travels much faster in liquids, about 1500 m/s. Sound travels fastest in solids. In metals like steel it can travel at 5000 m/s. You can explain why a sound wave travels faster in a solid than in a gas if you think about particles.



▲ The arrangement of particles explains the speed of sound in different materials.

The particles in a solid are very close together, so the vibration is passed along more quickly than in a gas.

The speed depends on the density of the material. Sound travels faster in a denser material, like metal, than a less dense material, like air. Solids are about 1000-times denser than gases.

Some people talk about the 'sound barrier'. There is no difference between travelling at or beyond the **speed of sound**.

Felix Baumgartner found this out when he became the first human to travel faster than the speed of sound when he jumped from a balloon 24 miles above the surface of the Earth.

◀ Felix Baumgartner travelled faster than sound.

C State the speed of sound.

How fast?

A student uses some secondary sources of information to make a list of the speed of sound in different materials.

a Draw a suitable table that she could use to record the data.

b State and explain which type of graph she could plot to show the data.

Which is faster: sound or light?

Light travels much faster than sound. The **speed of light** is 300 000 000 m/s, so it is almost a million times faster than sound. You notice this difference during a thunderstorm. The thunder and lightning are produced at the same time. You see the lightning almost immediately but it takes longer for the sound of thunder to reach you.

Light can travel through a vacuum. It doesn't need a medium to travel through.

Key Words

vibration, medium, vacuum, speed of sound, speed of light

Stormy night

A girl sees a flash of lightning and then hears the thunder 4 seconds later.

a How far away is the storm? State your answer in kilometres.

b What would she notice about the thunder and lightning when the storm is directly overhead?

Summary Questions

1 Copy and complete the sentences below.

Sound is produced by objects that are ________. This makes the air molecules ________ and produces a sound wave. Sound travels fastest in ________ and slowest in ________, and it cannot travel through a ________.

(5 marks)

2

a Explain why sound travels slower in a gas compared to a liquid.

b Explain why sound cannot travel through a vacuum.

(2 marks)

3 Compare the time it takes the light to travel from your teacher to your eye with the time it takes sound to travel the same distance. *(6 marks)*

Lesson 1: Answers

4.1.1 Sound waves and speed

In-text questions	**A** vibrations **B** solids, liquids, gases **C** 330 m/s
Activity	**How fast?** **a** Table should have two columns, with headings 'material' and 'speed (m/s)'. **b** A bar chart because one of the variables is categoric. **Stormy night** **a** distance = 330 m/s x 4 = 1320 m = 1.32 km **b** There would be no time difference between seeing the lightning and hearing the thunder.
Summary questions	**1** vibrating, vibrate, solids, gases, vacuum (5 marks) **2a** The particles in a gas are further apart than the particles in a liquid. The vibration is not passed on so quickly. (1 mark) **b** There are no particles in a vacuum to transmit the sound/through which a new sound wave can travel. (1 mark) **3** Example answers (6 marks): Light travels much faster than sound. So the light reaches you first. It takes about 0.03 seconds for the sound to reach you. The speed of sound is about 330 m/s. It would take 0.000 000 03 seconds for light to reach you. The speed of light is 300 million m/s. So light is about 1 million times faster than sound. The time it takes light to reach you is about a millionth of the time it takes sound to reach you.

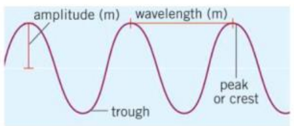
Lesson 2

4.1.2 Loudness and amplitude

Learning objectives

After this section you will be able to:

- describe the link between amplitude and loudness
- explain observations where sound is reflected or absorbed by different media
- describe the amplitude of a wave from a diagram or oscilloscope picture
- use drawings of waves to describe how sound waves change with volume.



▲ This diagram shows the amplitude and wavelength of a wave.

▲ You can make a longitudinal wave on a slinky.

Link

You can learn more about how a microphone works in Book 2, 4.3.1 Sound waves, water waves, and energy.

Key Words

amplitude, frequency, wavelength, peak, crest, trough longitudinal wave, oscilloscope, absorption, echo

How do you make waves on a slinky spring that behave like sound?

Sound waves

A wave carries energy or information from one place to another. We use sound waves to communicate information, but they also transfer energy. The wave moves through a material like air or water. The material moves back and forth but does not travel with the wave.

Features of a wave

All waves have three important features:

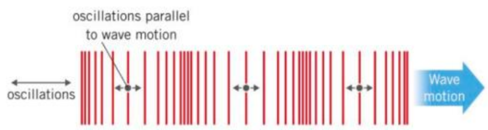
- an **amplitude**, which is the maximum amount of vibration as measured from the middle of the wave, measured in metres
- a **frequency**, which is the number of waves produced in one second, measured in hertz
- a **wavelength**, which is the distance between two corresponding points on a wave, measured in metres.

The top of a wave is called a **peak** or **crest**, and the bottom of a wave is called a **trough**.

A Name three properties of a wave.

Longitudinal waves

You can make a wave on a slinky spring by pushing and pulling it. This makes a **longitudinal wave**.

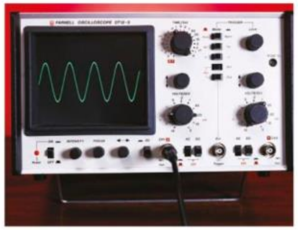


▲ In a longitudinal wave, the oscillation is parallel to the direction of the wave.

Using an oscilloscope to find amplitude

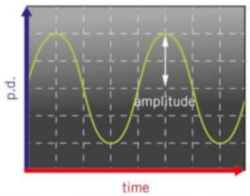
You can display a sound wave on an **oscilloscope** screen. The microphone converts the oscillations in the air to a changing p.d. The screen shows a p.d. vs. time graph.

If you know what each square (division) on the y-axis means in terms of p.d. (e.g., 3V/division), you can calculate the amplitude.



◀ An oscilloscope shows a representation of a sound wave made, for example, by a tuning fork.

B What does an oscilloscope screen show?



▲ If each square on the screen shows 3 V then the amplitude of this wave is 6 V.

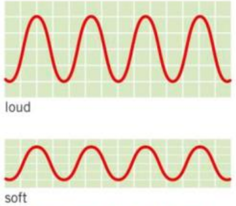
Link

You can learn more about the ear in 4.1.4 The ear and hearing.

What affects the loudness of a sound?

If a drummer hits the drum harder the sound is louder.

▲ A drum produces a sound with a large amplitude.



▲ A loud sound has a bigger amplitude than a soft sound.

You bang a drum harder or pull a guitar string more to produce a louder sound. A loud sound has a bigger amplitude than a soft sound. It transfers more energy than a soft sound. To make a louder sound you need to make the vibration bigger.

Sound and materials

You can hear people outside the room you are in but the sound is quieter. A sound wave travels through, or is transmitted through, the door. There is also **absorption**. When some of a sound wave is absorbed, its amplitude decreases and it sounds quieter.

Sound can also be reflected from surfaces, like in large caves, or from buildings. We call this an **echo**. You can use echoes to find distances to objects, like the bottom of the sea.

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

A wave is an oscillation or vibration that transfers **energy/matter**. The distance from the middle to the top of the wave is the **amplitude/wavelength**. The distance from one crest to the next crest is the **amplitude/wavelength**. Loudness depends on **wavelength/amplitude**. Sound waves are **longitudinal/light** waves, which means the vibration is in **the same/a different** direction to that of the wave. *(6 marks)*

2 The distance between the centre and peak of a wave on an oscilloscope screen is 3 divisions. There are 4 V/division. Calculate the amplitude. *(1 marks)*

3 Compare what you hear if you stand in a large empty cave and shout 'Hello' with what you hear if someone the other side of a door shouts 'Hello'. *(6 marks)*

Lesson 2: Answers

4.1.2 Loudness and amplitude

In-text questions	**A** Three from: amplitude, frequency, wavelength, speed **B** It shows a changing p.d. produced from a sound wave by a microphone
Summary questions	**1** energy, amplitude, wavelength, amplitude, longitudinal, the same (6 marks) **2** amplitude = 3 divisions x $\frac{4V}{division}$ = 12V (1 mark) **3** Extended response question. Example answer (6 marks): In a cave you hear an echo/multiple echoes because sound is reflected once/many times. The echoes get quieter because the sound spreads out and is eventually absorbed. You hear the sound travelling through the door because some is transmitted, but it is quieter than the shout because some is absorbed.

4.1.3 Frequency and pitch

Learning objectives

After this section you will be able to:

- describe the link between frequency and wavelength
- describe the frequency of a wave from a diagram or oscilloscope picture
- use drawings of waves to describe how sound waves change with pitch.

▲ A glass can shatter if you direct exactly the right sound at it

▲ An oscilloscope trace of someone speaking, or a musical instrument, contains lots of different frequencies

Foul Fact!

Grasshoppers make sounds that they cannot even hear.

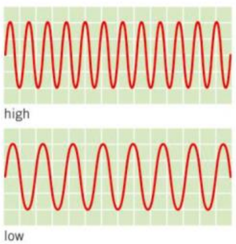
If you play a loud note of exactly the right pitch, you can shatter a glass. What's the difference between loudness and pitch?

What affects the pitch of a sound?

Some singers can sing higher-pitched notes than others. The **pitch** of a note depends on the frequency. High-pitched sounds have a high frequency and low-pitched sounds have a low frequency. Frequency is measured in **hertz** (Hz) or **kilohertz** (kHz).

1 kHz = 1000 Hz. To make a higher-pitched sound you need to make something vibrate faster so that there are more waves per second.

▲ A whistle produces a sound with a high frequency.



▲ A high sound has a higher frequency than a low sound.

You can have a loud, high-pitched sound or a loud, low-pitched sound. Changing the frequency does not affect the amplitude.

A State the property of a sound wave that affects the pitch of the sound.

The sound wave of a musical instrument, or your voice, is usually more complicated than those shown above. They contain lots of different frequencies.

What frequencies can you hear?

You can only hear a particular range of frequencies, called the **auditory range**. You have the biggest auditory range when you are young: 20–20 000 Hz. Your auditory range changes as you get older. You will find it more difficult to hear high-frequency sounds.

What frequencies can other animals hear?

Bats, dolphins, and grasshoppers have a completely different auditory range to humans. Lots of animals can hear frequencies that are much higher than the frequencies we can hear. Frequencies below 20 Hz are called **infrasound**. Frequencies above 20 000 Hz are called **ultrasound**.

Species	Auditory range (Hz)
bat	2000–110 000
cat	45–64 000
dog	67–45 000
dolphin	1000–100 000
goldfish	20–3000
hedgehog	250–45 000
whale	1000–123 000

B State which animal in the table above has the biggest auditory range

Using an oscilloscope to find frequency

You can find the frequency of a wave on an oscilloscope using the time base setting. This tells you what each square (division) on the x-axis means in terms of time (e.g., 10 ms/div).

For sound, each division will usually represent a time in milliseconds.

1 millisecond (1 ms) = 0.001 s

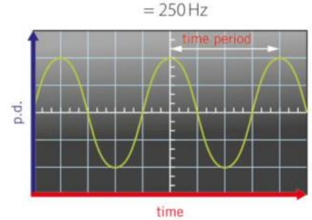
You find the time for one wave, called the time period, by counting the squares between one peak and the next peak, then multiplying by the time/division.

You calculate the frequency using this formula:

$$\text{frequency} = \frac{1}{\text{time period}}$$

In the diagram below, the time period of the wave is 0.004 s.

$$\text{frequency} = \frac{1}{0.004\,\text{s}}$$
$$= 250\,\text{Hz}$$



◀ If each square on the screen shows 0.001 s, then the time period of this wave is 0.004 s

Link

You can learn more about the ear in 4.1.4 The ear and hearing.

Conversions

a Convert the auditory range for humans into kilohertz.

b Convert the auditory range of the whale into kilohertz.

Key Words

pitch, hertz, kilohertz, auditory range, infrasound, ultrasound

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

Frequency is measured in **hertz/volts**. The pitch of a sound depends on the **amplitude/frequency**. You measure the frequency of a sound by finding the **amplitude/time period**. The range of frequencies you can hear is called the **auditory/visible range**. A goldfish can hear a **narrower/wider** range of frequencies than a human. *(5 marks)*

2 The time for one wave is 4s. Calculate the frequency. *(2 marks)*

3 A singer produces sounds that vary in pitch and loudness. Use the ideas above to suggest and explain in detail what her vocal chords do to produce different types of sound wave. *(6 marks)*

Lesson 3: Answers

4.1.3 Frequency and pitch

In-text questions	**A** Frequency **B** Whale
Activity	**Conversions** **a** 0.02 kHz-20kHz **b** 1 kHz-123 kHz
Summary questions	**1** hertz, frequency, time period, auditory, narrower (5 marks) **2** frequency $= \frac{1}{\text{period}}$ $= \frac{1}{4}$ = 0.25 Hz (2 marks) **3** Extended response question (6 marks). Example answers: Vocal chords vibrate to produce sound. Sound waves are made air is squashed and stretched. Pitch depends on frequency. To make a higher note her vocal chords vibrate more times per second. That makes the frequency of a sound wave higher. Loudness depends on amplitude. To make a louder note her vocal chords vibrate with a bigger amplitude. That makes the amplitude of a sound wave bigger.

4.1.4 The ear and hearing

Learning objectives

After this section you will be able to:

- name some parts of the ear
- describe how the ear works
- describe how your hearing can be damaged.

Foul Fact!

Your ossicles don't grow. They are the correct size when you are born. They are the smallest bones in your body.

Link

You can learn more about specialised cells in 8.2.3 Specialised cells.

Key Words

ear, pinna, auditory canal, eardrum, outer ear, ossicle, middle ear, amplify, oval window, cochlea, auditory nerve, inner ear, volume, decibel

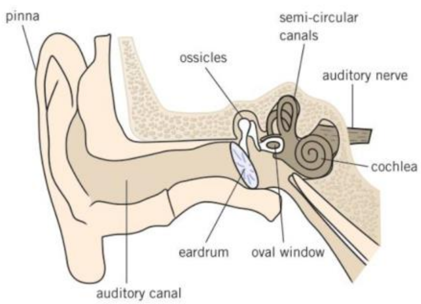
Foul Fact!

Your hearing starts to get worse from the age of 8. By the time you are 30 years old you can only hear sounds with a frequency of 14 kHz or below.

Your ear is your body's microphone. If you listen to really loud music it doesn't hurt but can it damage your hearing?

How do you hear?

Your **ear** detects sound waves.



▲ The structure of the ear.

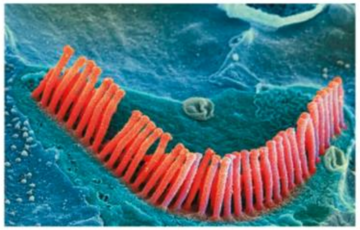
The part of your ear that you can see, called the **pinna**, directs the sound wave into your auditory canal towards your ear drum. The pinna, **auditory canal**, and **eardrum** make up your **outer ear**.

Your eardrum vibrates and passes the vibration on to the **ossicles**. The ossicles make up your **middle ear**. They are tiny bones that **amplify** the sound. They make the **oval window** vibrate.

This passes the vibration on to liquid in the **cochlea**. This contains thousands of tiny hairs. As the liquid moves, the hairs move. Specialised cells at the base of the hairs convert the movement to an electrical signal. The signal travels down the **auditory nerve** to your brain. You hear the music.

The cochlea and the semi-circular canals make up your **inner ear**. The semi-circular canals help you to balance.

A Name the first part of the ear that vibrates when a sound wave enters it.



◀ Without these tiny hairs inside your cochlea, you would not be able to hear.

How do you measure loudness?

In the 2010 World Cup in South Africa, the crowd used vuvuzelas to make very loud sounds. Vuvuzelas can be so loud that they are painful.

You measure sound intensity, or **volume**, in **decibels** (dB). The decibel scale is not like a ruler. Each increase of 10 dB increases the sound intensity by 10 times. A 40 dB sound is 100 times more intense than a 20 dB sound.

0 dB	20 dB	40 dB	60 dB	80 dB	100 dB	120 dB	140 dB
cannot be heard	leaves rustling	talking quietly	normal speech	heavy traffic	jet taking off	pain threshold	gun shot

B Write down the unit of volume.

How can you damage your hearing?

Anything that affects the transmission of sound through your ear can affect your hearing.

In your outer ear, the auditory canal can be blocked by ear wax or an object.

In your middle ear, a sharp object inserted in the ear can make a hole in your eardrum, but your eardrum will grow back. Very loud sounds or head injuries can damage your eardrum or shatter the ossicles.

Infections can affect the cochlea or the ability to send signals down the auditory nerve. As you get older, the tiny hairs in your cochlea break off and do not grow back.

All of these problems can affect the volume of sound you hear, the frequency of sounds you hear, or whether you hear a sound at all.

You can reduce the risk of damage by turning down the **volume** or using ear defenders.

C State which part of the ear vibrates less if you have ear wax in your ears.

What protection?

Two companies make ear defenders. Plan an experiment to find out which pair is best at reducing sound intensity.

Summary Questions

1. Copy and complete the sentences below.
   When a sound wave enters your ear it makes the __________ vibrate. This makes the __________ vibrate. The __________ vibrates and this makes the liquid inside your __________ vibrate. Cells at the base of __________ inside your __________ produce an electrical signal that travels up your __________ to your brain. Volume is measured in __________. Your hearing can be __________ by loud sounds.
   (9 marks)
2. Describe one way that your hearing can be damaged that is not permanent and one way that it can be permanently damaged.
   (2 marks)
3. Suggest how the length of hairs in your cochlea detect different frequencies and why your hearing changes as you get older.
   (4 marks)

Lesson 4: Answers

4.1.4 The ear and hearing

In-text questions	**A** ear drum **B** decibel **C** ear drum
Activity	**What protection?** Example: somebody wears the ear defenders, another person reduces a loud sound until the person with the ear defenders cannot hear it. Change ear defenders and repeat. The independent variable is the ear defenders. The control variables are person, distance to loudspeaker, frequency of sound. Repeat with different people and compare results.
Summary questions	**1** ear drum, ossicles, oval window, cochlea, hairs, cochlea, auditory nerve, decibels, damaged (9 marks) **2** Not permanent: ear wax, perforated ear drum, ear infection Permanent: listening to loud music, head injury (2 marks) **3** Shorter hairs in your cochlea detect higher frequencies. Longer hairs detect lower frequencies. As you get older, the shorter hairs break off/are damaged. So you cannot hear such high frequencies. (4 marks)

Lesson 5

4.2.1 Light

Learning objectives

After this section you will be able to:

- describe what happens when a light ray meets a different medium
- state the speed of light
- use ray diagrams of eclipses to describe what is seen by observers in different places.

▲ You can see a starfish through water.

▲ Frosted glass is translucent.

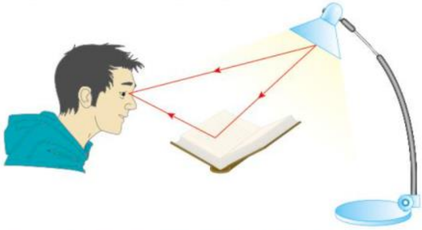
Key Words

reflect, absorb, luminous, non-luminous, transparent, translucent, opaque, eclipse

As you go deeper and deeper into an ocean it gets darker and darker until you can hardly see a thing. Some fish that live there make their own light. Why is it so dark?

What happens to light as it travels?

You look at a book. A source of light, like a light bulb, emits light. This light **reflects** off the book and into your eye. You see the book when the light is **absorbed** in your eye.



▲ You see objects because light reflects off them or because they emit light.

Something that gives out light is **luminous**. Most objects that you look at are **non-luminous**. You see them because they reflect light into your eyes. Light spreads out, just like sound.

When you look through a window, light travels through the glass and into your eye. The glass transmits the light. When light travels through glass, Perspex, or shallow water most of the light goes through but a small amount is absorbed. They are **transparent** and you can see through them. In very deep water, most of the light is absorbed.

Materials like frosted glass and tissue paper are **translucent**. Light can travel through them but it is scattered so you cannot see clearly.

A State the difference between a translucent and a transparent material.

Materials that do not transmit light are **opaque**.

Opaque materials produce shadows. You can predict the size and shape of shadows. This is because light travels in straight lines.

What can light travel through, and how fast does it travel?

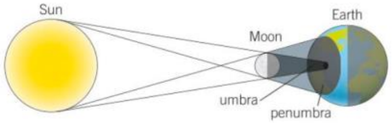
Light can travel through gases like the air, some liquids like water, and some solids like glass. It can even travel through completely empty space, which is called a vacuum. It does not need a medium to travel in. Light travels as a wave at a speed of about 300 million m/s.

B State the speed of light.

Why do we see eclipses?

Solar eclipses

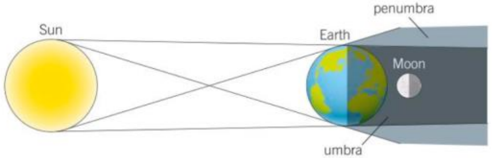
When the Moon comes between the Sun and the Earth, it makes a shadow on the Earth's surface. If you are standing in the umbra, the Moon completely blocks the light from the Sun and you see a total solar **eclipse**. If you are standing where only part of the Sun's light is blocked (the penumbra), you will see a partial solar eclipse.



▲ A solar eclipse happens when the Moon blocks the light from the Sun. *Not to scale.*

Lunar eclipses

You see partial and total eclipses of the Moon as it moves through the umbra and penumbra produced when the Earth is between the Moon and the Sun.



▲ A lunar eclipse happens when the Earth comes between the Sun and the Moon. *Not to scale.*

C State the positions of the Earth, the Moon, and the Sun in a solar eclipse and in a lunar eclipse.

Sort those words

Use the words below to make up three sentences involving a light bulb and a flower in a vase of water. The words can be used more than once but try to use them only once if you can.

emit transmit reflect absorb luminous non-luminous transparent opaque

Fantastic Fact!

It takes about 8 minutes for light to travel to the Earth from the Sun, a distance of about 150 million km.

Summary Questions

1. Copy these sentences, choosing the correct bold words.
   The Sun is **luminous/non-luminous** because it **emits/transmits** light. The light **reflects/transmits** off an object that is **luminous/non-luminous** into your eye so that you see it. Most objects do not transmit light; they are **translucent/opaque**.
   (5 marks)
2. Explain why it is so dark at the bottom of the ocean even though water is transparent.
   (2 marks)
3. Describe and explain how a solar eclipse appears from the beginning to the end.
   (6 marks)

Lesson 5: Answers

4.2.1 Light

In-text questions	**A** You can clearly see through a transparent material but not through a translucent material, even though light travels through both. **B** 300 million m/s **C** In a solar eclipse the moon is between the Earth and the Sun. In a lunar eclipse the Earth is between the Sun and the moon.
Activity	**Sort those words** For example, the light bulb emits light because it is luminous. The flower reflects light because it is non-luminous and opaque. This light is then absorbed by your eye. The water transmits light and is transparent.
Summary questions	**1** luminous, emits, reflects, non-luminous, opaque (5 marks) **2** Light is absorbed by water even though you can see through it. Only a small amount is absorbed, so you need a lot of water for it to become dark. (2 marks) **3** Extended response question (6 marks). Example answers: Light from all parts of the Sun reaches the Earth. So the Sun appears as a disc. As the Moon passes in front of the Earth you see a section of the Sun is now black/a partial eclipse. Light from part of the Sun no longer reaches the Earth at that point. If you are in the right place on the Earth’s surface you will see the Sun as a black disc with a halo/corona around it/total eclipse The Moon blocks the light from all of the Sun.

Lesson 6

4.2.2 Reflection

Learning objectives

After this section you will be able to:

- describe how light is reflected from a mirror
- describe how images are formed in a plane mirror
- use ray diagrams to show how light reflects and forms images.

▲ You see a reflection in a window.

Angular problem

A student makes a mistake and measures the angle between the mirror and the incident ray. It is 40°.

a What is the angle of incidence?

b What is the angle of reflection?

c He says the angle of incidence and the angle of reflection always add up to 90°. Is he correct? Explain your answer.

There are lots of places that you see your reflection every day. Shop windows, saucepans, car doors . . . why do you see your image in some surfaces but not others?

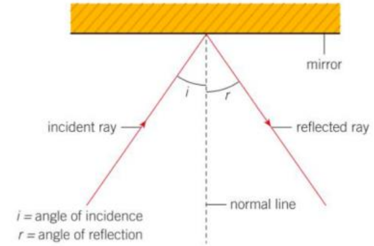
Why do I see an image in the mirror?

When you look in the mirror, it appears that there is someone who looks just like you behind the mirror. The **image** is a **virtual** image. Your brain uses the fact that light travels in straight lines to work out where the light appears to come from. This is where you see the image.

When you look at your mirror image in a flat, or **plane**, mirror, it is the same shape and size as you are. It appears to be as far behind the mirror as you are in front of the mirror. Left and right appear swapped, but a mirror really swaps back and front.

The law of reflection

You know that you need light to reflect from an object for you to see it. We use rays to show where beams of light go. A ray is a model.



▲ Light is reflected at equal angles.

The ray you draw from the ray box to the mirror is called the **incident ray**. The ray you draw that reflects off the mirror is called the **reflected ray**.

There is an imaginary line at 90° to the mirror called the **normal line**. You measure angles from the normal to the rays of light. The angle between the incident ray and the normal is the **angle of incidence**. The angle between the normal and the reflected ray is the **angle of reflection**.

When light is reflected from a mirror, the angle of incidence is equal to the angle of reflection. This is the **law of reflection**.

A State the law of reflection.

Forming an image

You can use a ray diagram and the law of reflection to work out where to find the image in a mirror. The rays represent beams of light produced by the object or reflected from the object.

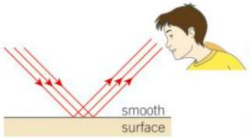
You usually draw one or two rays from the top and bottom of the object so that they reflect off the mirror into your eyes. Then you trace the rays back to work out where the image is.

Rough surfaces

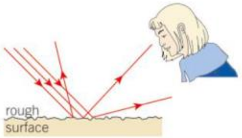
Every surface reflects at least some light. You can only see your image in surfaces that reflect light in a regular way. You don't see your reflection in a piece of paper. The light is **scattered** from paper. It bounces off the paper in all directions.

Reflection from a smooth surface is called **specular reflection**. Reflection from a rough surface is called **diffuse reflection**.

To form an image, the light from each part of the object has to reflect off a surface in the same way. If two parallel beams are reflected at different angles, you won't see an image.



▲ Reflection from a smooth surface (specular reflection).

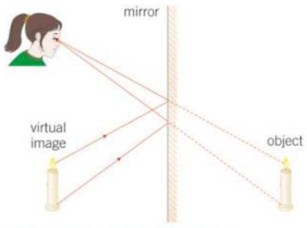


▲ Reflection from a rough surface (diffuse reflection), or scattering.

B State what is meant by scattering.

Key Words

image, virtual, plane, incident ray, reflected ray, normal line, angle of incidence, angle of reflection, law of reflection, scattered, specular reflection, diffuse reflection



▲ You see an image in a mirror.

Fantastic Fact!

The Salar de Uyuni in Bolivia, South America is a huge dry salt lake that acts like a mirror. It is so big that you can see it from space.

Summary Questions

1 Copy and complete the sentences below.

When you look in a mirror, you see a ________ image of yourself. The image is the same ________, ________, and ________ from the mirror. When you close your left eye, the image appears to close their ________ eye. The image is formed because light reflects off the mirror so that the angle of ________ is equal to the angle of ________.

(7 marks)

2 Draw a ray diagram to show how your image is formed when you look in a full length plane mirror. *(3 marks)*

3 Use ray diagrams to show that you see four images when you look at the image of an object in two mirrors at 90 degrees to each other. *(4 marks)*

Lesson 6: Answers

4.2.2 Reflection

In-text questions	**A** When light is reflected from a mirror, the angle of incidence is equal to the angle of reflection **B** When light reflects from a surface in all directions it is scattered.
Activity	**Angular problem** **a** 50° **b** 50° **c** No, the angle of incidence is equal to the angle of reflection and the angle between them can be anything from nearly 180° to 0°.
Summary questions	**1** virtual, size, shape, distance, right, incidence, reflection (7 marks) **2** Ray from top of head to mirror and then to the eye. (1 mark) Ray from the feet to the mirror and then to the eye. (1 mark) Rays traced back to show virtual image. (1 mark) **3** See the teacher notes in the Kerboodle lesson player for this section. (4 marks)

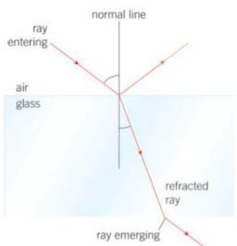
Lesson 7

4.2.3 Refraction

Learning objectives

After this section you will be able to:

- describe what happens when light enters a medium
- use a ray-diagram model to describe how light passes through lenses and transparent materials
- construct a ray diagram to show how light refracts.



▲ Light refracts when it enters or leaves a glass block.

▲ A pencil looks bent when you put it in a glass of water.

You can bend a pencil without touching it. Put it in a glass and fill it with water. It looks bent but it isn't. Why?

Optical illusions

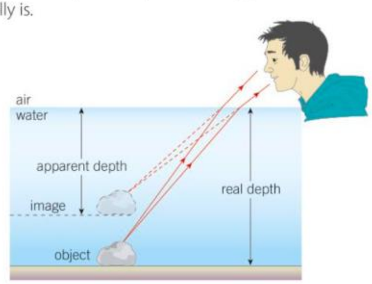
The pencil scatters light and the light travels from the pencil through the water. It then travels through the air into your eye. As the light leaves the water, the direction it is travelling in changes. This is called **refraction**.

Refraction happens whenever light travels from one **medium** (material) to another.

The change in direction explains why the pencil appears to be bent. Your brain thinks that the light has travelled in a straight line. You see the end of the pencil in a different place to where it actually is.

A State the difference between reflection and refraction.

Refraction also explains why a swimming pool looks shallower than it actually is.



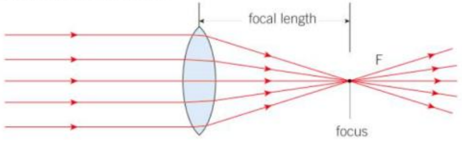
▲ A rock at the bottom of a pool looks closer to the surface than it actually is.

You may have noticed that you can see your image in a shop window at night. Light is reflected and refracted when it hits glass.

You can also see your image in a smooth metal surface, such as a saucepan. Metal is opaque so light is not refracted when it hits the surface. If the surface is rough, light is scattered.

What does a lens do?

There are two lenses in your body. The **lens** in each of your eyes is a **convex** or **converging** lens. It focuses the light and enables you to see. The point where the rays in a ray diagram cross is called the **focus** or **focal point**. The light is refracted as it goes into the lens and as it comes back out.



▲ A piece of glass shaped like a lens focuses light.

You can also find convex lenses in cameras, telescopes, glasses, and contact lenses.

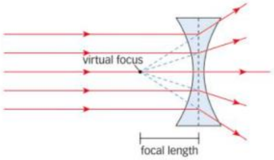
Convex lenses produce **real** images that you can put on the screen in a camera, and **virtual** images when you use them in a magnifying glass.

B Describe what a convex lens does to light.

Another type of lens is a **concave** or **diverging** lens. It spreads light out.

The point where the rays in the ray diagram appear to come from is the focus.

Just like in a convex lens, light is refracted at both surfaces of the lens.



You can find concave lenses in the spyholes in doors.

The image in a concave lens is always virtual. You cannot put it on a screen.

Watch that spelling!

In each list below, choose the correct spelling of the word. Make up a rule that will help you to remember the spelling.

a lense, lenz, lens **b** parallel, parrallel, paralell

Key Words

refraction, medium, lens, convex, converging, focus, focal point, real, virtual, concave, diverging

Fantastic Fact!

Stars twinkle because light is refracted as it travels through the atmosphere.

Summary Questions

1 Copy the sentences below, choosing the correct bold word.
When light goes into a denser medium, it bends **away from/towards** the normal. When it goes into a less dense medium, it bends **away from/towards** the normal.
You can use a **ray/wave** diagram to show the path of the light. *(3 marks)*

2 Use the ray diagrams on these pages to:
a compare convex and concave lenses
b compare light travelling through a convex lens with light travelling through a glass block. *(6 marks)*

3 You look out the window at a distant building.
a Describe in detail what happens to the light as it interacts with each object before it enters your eye.
b Draw a ray diagram to show light travelling through the window. *(6 marks)*

Lesson 7: Answers

4.2.3 Refraction

In-text questions	**A** In reflection light bounces off something, in refraction it changes direction. **B** A lens focuses or bends the rays of light to a focal point.
Activity	**Watch that spelling!** **a** lens **b** parallel
Summary questions	**1** towards, away from, ray (3 marks) **2a** Ray diagrams that show: A convex lens is thicker in the middle than at the edges A concave lens is thicker at the edges than in the middle A convex lens focuses light A concave lens spreads light out (4 marks) **b** Ray diagrams that show: Light travelling through a block is refracted, and so is light through a convex lens. (1 mark) Light travelling through a block continues in a direction parallel to the initial direction, but light through a lens comes to a focus. (1 mark) **3a** Light is scattered from the building towards your eye (1 mark) It refracts towards the normal going into the glass (1 mark) And away from the normal as it comes out (1 mark) Some of it is reflected. (1 mark) **b** Diagram as on page 68 (1 mark) showing bending towards/away from labelled normal (1 mark).

4.2.4 The eye and vision

Learning objectives

After this section you will be able to:

- name parts of the eye
- use ray diagrams to describe how light passes through the lens in your eye
- describe how lenses may be used to correct vision.

▲ No-one has the same pattern in their iris as you.

Key Words

retina, pupil, iris, cornea, inverted, photoreceptor, optic nerve, brain

Foul Fact!

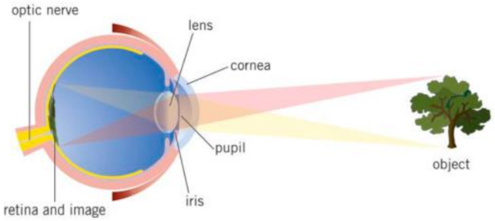
The pupil is a hole in the front of your eye. If you dissect a cow's eye you can put your finger through it.

Link

You can learn more about specialised cells in 8.2.3 Specialised cells.

The iris is the coloured part of your eye. Everyone's iris is unique. It is like a fingerprint.

How do you see?



▲ How an image is formed in your eye.

When you look at your friend, an image of your friend is formed on the **retina** of your eye. Light reflected from your friend goes through the **pupil** of your eye. The **iris** is a muscle that controls the size of the pupil. The **cornea** (the transparent outer part of your eye) and the lens focus the light onto the retina. This forms an image.

The image is **inverted** (upside down) but your brain sorts it out so you see an image of your friend that is the right way up.

A State which parts of the eye focus the light.

What happens in the retina?

The retina is a photosensitive material that contains cells that respond to light. They are called photoreceptors. There are two types of **photoreceptor**: rods and cones.

- Rods are sensitive to movement and dim light.
- Cones are sensitive to bright light and colour.

When light hits the rods and cones, chemical reactions produce an electrical impulse that travels up the **optic nerve** to your **brain**.

B State the type of reaction that takes place in the retina.

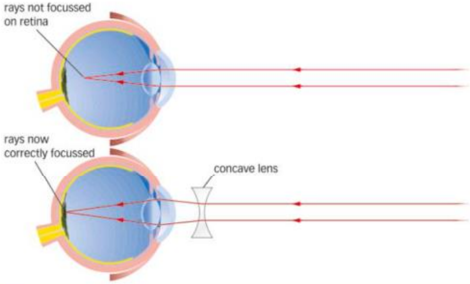
Correcting vision

To see an object clearly, each point on the object needs to correspond to a single point on the image on your retina.

Short sight

If you are short-sighted, you cannot see distant objects very clearly. Your eyeball may be too long, or your lens and cornea may refract the light too much. The image is in front of the retina.

To correct for this, you need to wear glasses or contact lenses that contain concave lenses. These lenses spread out the light so that it focuses on the retina instead.

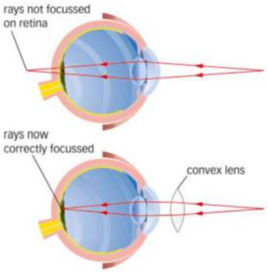


C State which lens corrects short sight.

Long sight

If you are long-sighted you cannot see close by objects very clearly. Your eyeball may be too short, or your lens and cornea may not refract the light enough. The image is behind the retina.

To correct for this, you need to wear glasses or contact lenses that contain convex lenses. These lenses pull the light in so that it focuses on the retina and you see a clear image.

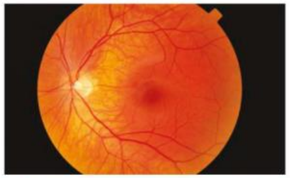


D State which lens corrects long sight.

Real or virtual?

Here are some words that describe real and virtual images. Use these words to explain the difference between the two types of image.

screen virtual real mirror



▲ This is the view of your retina that an optician would see.

Summary Questions

1 Copy and complete the sentences below.

When you look at an apple, light ________ off the apple into your eye. The light enters your eye through the ________ . The ________ and the ________ focus the light onto the ________ . The light forms a ________ image. A chemical reaction produces an ________ signal that is sent down your ________ ________ to your brain.

(9 marks)

2 Compare short-sight and long-sight.

(4 marks)

3 Suggest why contact lenses need to refract light less than the lenses in your glasses.

(4 marks)

Lesson 8: Answers

4.2.4 The eye and vision

In-text questions	**A** the cornea and the lens **B** chemical reaction **C** concave **D** long sight
Activity	**Real or virtual** A real image is an image that you can put on a screen whereas a virtual image is one that you can see in a mirror.
Summary questions	**1** reflects, pupil, cornea, lens, retina, real, electrical, optic nerve (9 marks) **2** If you are short sighted you cannot see distant objects You correct this with a concave lens If you are long sighted you cannot see nearby objects You correct this with a convex lens (4 marks) **3** In long-sight light from a distant object is focused behind the retina The convex lenses in glasses refract the light inwards so that the light focusses on the retina The contact lens is closer to your eye than glasses So can be thinner because it needs to refract light less to focus the image on the retina. (4 marks)

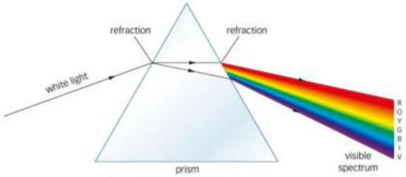
Lesson 9

4.2.5 Colour

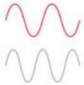
Learning objectives

After this section you will be able to:

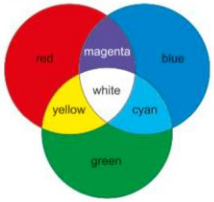
- state the difference between different colours in terms of frequency
- use the ray model to describe how objects appear different colours and how light is refracted through a prism
- explain observations where coloured lights are mixed or objects are viewed in different lights.



▲ A prism splits white light into a spectrum.



▲ Red light has a lower frequency than blue light.



▲ This Venn diagram shows the primary and secondary colours of light.

Have you ever seen really big bubbles? There are colours on the bubbles just like the colours in a rainbow or on a CD or DVD.

◀ Where do the colours come from?

Splitting white light

You can use a **prism** to split white light into a **spectrum**. This is called **dispersion**. The spectrum of white light is **continuous**. There are no gaps.

Dispersion happens because different colours of light are refracted by different amounts. Violet is refracted the most and red is refracted the least. Violet light has a higher **frequency** than red. Light with a higher frequency is refracted more than light with a lower frequency.

We say white light is made up of seven different colours of light. When we say 'blue light' we mean a band of frequencies of light that appears blue.

A State what a prism does to light.

Adding colours

You can make all the colours of light from just three colours: red, green, and blue. These are called the **primary colours** of light. We talk about these colours as primary because your eye detects these three colours. You can make any colour from different amounts of red, green, and blue. When you mix two primary colours you get **secondary colours** of light: cyan, yellow, and magenta. You get white light when you mix all three colours of light.

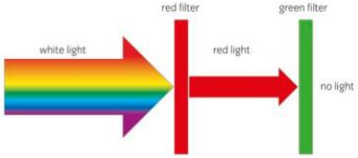
B Name the secondary colours of light.

Subtracting colours

Coloured lights on a stage can make a spectacular display. White light contains all the colours of light so if you want blue light you need to get rid of all the other colours.

What do filters do to light?

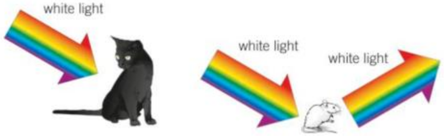
A red **filter** subtracts colours from white light. It transmits red light and absorbs the rest. It does not change the colour of light. If you put a red and a green filter together no light would get through them.



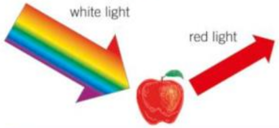
▲ Filters transmit the colours that they are and absorb the rest.

Why are objects different colours?

A red car reflects red light into your eyes. When the white light from the Sun hits the car, the paint absorbs all the other colours except red. Any coloured object reflects the colour that it is and absorbs the rest. Black objects absorb all the colours. White objects absorb no colours and reflect all the light. When light is absorbed, the material heats up.



▲ Your eye and brain perceive no light as black and all the frequencies of light as white.



◀ An apple reflects red light and absorbs the other colours.

What table?

A student wants to record data in an experiment where she is shining all the primary and secondary colours of light onto pieces of coloured material. Draw a table to show how she could record her results.

C State what a black object does to white light.

Fantastic Fact!

You can never see a rainbow when the Sun is in front of you.

Key Words

prism, spectrum, dispersion, continuous, frequency, primary colour, secondary colour, filter

Summary Questions

1 Copy the sentences below, choosing the correct bold words.

When white light goes through a prism, red light is **reflected/refracted** the **most/least** and violet light is refracted the **most/least**. This is called **dispersion/refraction**. A green filter **absorbs/transmits** green light and **absorbs/transmits** the rest.
A cyan object **absorbs/reflects** red light, **absorbs/reflects** blue light, and **absorbs/reflects** green light. A magenta object would look black in **blue/green** light. *(10 marks)*

2 Draw a ray diagram to show how a spectrum is produced when white light goes through a prism. *(3 marks)*

3 Suggest, in terms of frequencies of light, why you can usually see a small amount of light coming through a red filter and green filter when you put them together and look at a white light source. *(3 marks)*

Lesson 9: Answers

4.2.5 Colour

<table>
<tr><td>In-text questions</td><td>A splits white light into a spectrum
B cyan, yellow, magenta
C A black object absorbs all colours of light.</td></tr>
<tr><td>Activity</td><td>What table?
<table>
<tr><td>Colour of material</td><td>Appearance in red light</td><td>Appearance in green light</td><td>Appearance in blue light</td><td>Appearance in cyan light</td><td>Appearance in magenta light</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Summary questions</td><td>1 refracted, least, most, dispersion, transmits, absorbs, absorbs, reflects, reflects, green (10 marks)
2 Diagram shows white light hitting a prism at a glancing angle (1 mark)
Refracted at both surfaces (1 mark)
Violet refracted more than red. (1 mark)
3 A white light source emits all the frequencies of light (1 mark)
The filter absorbs most frequencies but transmits a narrow range of frequencies (1 mark)
If some of the frequencies that pass through the green and red filters are the same you will see some light. (1 mark)</td></tr>
</table>

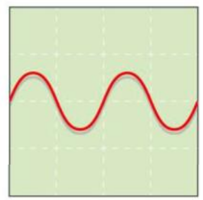
Part 1 – Revision Questions

End-of-Big Idea questions

1 Draw a wave and label the amplitude and the wavelength. ***(2 marks)***

2 Mirrors reflect light. State which capital letters of the alphabet would look the same if you saw them in a mirror. ***(1 mark)***

3 A tuning fork produces this wave on an oscilloscope:



a Draw the wave you would see if the sound was louder. *(1 mark)*
b Draw the wave you would see if the sound had a higher pitch. *(1 mark)*
c Label the amplitude on your sketches from parts **a** and **b**. *(2 marks)*
(4 marks)

4 An actor is wearing a uniform that has a blue jacket and red trousers. Suggest and explain what the audience would see if he stood on stage in:

a white light *(2 marks)*
b green light. *(2 marks)*
(4 marks)

5 A hunter is trying to spear a fish.

a Explain why he aims above where he sees the fish. *(2 marks)*
b Explain why diving birds dive straight down to catch fish. *(2 marks)*
(4 marks)

6 Suggest a situation where you might need to use ear defenders. ***(1 mark)***

7 Here is a table showing the speed of sound in three different materials: A, B, and C.

Material	Speed (m/s)
A	1250
B	300
C	5000

a State which material, A, B, or C, is probably a solid. *(1 mark)*
b State which material, A, B, or C, is probably a gas. *(1 mark)*
c Suggest a reason why the three speeds are different. *(3 marks)*
(5 marks)

8 A student makes a wave on an oscilloscope screen. The time base is 2 ms/division, and there are five waves covering 10 divisions.

a Calculate the frequency of the wave. *(3 marks)*
b The height of the wave (from peak to trough) on the screen is 5 squares, and the p.d. per division is 2 V. Calculate the amplitude in volts. *(2 marks)*
(5 marks)

9 A student is measuring sound intensity with a meter. He wonders if there is a link between the loudness of a sound and how far away you are from the source.

a Suggest a question that the student could investigate based on this idea. *(1 mark)*
b Name the independent, dependent, and control variables in the investigation. *(1 mark)*
c State the type of graph that he could plot with the results of this investigation. *(1 mark)*
(3 marks)

Lesson 10: Revision Answers

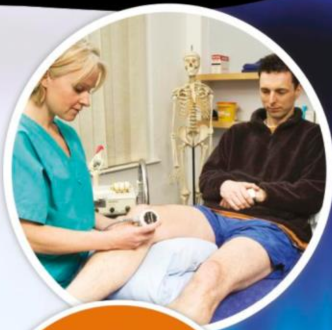
4 Waves – Part 1 Checkpoint

End-of-Big Idea questions	**1** Diagram with correct label of amplitude and correct label of wavelength. (2 marks) **2** A, H, I, M, O, T, U, V, W, X, Y (1 mark) **3a** Diagram with the same wavelength but larger amplitude. (1 mark) **b** Diagram with the same amplitude but smaller wavelength. (1 mark) **c** Amplitude correctly labelled on diagrams from part **a** and **b**. (2 marks) **4a** Blue jacket and red trousers. All colours are in white light, the blue jacket reflects blue and the red trousers reflect red. (2 marks) **b** Black jacket and black trousers. The blue jacket and red trousers would absorb green light do no light is reflected. (2 marks) **5a** The light is refracted so the image of the fish is below where it really is. (2 marks) **b** The light does not change direction so the fish is below the bird. (2 marks) **6** Credit a sensible situation where ear defenders might be needed, such as on a building site. (1 mark) **7a** C (1 mark) **b** B (1 mark) **c** The particles in C are closer together than the particles in A. The particles in A are closer together than the particles in B. Sound travels better through materials where the particles are closer together. (3 marks) **8a** 10 divisions means a time of 10 divisions x $\frac{\text{2 ms}}{\text{division}}$ = 20 ms = 20 × 10^{-3}s, or 0.02s (1 mark) There are 5 waves in 0.02s So frequency = $\frac{\text{5 waves}}{\text{0.02s}}$ (1 mark) = 250 Hz (1 mark) **b** p.d. =5 divisions x $\frac{\text{2 V}}{\text{division}}$ (1 mark) = 10 V (1 mark) **9a** How does the intensity of a sound vary with distance from the source? (1 mark) **b** Independent – distance from sound source; dependent – loudness of sound; controls – frequency and loudness of sound from source (1 mark) **c** line graph (1 mark)

Part 2

Part 2 – Summary (Check List)

4 Waves



Tsunamis, sound, infrared, and light all have something in common. They are waves and transfer energy. In this Big Idea you will learn about what affects the energy that waves transfer, and how they interact with surfaces they hit and with matter they travel through. You will find out about ultrasound and some of its uses. You will learn how the wave model can help you to explain wave behaviour.

Waves can cause damage, and not just by damaging objects on a large scale. Radiation can cause damage to the human body.

Q

How is your mirror image the same as you, and how is it different?

You already know

- Light from the Sun can be dangerous and you need to protect your eyes.
- Light is reflected from surfaces.
- Sounds are made by vibrating objects.
- Vibrations from sounds travel through a medium.

4 Waves: Summary

Key Points

Wave effects

- When a wave travels through a substance, particles move to and fro.
- Energy is transferred in the direction of movement of the wave.
- Waves with a higher frequency or larger amplitude transfer more energy.
- You can use high-frequency sound waves to agitate a liquid for cleaning objects, or to massage muscles for physiotherapy. You can also use waves to generate electricity.
- A microphone turns the pressure wave of sound hitting it into an electrical signal (a changing potential difference).
- Light and other electromagnetic radiation can damage living cells. Low-frequency radiation, like microwaves and infrared, have a heating effect on human tissue. High-frequency radiation, like ultraviolet and X-rays, can cause cancer. Lower-frequency radiation can cause skin cancer.

Wave properties

- A wave is a vibration that transports energy from place to place without transporting matter.
- In a transverse wave the vibration is perpendicular (at 90°) to the direction of travel of the wave.
- When waves combine (superpose) they can add up or cancel out.
- Slinkys and water waves are physical models that you can use to demonstrate wave properties such as reflection, refraction, transmission, absorption, and superposition.
- Waves differ in the medium that they can or cannot travel through, in their speed, and in how they interact with matter.
- Sound is longitudinal, needs a medium to travel through, and travels at 330 m/s in air. Light is transverse, does not need a medium to travel through, and travels at 300 000 km/s in air.

Key Words

compression, rarefaction, pressure wave, microphone, loudspeaker, ultrasound, visible light, electromagnetic spectrum, ionisation, radio waves, microwaves, infrared (IR), ultraviolet (UV), X-rays, gamma rays, transverse wave, wave, longitudinal wave, transmission, superpose

Lesson 11

4.3.1 Sound waves, water waves, and energy

Learning objectives

After this section you will be able to:

- describe how sound transfers energy
- describe the link between amplitude or frequency and energy
- explain how a microphone and loudspeaker work.

▲ Sometimes you need objects to be so clean that you need to use sound to clean them.

▲ When a changing current flows through a wire in the magnetic field in a loudspeaker the cone moves in and out.

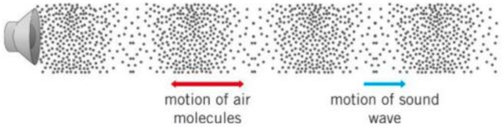
Key Words

compression, rarefaction, pressure wave, microphone, loudspeaker, ultrasound

How do you clean an object without touching it?

How does sound transfer energy?

Sound transfers energy. The vibration that makes the sound makes the air molecules vibrate to and fro in the direction of motion of the sound waves. This produces **compressions** and **rarefactions**. These are regions of high and low air pressure, so sound is a **pressure wave**.



▲ Air molecules move backwards and forwards.

A Define compression and rarefaction.

When the regions of high and low pressure interact with particles in a solid or a liquid they exert a force on them.

This means that the walls of your classroom are a little bit warmer at the end of the lesson than at the start. The sound waves have interacted with the particles in the wall and made them vibrate a little more. The wall heats up.

Sound waves transfer energy in the direction of the sound wave. If the sound wave has a bigger amplitude or frequency it transfers more energy.

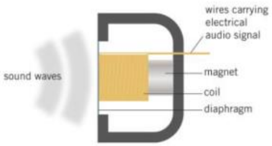
Making and detecting sound waves

You can make sound with a **microphone**, and detect it with a **loudspeaker**.

- A microphone converts changes in air pressure to a changing potential difference.
- A loudspeaker converts a changing potential difference to changes in air pressure.

When a singer sings into a microphone the sound wave hits a flexible plate called a diaphragm. The diaphragm vibrates, like your eardrum. It produces a changing potential difference.

Loudspeakers convert the changing potential difference back into sound when they vibrate.



▲ A microphone detects sound in a similar way to your ear.

▲ The oscilloscope screen displays the changing potential difference that the microphone produces from the changing air pressure from the vibration of the girl's vocal chords.

What is ultrasound?

You can only hear frequencies up to 20 000 Hz. **Ultrasound** is sound with a frequency above 20 000 Hz.

B State the frequency of ultrasound.

How do we use ultrasound?

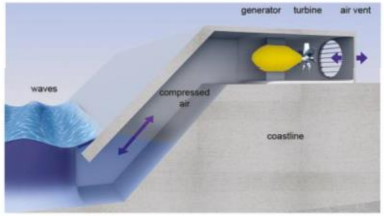
When sound or ultrasound interacts with solids or liquids it makes the particles in those materials vibrate. This means that you can use ultrasound to shake dust or dirt from objects. Scientists use ultrasonic cleaning to clean parts of their equipment that need to be very clean.

Physiotherapists also use ultrasound. Your body is mainly made of water, and when ultrasound interacts with liquids it can make the molecules move faster. The liquid gets warmer.

C State a use of ultrasound.

Wave energy and electricity

You can use the energy in water waves to generate electricity. Waves push air through a turbine and generator to produce electricity.



◀ You can use the energy transferred by water waves to generate electricity.

Link

You can learn more about how a loudspeaker works in 2.4.2 Using electromagnets.

▲ The ultrasound warms muscles and ligaments, which helps them to heal faster.

Summary Questions

1. Copy and complete the sentences below:
   The particles in a sound wave move ______ and ______. The direction of vibration is the ______ direction as that of the wave. When a sound wave interacts with particles it makes them vibrate or move ______. This can make the temperature ______. A wave with a higher ______ or higher ______ has more energy. *(7 marks)*
2. Describe how a microphone works. *(3 marks)*
3. Suggest why you need to use ultrasound and not sound to clean objects or for physiotherapy. *(3 marks)*

Lesson 11: Answers

4.3.1 Sound waves, water waves, and energy

In-text questions	**A** compression: an area of high pressure; rarefaction: an area of low pressure **B** higher than 20 kHz **C** One from: to clean objects, to warm muscles and ligaments
Summary questions	**1** to, fro, same, faster, higher, amplitude, frequency (7 marks) **2** A sound wave hits a diaphragm and makes it vibrate. This makes a magnet move backwards and forwards. This produces a changing potential difference. (3 marks) **3** Ultrasound has a higher frequency than sound waves. The energy of a wave depends on its frequency. Sound waves do not transfer enough energy to clean materials or heat muscles. (3 marks)

4.3.2 Radiation and energy

Learning objectives

After this section you will be able to:

- describe the electromagnetic spectrum
- explain the effect of radiation on living cells
- explain, in terms of frequency, the difference in damage done by electromagnetic waves.

▲ NASA made a phantom torso to find out about radiation in space.

▲ An image produced by a thermal imaging camera of someone using a mobile phone.

Key Words

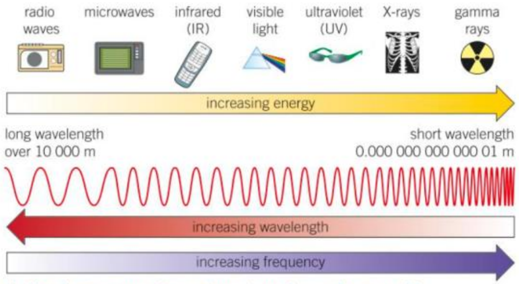
visible light, electromagnetic spectrum, ionisation, radio waves, microwaves, infrared (IR), ultraviolet (UV), X-rays, gamma rays

Do the astronauts on the International Space Station need to wear sunscreen?

To find out, NASA made a fake human torso with artificial skin, and put it on the space station for four months. They found that there was an increase in the radiation absorbed by the skin compared to Earth, but this did not pose a risk to astronauts.

The electromagnetic spectrum

The Sun emits a continuous spectrum of radiation. **Visible light** is just one part of this **electromagnetic spectrum**.



▲ The electromagnetic spectrum is made up of waves with different properties.

A State the waves of the electromagnetic spectrum.

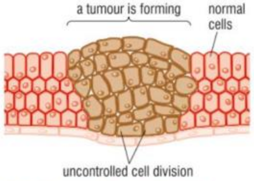
The electromagnetic spectrum is continuous, but we separate it into different bands of frequencies. Visible light has a range of frequencies. You have seen this when you split white light with a prism. Our eyes can detect visible light, but not the other waves of the electromagnetic spectrum.

The energy of a wave depends on its frequency. The higher the frequency the more energy the wave transfers.

Radiation and the human body

The Sun emits all the waves of the electromagnetic spectrum, but only some get through the atmosphere. The different waves have different effects on the body.

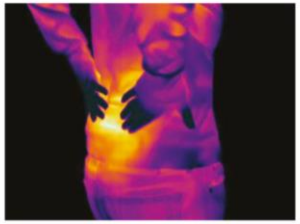
Waves with a low frequency and energy have a heating effect, but waves with a higher energy can knock electrons out of atoms in living cells. This is called **ionisation**. If the atoms are in your DNA then this can cause a mutation. The cell can replicate which can produce cancer.



▲ Cells can divide abnormally, resulting in cancer.

The type of cancer that you can develop depends on the type of radiation. Ultraviolet radiation is not very penetrating but can cause skin cancer.

Wave	Does it get through the atmosphere?	Is it absorbed by the body?	Effect on the body
radio waves	most gets through	all goes through you	heating
microwaves	hardly any gets through	most goes through you	heating
infrared (IR)	some gets through	most absorbed by your skin	heating
visible light	all gets through	a little absorbed by your skin	heating
ultraviolet (UV)	some gets through	nearly all absorbed by your skin	ionising
X-rays	hardly any gets through	most goes through you	ionising
gamma	hardly any gets through	most goes through you	ionising



▲ A thermal image of a woman with back pain.

X-rays and **gamma rays** are much more penetrating, and could cause cancer in any part of the body. Luckily the atmosphere blocks X-rays and gamma rays from the Sun.

Other sources of radiation

Not all the radiation that we are exposed to comes from the Sun. Here are some uses of the waves of the electromagnetic spectrum.

wave	radio waves	microwaves	infrared	visible light	ultraviolet	X-rays	gamma rays
use	TV signals	mobile phones	heating, cooking	photography	detecting forgeries	seeing broken bones	killing cancer cells

When we are using any device that emits electromagnetic radiation we need to assess the risks and benefits. Gamma rays cause so much damage to cells that we can use it in radiotherapy to kill cancer cells. This gives the rest of the body a dose of radiation, which is a risk because it could cause more damage.

Remember those waves!

Make up a mnemonic so that you can remember the waves of the electromagnetic spectrum.

Summary Questions

1 Copy and complete these sentences:

The electromagnetic spectrum consists of these waves: gamma rays, ________, ________, ________, ________, ________, and ________.
This list is in order of increasing ________. Electromagnetic radiation can have a ________ effect on the body or can ________ atoms, which can cause ________.

(10 marks)

2 Describe the difference between the effect of light on the body and the effect of ultraviolet on the body.

(6 marks)

3 Suggest and explain which wave of the Sun's spectrum is most dangerous to humans.

(2 marks)

Lesson 12: Answers

4.3.2 Radiation and energy

In-text questions	**A** Radio waves, microwave, infrared, visible light, ultraviolet, X-rays, gamma rays
Activity	**Remember those waves!** Any suitable mnemonic of the waves in order.
Summary questions	**1** X-rays, ultraviolet, visible, infrared, microwaves, radio waves, wavelength, heating, ionise, cancer (10 marks) **2** Example answers (6 marks): When light hits the body some is reflected and some is absorbed. When light is absorbed it heats the body. Ultraviolet radiation can also be reflected and absorbed. Ultraviolet radiation is ionising. It can damage the DNA of cells. It can cause cancer. **3** Ultraviolet is ionising/can cause cancer. The other ionising radiations are absorbed by the atmosphere. (2 marks)

Lesson 13

4.4.1 Modelling waves

Learning objectives

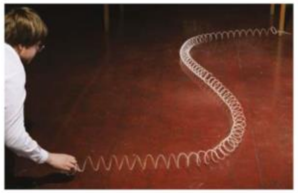
After this section you will be able to:

- compare transverse and longitudinal waves
- use wave models to explain observations of wave behaviour
- describe what happens when waves superpose.

▲ We have drilled 12 km (7.5 miles) below the surface of the Earth.

Key Words

transverse wave, wave, longitudinal wave, transmission, superpose



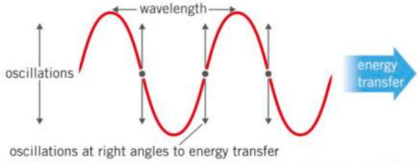
▲ You can make a transverse wave on a slinky.

How do we know what is inside the Earth, when the biggest distance we have drilled down is not much more than the height of Everest?

Transverse or longitudinal?

You can send pulses down a slinky spring. You can make the pulses in two ways.

You can move your hand at right angles to the spring. This produces a **transverse wave** on the slinky. In a transverse wave the oscillation is at 90° to the direction of the **wave**.



▲ In a transverse wave the oscillation is at 90° to the direction of the wave.

You can also push and pull the spring. This produces a **longitudinal wave** on the slinky. The oscillation is parallel to the direction of the wave – it is in the same direction as the spring itself.

A Write down the direction of oscillation in a transverse wave.

You have already modelled light using rays. There are other models you can use.

Modelling waves – the slinky

You can use a slinky to model longitudinal waves and transverse waves depending how you make the wave. You can change the speed of the wave by changing the material of the slinky, or using a rope.

This physical model shows that:

- the wave moves but the slinky does not
- *reflection*: you can reflect a pulse from a fixed end
- **transmission**: the pulse moves along the spring
- *absorption*: the amplitude decreases as the wave moves because energy is transferred by friction, heating up the ground a bit.

Modelling waves – ripples

In the wave model light behaves like ripples on water. If we see something happening to the water, we can use the idea to explain what happens with electromagnetic waves or sound.

- the wave moves but the water does not
- *frequency and wavelength*: as you move your hand more quickly the waves travel at the same speed but the wavelength decreases as the frequency increases
- *reflection*: you can reflect a wavefront from a barrier
- *refraction*: waves slow down when they go from deep to shallow water, and change direction. This explains why light is refracted when it goes from one medium to another with a different density.

Adding waves

When waves are put together they **superpose**. This means that they add up or they cancel out.

If the waves are in step they will add up. You get more than you had before. If they are not in step then they cancel out and you get less than you had before.

B Write down two things that happen when waves combine.

Different types of wave

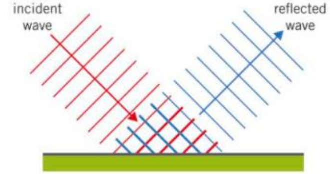
All waves transfer energy without transferring matter. They are reflected, and can be refracted, transmitted, or absorbed when they travel through media. They can all superpose.

They have different speeds, and travel in different media.

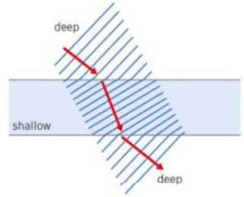
Wave	Type	Speed	Media
electro-magnetic	transverse	300 000 km/s in air	any, including a vacuum
sound/ultrasound	longitudinal	300 m/s in air, 3 km/s in rock	any, but not a vacuum
earthquake	transverse	2 km/s in rock	solid rock
earthquake	longitudinal	same as sound	solid and liquid rock

Scientists have worked out that the centre of the Earth has a solid inner core and liquid outer core by detecting earthquake waves on the other side of the Earth to the earthquake's centre. They measured:

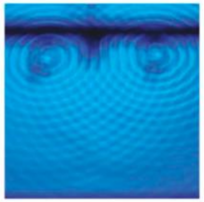
- which types of wave arrived
- the times of travel of the waves.



▲ A wave reflects off a barrier.



▲ Waves are refracted when they slow down.



◀ Water waves in a ripple tank add up and cancel out to make an interference pattern.

Summary Questions

1 In a transverse wave the vibration is at ________ to the direction of travel. You use springs or ________ to model waves like light or sound being reflected or ________ (change direction). *(3 marks)*

2 Compare light and sound waves. *(6 marks)*

3 Suggest how you can use a wave model to explain how noise-cancelling earphones work. *(6 marks)*

Lesson 13: Answers

4.4.1 Modelling waves

In-text questions	**A** Direction is at right angles/90° to the direction of motion of the wave. **B** They add up or they cancel out.
Summary questions	**1** 90°, ripples, refracted (3 marks) **2** Example answers (6 marks): Light waves are electromagnetic. Sound waves are mechanical. Light does not need a medium to travel through, sound does. Light waves are transverse, and oscillations are at right angles to the direction of motion. Sound waves are longitudinal and vibrations are in the same direction as light. Light travels a million times faster than sound. **3** Waves travel at different speeds in different media. They travel faster in solids than in liquids or gases. Waves that can travel through liquids arrived at detectors, but waves that could not did not arrive, so scientists worked out that part of the Earth was liquid. (4 marks)

Part 2 – Revision Questions

End-of-Big Idea questions

1 Radiation can affect human tissue.

a Name two types of radiation that have a heating effect on human tissue. *(2 marks)*

b Name two types of radiation that have an ionising effect on human tissue. *(2 marks)*

(4 marks)

2

a Describe what happens when a wave hits a barrier. *(1 mark)*

b Describe what happens when waves superpose. *(2 marks)*

c Describe two models of light that you have used. *(2 marks)*

(5 marks)

3 Waves can be transverse or longitudinal.

a Explain why a Mexican wave is transverse. *(1 mark)*

b Explain why sound is a longitudinal wave. *(1 mark)*

(2 marks)

4 A student has collected data about different types of plastic block. He measured the mass and the angle of refraction of a ray of light going into the block. Each block is the same size.

Here are his results:

Mass of block (g)	Angle of refraction (°)
250	27
220	32
275	24
300	21

a State **one** variable that the student must keep the same during this investigation. *(1 mark)*

b State the name of the independent variable. *(1 mark)*

c State the name of the dependent variable. *(1 mark)*

d Describe the relationship between the mass and the angle of refraction. *(1 mark)*

e Describe **one** way that the student could improve the way that the results are presented in the table. *(1 mark)*

(5 marks)

5 You can detect sound with your ear or a microphone.

a Describe two similarities between the ear and the microphone. *(2 marks)*

b Explain why exposure to sound does not increase your risk of cancer, but exposure to radiation might increase the risk. *(4 marks)*

(6 marks)

6 Light slows down from 300 000 km/s to 200 000 km/s in glass and to 226 000 km/s in water. A ray of light enters each medium with an angle of incidence of 40°. State and explain whether the angle of refraction would be bigger or smaller in water than in glass.

(2 marks)

7 Apply ideas about light, sound, and materials to describe and explain what happens to the material in the room during and after a science lesson.

(6 marks)

Lesson 14: Revision Answers

4 Waves – Part 2 Checkpoint

End-of-Big Idea questions	**1a** Any two of the following, for one mark each: radio (1), microwaves (1), infrared (1) **b** Any two of the following, for one mark each: ultraviolet (1), X-rays (1), gamma rays (1) **2a** It reflects. (1 mark) **b** They add up or cancel out. (2 marks) **c** Any two of the following, for one mark each: rays (1), ripples/waves (1), slinky (1) **3a** The oscillation is at 90° to the direction of travel. (1 mark) **b** The oscillation is parallel to the direction of travel. (1 mark) **4a** angle of incidence (1 mark) **b** mass of plastic (1 mark) **c** angle of refraction (1 mark) **d** As the mass increases, the angle of refraction decreases. (1 mark) **e** The mass could be recorded from smallest to largest. (1 mark) **5a** Both contain a component that moves when the sound wave hits it (ear drum/diaphragm). Both produce an electrical signal. (2 marks) **b** Some radiation is ionising, which can damage DNA and cause cancer. Sound is a pressure wave/mechanical wave, which does not ionise/damage DNA. (4 marks) **6** Examples of correct scientific points (6 marks): During the lesson sound is produced by various sources, including people. Light is emitted by sources (light bulbs/Sun). Sound is a pressure wave. When sound hits a solid material it makes the particles vibrate more. This raises the temperature of the material. Light from sources is reflected, transmitted, or absorbed by materials in the room. If it is absorbed it raises the temperature of the material. **7** Angle would be bigger in water. Water slows light down less. (2 marks)

Attainment Band	**Waves: Sound & Light** Knowledge and Understanding
Yellow/Yellow +	• Use the slinky model to make connections between loudness and amplitude • Draw and interpret wave diagrams that represent different sounds • Explain how echoes can be used to measure the speed of sound and the distance of objects in different applications • Use the particle model to explain why the speed of sound is different in different materials • Explain why some materials are good at reflecting and absorbing sound • Compare and contrast detection of sound by the ear and by a microphone • Use a knowledge of the structure of the ear to explain how to prevent damage to the ear; use data to identify the hearing ranges of different organisms • Explain why these waves are suitable for their applications • Explain how waves can add or cancel out • Explain what is meant by the frequency of a wave • Compare diffuse scattering and specular reflection • Draw ray diagrams to show how the eye works • Explain that the higher the frequency, the shorter the wavelength and the more light is refracted Explain in outline photosynthesis, the photoelectric effect and photochemical smog
Blue	• Describe the features of a longitudinal sound wave • Relate the terms 'frequency', 'wavelength' and 'amplitude' to different waves • Describe how echoes can be used in different applications • Use the particle model to explain why sound cannot travel through a vacuum • Design an investigation and collect evidence about the ability of different materials to reflect and absorb sound • Explain how parts of the ear are adapted to enable us to hear • Describe different ways the ear may become damaged and possible solutions to these problems • Describe a wide range of applications for ultrasound and infrasound • Explain that waves can be reflected • Compare the properties of water waves and light waves • Explain how light is absorbed by opaque materials • Explain what happens when light is reflected and when it is refracted • Explain that the colour of light in a spectrum depends on its frequency • Describe examples of chemical and electrical effects caused when materials absorb light

Green	• Recognise the need for vibrations to make sound waves • Recall that sound transfers energy from place to place • State what is meant by the term 'frequency' and how it relates to the pitch of sound • Recognise an echo as a reflection of sound; follow a procedure to measure the speed of sound • Describe the effects of different materials on the transmission of sound • Name materials that reflect and absorb sound • Name different parts of the ear • Describe what is meant by the loudness of sound and how we can protect ourselves from loud sounds • Describe the range of sounds relating to ultrasound and infrasound • Describe how ripples and waves move in water • Recall that light travels in waves • Recall that light passes through transparent materials • Recall that the ray model is a way of showing the direction of light and how it changes • Recall ways that a spectrum can be made, including using a prism • Describe the range of "light" (relating to the EM spectrum) focus on light • Recall that light transfers energy from place to place
White	• Some of the above elements have been achieved