PHYSICS

Waves

Ideas you have met before

Different types of sound

Sounds are only possible when a vibration occurs. Banging on a drum or plucking a guitar produces vibrations that cause a sound to be made.

We can change the vibrations of a sound by giving them more energy. The stronger the vibrations, the louder the sound.

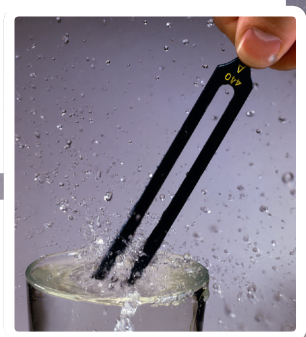
Some sounds we hear have a high pitch, like a whistle or a siren. Some have a low pitch, like the rumble of thunder. When we change the pitch, we change how rapidly an object vibrates.

How sounds behave

We hear sounds because the vibrations travel through a medium to the ear.

Sounds may be reflected by hard materials and absorbed by soft materials.

Sounds get fainter as they travel further from the source.



How light behaves:

Light appears to travel in straight lines.

Shadows have the same shape as the objects that made them because of light travelling in straight lines.

Please specify which photo is to go with which box. KVGD

How we see things:

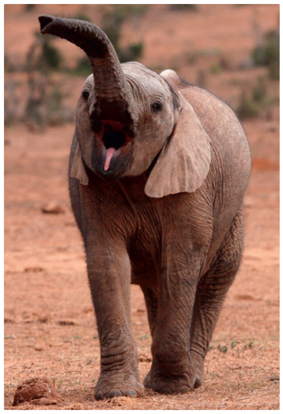
We see objects because they emit or reflect light into our eyes.

We can see objects that don't emit their own light because they reflect light from sources into our eyes.

We can explain this using the idea that light travels in straight lines.

In this chapter you will find out

What sound is:



- Energy is transferred by sound in the form of waves.
- Sound energy is transmitted by longitudinal waves (vibrations) being passed on by particles of a medium.
- The denser the medium, the faster sound travels.
- Sounds can be represented by waveforms, showing wavelength, frequency and amplitude.
- The greater the amplitude of the waveform, the louder the sound.
- The greater the frequency (and therefore the shorter the wavelength), the higher the pitch.

How sound behaves:

- Sound is transmitted, reflected or absorbed by different media.
- Echoes occur when sound waves are reflected by hard materials.
- The ear is designed to capture sound waves.

What light is

- Light travels as transverse waves that carry energy.
- White light can be split into a spectrum of colours.
- Light can be represented as rays.

Please specify which photo is to go with which box. KVGD

How light behaves:

- Light waves can travel through a vacuum.
- Light can be reflected, absorbed and refracted.
- When it is reflected, the angle of incidence equals the angle of reflection. Light can form an image in a mirror and cause objects to appear different colours.
- Light can be refracted through lenses and prisms.
- Wave properties can be described using a ray diagram as a model.

Exploring sound

We are learning how to:

- Identify how sounds are made.
- Describe how sound waves transfer energy.
- Explain how loud and quiet sounds are made.

Sounds are made in different ways and by lots of different things. We need to understand what sound is, what all sounds have in common and how they vary.

FIGURE 1.4.2a: How does a guitar make a sound?

Making sounds

If you place a finger over your voice box when speaking or singing, you will feel your voice box **vibrate**. This is where the sound comes from.

When an instrument is plucked or blown through, the string or the air vibrates. Often the vibrations are too small to see.

All vibrations result in a sound. The vibrations from the object are passed on to air particles. These air particles bump into others and the wave progresses. Eventually the energy of the vibrations is transferred to your ears.

1. What causes the sound when a bell is rung?
2. How does the sound from a concert reach the audience?

Making waves

Energy is transferred by sound in the form of waves. In Figure 1.4.2b a slinky spring provides a model that shows how these waves work. When you push the end of a slinky back and forth, some of the coils squash together and others pull apart. A wave of energy passes along the length of the spring. A wave like this which travels in the same line as the vibrations of the source is called a **longitudinal wave**.

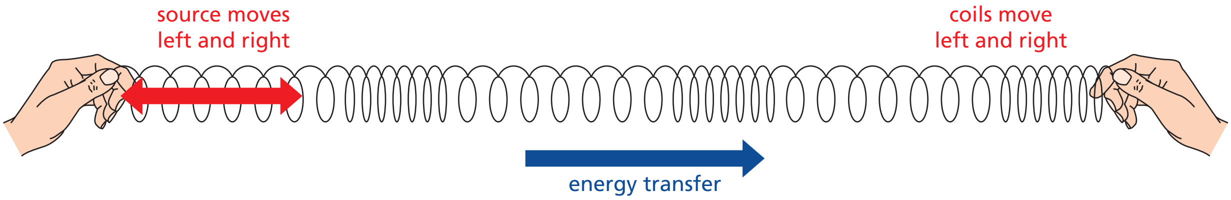


FIGURE 1.4.2b: Why is this called a longitudinal wave?

A sound wave works in the same way. Vibrations push air particles together and also pull them apart, creating a longitudinal wave of energy. The energy passes from the source of the vibration to our ears.

3. Describe the movement of air particles in a longitudinal sound wave.
4. What happens to the energy in a longitudinal wave?

Loudness and sounds

Volume is a measure of how loud a sound is. Sounds can be made louder by increasing the energy in the vibration. Plucking a string harder, blowing harder through a wind instrument or beating a drum harder will all transfer more energy. The loudness of sound is measured in a unit called a **decibel** (**dB**). The loudest sound that humans can listen to without damage to their hearing is about 120 dB.

The size of a vibration is represented by its **amplitude**. Figure 1.4.2d shows that the amplitude is the maximum distance that a particle travels in the to-and-fro vibration. The greater the amplitude, the greater the energy of the vibration and the louder the sound. In other words, a bigger wave will transfer more energy and be heard as a louder sound.

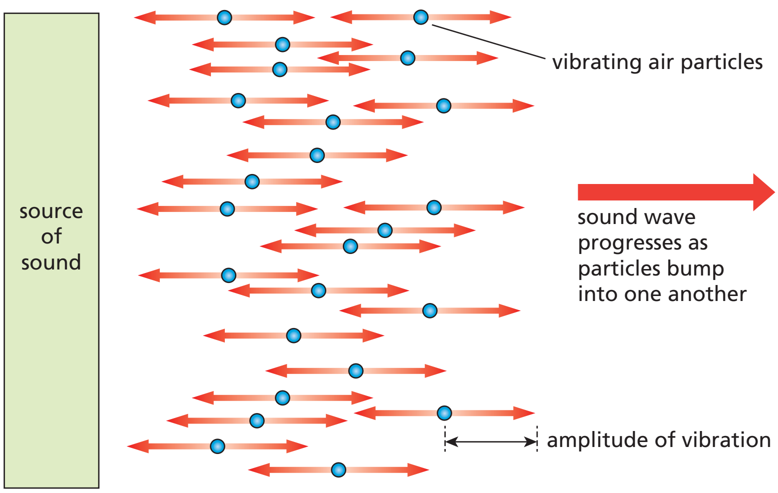


FIGURE 1.4.2d: What effect will a smaller amplitude have?

5. Look at Table 1.4.2. Match the sounds to the correct loudness.
6. The loudness of a sound also depends on the distance from the source. Explain what happens to the energy as you get further away.
7. Is there a limit to how loud a sound can be made? Explain your answer.

Did you know...?

The ocean-dwelling tiger pistol shrimp is known to produce the loudest sound on Earth, reaching over 200 dB. It uses the sound as a defence mechanism. The vibrations can kill prey and fish up to 2 metres away!

FIGURE 1.4.2c: A pistol shrimp

TABLE 1.4.2

Sound	Loudness (dB)
1 whisper	a) 80
2 phone dial tone	b) 140
3 jet engine	c) 100
4 motorbike	d) 30

Know this vocabulary

vibration
longitudinal wave
decibel (dB)
volume
amplitude

Describing sound

We are learning how to:

- Explain what is meant by pitch.
- Understand frequency, wavelength and amplitude.
- Relate sounds to displayed waveforms.

There are many different types of sound. Think of the sounds made by a whale compared with the high-pitched screeching of a monkey, or the sound of a bass guitar compared with a violin. Differences in sound waves arise from different characteristics of the sound waves.

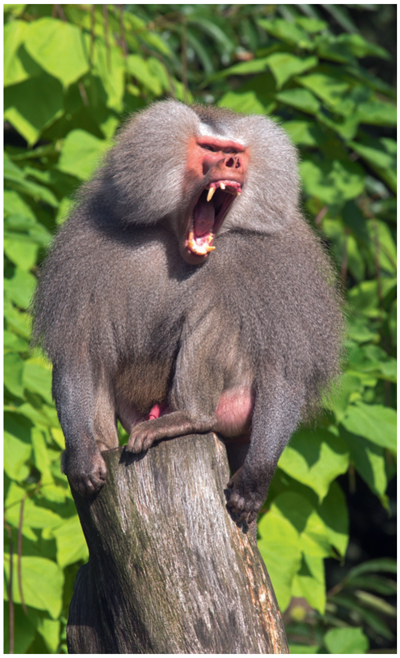


FIGURE 1.4.3a: How would you describe the scream of a monkey?

What is pitch?

A ship's horn produces a sound that is very deep and low – this is known as a low pitch. Whistles, alarms and sirens produce high-pitched sound.

The pitch of a note is also called its **frequency**. A high frequency means a high pitch and a low frequency means a low pitch. Muscial notes change in pitch by changing the frequency of the vibration.

Feel your voice box as you make sounds of different pitches. What do you notice?

1. Describe one other sound with a low pitch and one other sound with a high pitch.
2. What is meant by the 'frequency' of a note?

Frequency, wavelength and amplitude

The speed of sound in air is 330 m/s, a million times slower than light. Sound waves can be represented in a diagram like that shown in Figure 1.4.3b. The curve, or **waveform**, is a graph of the displacement of the air particles at different distances along the wave. The **wavelength** is the distance along a wave from one point to the next point where the wave motion begins to repeat itself.

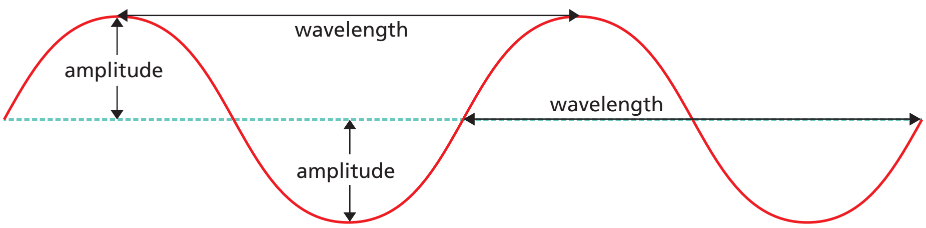


FIGURE 1.4.3b: Parts of a wave

The higher the frequency of a wave, the shorter the wavelength. A high frequency means more vibrations are produced per second.

The maximum dispacement is called the **amplitude**. The energy transferred by the wave depends on this. The larger the amplitude of a sound wave, the louder the sound.

3. Why is it more useful to use the wave representation in Figure 1.4.3b, compared with a drawing of a longitudinal vibration, as in Figure 1.4.2d of Topic 4.2?

4. How could you tell from a waveform whether a sound is getting:

a) louder? **b)** higher pitched?

Interpreting sound waves

All sound waves can be detected using a **microphone** and shown as a waveform on a screen. The microphone receives the sound waves and converts them into electrical signals. Some typical examples are shown in Figure 1.4.3c.

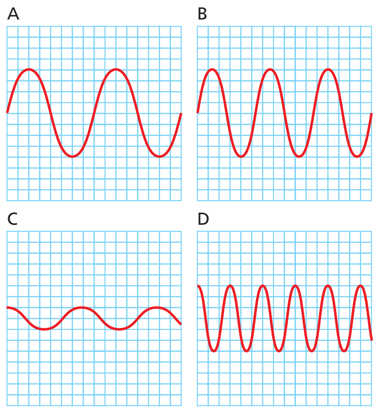


FIGURE 1.4.3c: How are these waves different?

Detectives use traces like these to match voices patterns from recordings to known criminals or to identify patterns from the shots of particular guns.

5. a) Which wave in Figure 1.4.3c results from the loudest sound?

b) Which wave results from highest-pitch sound?

c) Which wave is transferring the most energy? Explain your answer.

6. Draw waves to represent a loud high-pitched sound and a quiet low-pitched sound.

7. Look at the graph in Figure 1.4.3d, which shows the sound wave detected from a gun as time progresses. Describe what is happening to the frequency, wavelength and amplitude of the wave.

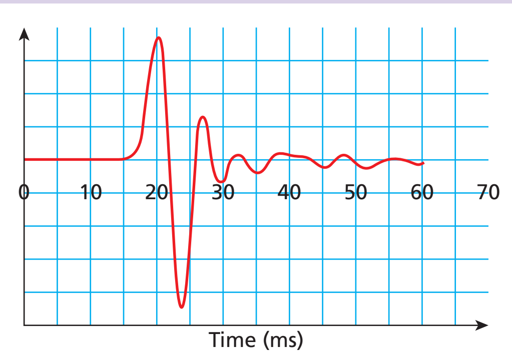


FIGURE 1.4.3d: Sound wave from a gun

Did you know...?

Microphones have a thin diaphragm made of plastic or metal. This vibrates when even small sound vibrations hit it. The energy from the vibrations is transferred by electric current and can be fed to a loudspeaker. This transfers the electrical energy back into sound energy.

Know this vocabulary

pitch
waveform
amplitude
wavelength
oscilloscope

Hearing sounds

We are learning how to:

- Describe the structure and function of different parts of the ear.
- Explain how the ear is able to hear and detect sounds.

The ability to hear is important in all animals for communication, hearing predators, knowing when there is danger and seeking prey. The human ear relies on a combination of processes and ingenious engineering to help us to identify the wide range of sound waves we receive.

Ears for hearing

A human ear is divided into three parts – the outer ear, the middle ear and the inner ear.

The outer ear is the part that can be seen, on the outside of your head. Its job is to capture sound waves. The waves pass along the **ear canal** to the **ear drum**. This separates the outer ear and middle ear. The ear drum transfers the energy from the vibrations to bones called **ossicles** in the middle ear, which make the tiny vibrations much bigger. This energy is passed on to the inner ear, which contains specialised cells that detect the vibrations and convert them into electrical signals. These are sent to the brain, which interprets them.

1. What are the jobs of the outer, middle and inner ear?

2. Suggest why are our ears are located in our head.

Structure of the human ear

The function (job) of the ear is to transfer energy by sound into electrical impulses that are interpreted by the brain.

Figure 1.4.4a describes what happens to the sound waves as they enter the ear.

3. Suggest why incoming sound vibrations need to be amplified (amplitude made bigger) in the ear.

4. Where in the ear are:

a) electrical signals transmitted to the brain?

b) sound vibrations amplified?

c) vibrations first detected?

Did you know...?

Elephants can hear frequencies 20 times lower than the lowest frequency we can hear. They use their trunks as well as their ears to detect low frequency vibrations. This enables them to hear other elephants up to 6 km away.

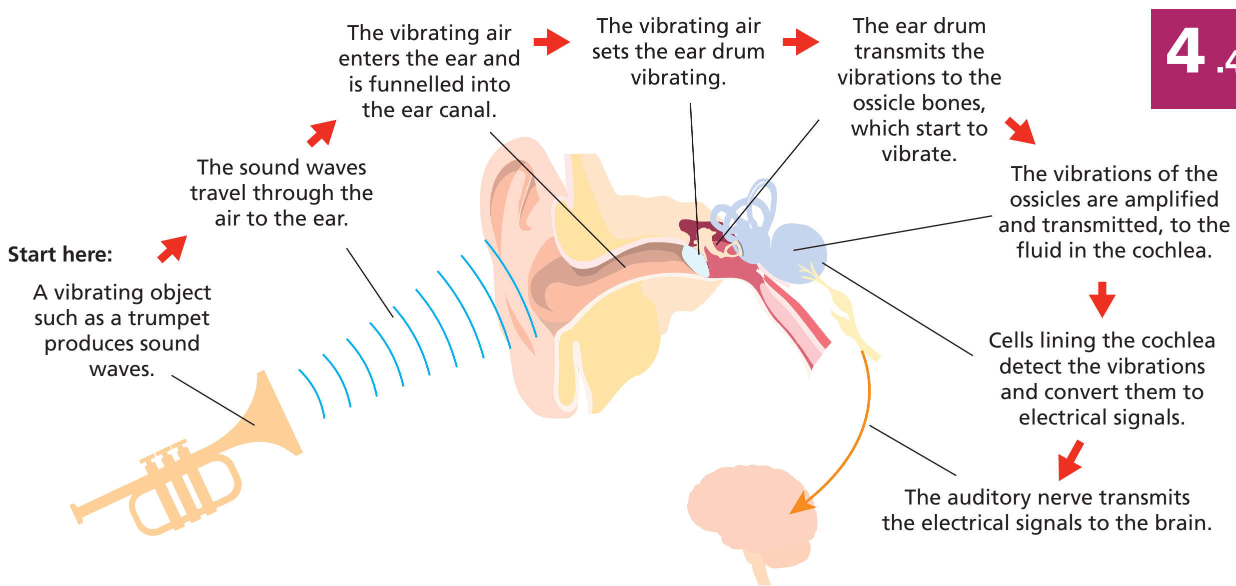


FIGURE 1.4.4a: How we hear

Factors affecting hearing

Several factors can affect the health of our ears. Read about these in Table 1.4.4.

5. Why can some ear problems not be cured?

6. Who is most likely to be most at risk of having problems with poor hearing?

TABLE 1.4.4: Causes of ear damage and what can be done

Causes of poor hearing or ear damage	Possible solutions
Ear canal can become blocked with wax.	Have the ear canal cleaned out.
Very loud sounds can rupture the ear drum.	Ear drum may heal itself over a long period of time.
Ear drum can be damaged by infection.	Use antibiotics to get rid of the infection.
Ossicles can become fused together.	An operation is needed.
Infection may occur in the middle ear.	Use antibiotics to get rid of the infection.
Hair cells and nerves in the cochlea may be damaged by loud noises.	There is no cure.
In older people, nerves cells may deteriorate.	There is no cure.

Know this vocabulary

hearing range
ear canal
ear drum
ossicles
cochlea
auditory nerve

Learning about the reflection and absorption of sound

We are learning how to:

- Recognise which materials reflect the quality of sound.
- Analyse the effect of different materials on sound waves.
- Use ideas about energy transfer to explain how soundproofing works.

Concert halls are designed for good acoustics – so that the music sounds good to the whole audience. This means controlling the amount of echo and making sure sound reaches all corners. Different materials and shapes are used to achieve this.

FIGURE 1.4.5a: Can you identify materials that help to reflect sound and those that help to absorb it?

Effect of materials on sound waves

Echoes are sound waves that are reflected back to our ears. Hard, flat surfaces **reflect** sound well and produce strong echoes.

Soft surface materials that contain lots of air pockets, like fabric, foam and sponge, are not good at reflecting sound. They **absorb** it. The sound waves transfer energy to the air in the pockets so less is reflected.

1. What do we mean by 'absorbing' sound?
2. **a)** What would you hear if the sound waves from a bell were directed at a metal panel?

   b) What would you hear if the sound waves from a bell were directed at a panel made of sponge?
3. When might it be useful to absorb sound waves?

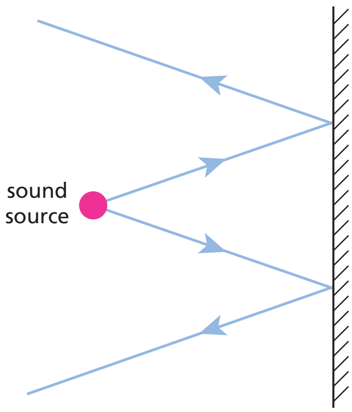


FIGURE 1.4.5b: What kind of echoes will this produce? How can the echoes be reduced?

Effect of shapes on sound waves

Some materials can be shaped to reflect sounds in different ways. Look at the jagged surface in Figure 1.4.5c. When sound waves hit this surface, the reflected waves do not bounce back to the source. They are, instead reflected randomly, mostly away from the source.

The curved surface, on the other hand, reflects the sound until all the energy focuses towards a particular point. The sound at this point will be the loudest, whereas in places away from it, hardly any sound will be heard at all.

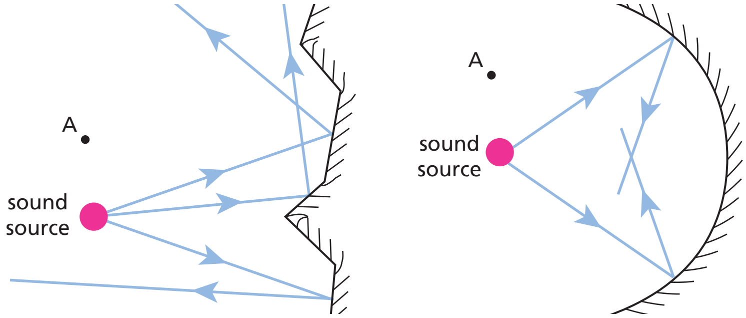


FIGURE 1.4.5c: How sound is reflected off a jagged and a curved surface

4. Imagine you are standing in position A in each of the diagrams in Figure 1.4.5c. Describe what you will hear if the surface is:

a) jagged **b)** curved

compared with the flat surface in Figure 1.4.5b.

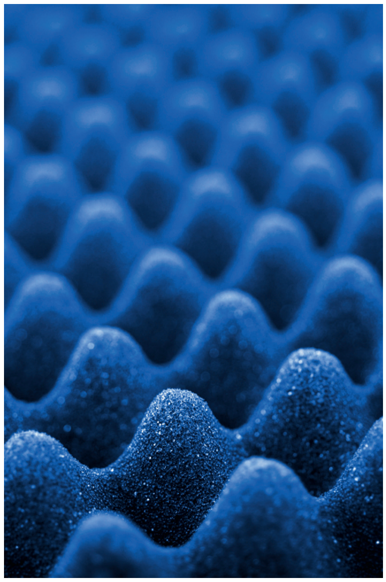


FIGURE 1.4.5d: This material is used in soundproofing. What makes it a good choice?

Soundproofing

When sound waves hit soft surfaces, they are absorbed by the air pockets. The sound waves become trapped, bouncing around in the air pockets, until all the energy is transferred as heat. Any sound reflected from the surface is therefore much quieter, as the sound waves have much less energy.

These soft materials are useful as **soundproofing**. A vacuum is also useful in soundproofing. Sheets of glass with a near-vacuum between them (very few gas particles) are very effective in stopping sound.

In the outdoor environment, trees, embankments and dense bushes are often for soundproofing around mining areas.

5. What happens to the energy of the sound wave during absorption?

6. Design a soundproofing plan for a hospital in a busy town centre.

Did you know...?

A 'whispering gallery' is the name given to a large circular room, where a whisper made in one place is reflected to the opposite side of the room and heard there but nowhere else. St Paul's Cathedral contains one.

Know this vocabulary

absorption
reflection
soundproofing

Exploring properties of light waves

We are learning how to:

- Describe how light passes through different materials.
- Explain how shadows are formed in eclipses.
- Explain the difference between diffuse scattering and specular reflection.

Simple sundials can be made easily. The pointer is made of an opaque material that blocks light and produces a shadow. The position of the shadow can be used to tell the time.

FIGURE 1.4.6a: A sundial

See-through?

Light passes through gases, some liquids and some solids. Materials that light waves can pass through freely are said to be **transparent**. They do not produce shadows.

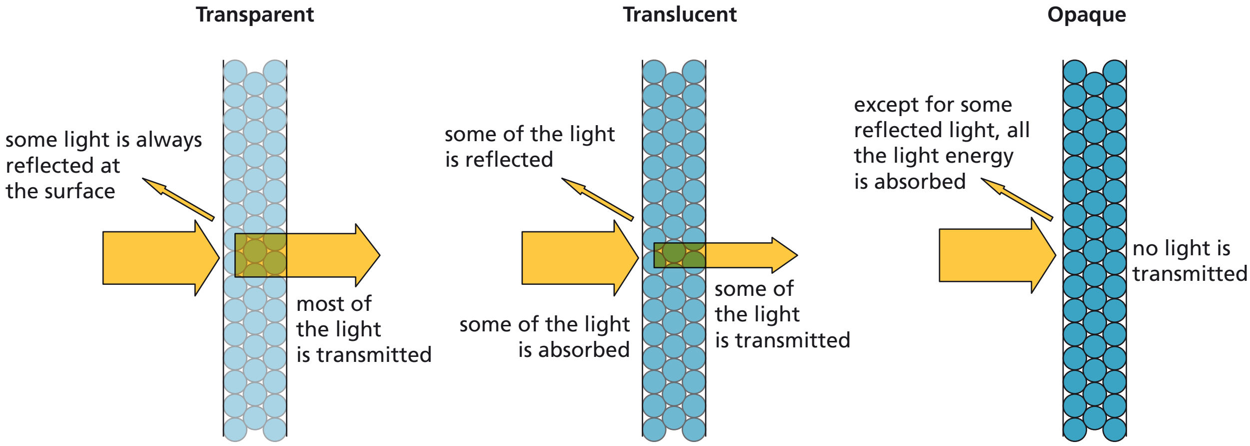


FIGURE 1.4.6b: This shows what happens to light when it falls on transparent, translucent and opaque materials.

Other materials cast shadows by either completely or partially blocking the passage of light. **Opaque** materials block the passage of light waves completely, producing a dark shadow, whereas **translucent** materials only allow some of the light to pass through, casting weak shadows.

1. Give three examples of transparent materials.
2. Compare the shadows produced by an opaque material and those by a translucent material.
3. Explain why an opaque object casts a shadow.

FIGURE 1.4.6c: Frosted glass provides some privacy because it does not allow all the light to pass through it.

Specular and diffuse reflection

When light hits a surface or a boundary, some or all of it is reflected – it bounces back in a direction away from the surface. The reflection produced by a flat, smooth surface is called **specular reflection**. All the light is reflected in the same direction. It allows us to see an **image**.

A rough reflective surface bounces light back in many directions. We can think of the surface as being a mixture of small flat surfaces at different angles. The effect is called diffuse reflection, or **diffuse scattering**.

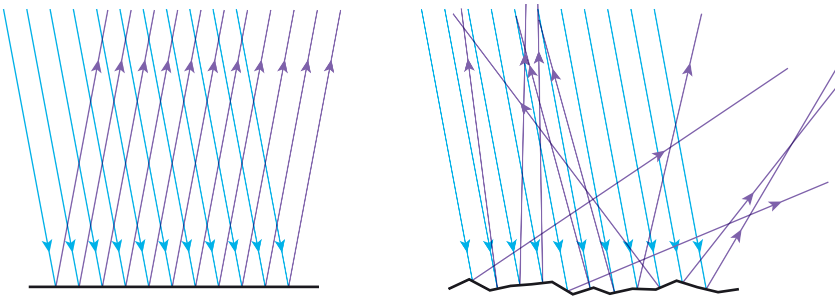


FIGURE 1.4.6e: The diagram on the left shows specular reflection. The one on the right shows diffuse reflection.

4. Describe the difference between specular reflection and diffuse reflection.

5. Explain why diffuse scattering happens on rough surfaces.

6. Explain why reflections in lakes or ponds cannot be seen if the water is choppy.

FIGURE 1.4.6d: The result of specular reflection in a calm lake

Did you know…?

You can see through a piece of frosted glass (make it 'see-through') simply by putting a piece of clear sticky tape on it.

Understanding eclipses

A solar eclipse happens when the Moon is in between the Earth and the Sun. For a viewer on the Earth the effect is spectacular; for a few minutes the sky is plunged into darkness and a vivid ring of light is seen. However, it isn't the same for everyone.

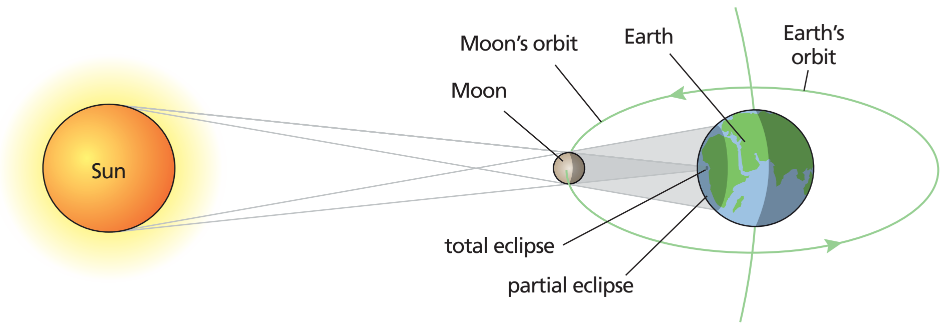


FIGURE 1.4.6g: Caption XXXX XXXX XXXXX XXXXX

FIGURE 1.4.6f: Caption XXXX

Know this vocabulary

transparent, opaque
translucent
absorption
scattering
reflection

OVERMATTER

1.4.6: OVERMATTER

The Moon's shadow isn't big enough to cover the whole of the Earth. You only see a total eclipse in one fairly small area. Just outside that viewers experience a partial eclipse and in other places, nothing at all.

This is because light travels in straight lines. The Moon is much smaller than the Sun so its shadow is smaller still. An eclipse is an amazing sight but you have to be in the right place.

7. What would you see if you were in an area of partial eclipse?

8. Why does the effect only last for a few minutes?

Using the ray model

We are learning how to:

- Describe the ray model of light.
- Explain how the direction of light rays can be changed.

If you look at a swimming pool from above, it looks shallower than it really is. If a spoon is placed at an angle in a glass of water, it appears to have bent or broken at the water surface. Both of these effects are caused by refraction. To explain refraction, and reflection, we need to use the ray model.

FIGURE 1.4.7a: Refraction causes the spoon to look as if it has broken into two parts.

Explaining reflection

Light travels as waves, but a **ray model** allows us to show clearly in a diagram the direction of light and how it can change its direction when it meets a surface.

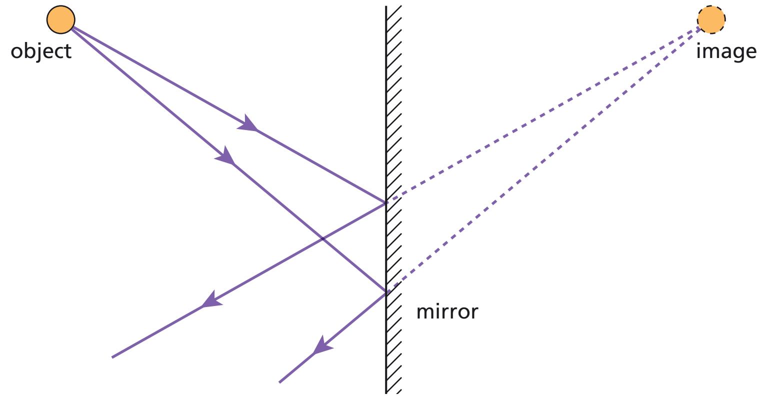


FIGURE 1.4.7b: The solid lines represent light rays. The dashed lines show where the light rays appear to be coming from – the image. This is the same distance from the mirror as from the object to the mirror.

FIGURE 1.4.7c: The specular reflection of light from a mirror allows you to see an image.

1. Describe what Figure 1.4.7b shows.
2. Describe how the ray diagram showing image formation in a mirror needs to be changed if the object is:

   a) further away b) closer

Refraction

Light travels through transparent materials, such as glass and air. However, its speed depends on the density of the material. The denser the transparent material, the slower light travels through it. Glass is denser than air, so light travels through it slower than it travels through air.

When the light slows down, the wavelength of its waves becomes shorter. Each of the crests catches up with the one in front. If the light then emerges into a less-dense medium it will speed up again. This effect is called **refraction**, and can cause the direction of the light to change.

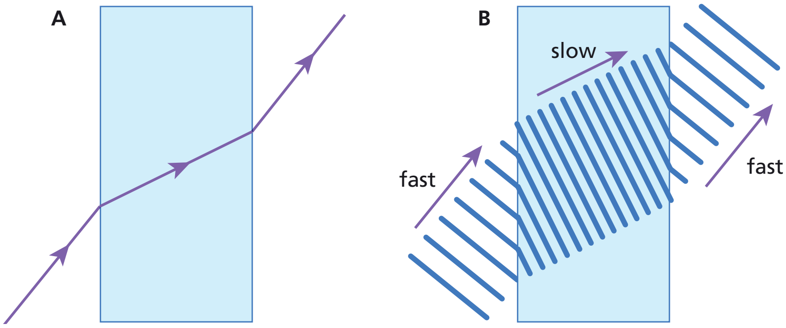


FIGURE 1.4.7d: A: ray model to show refraction of light; B: the wavelength shortens in a denser material.

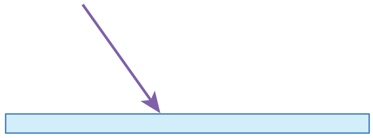


FIGURE 1.4.7e: A light ray hitting a glass rod – what happens?

3. Describe what happens to light waves when they travel into a dense material.
4. Sketch a diagram to suggest what would happen if a light ray was to hit a glass rod as shown in Figure 1.4.7e.

The human eye

Light enters an eye through the **cornea** and then travels through the **lens**. These both refract light rays, focusing them on a common point. An image forms on the **retina**. The optic nerve sends information to the brain, which interprets it.

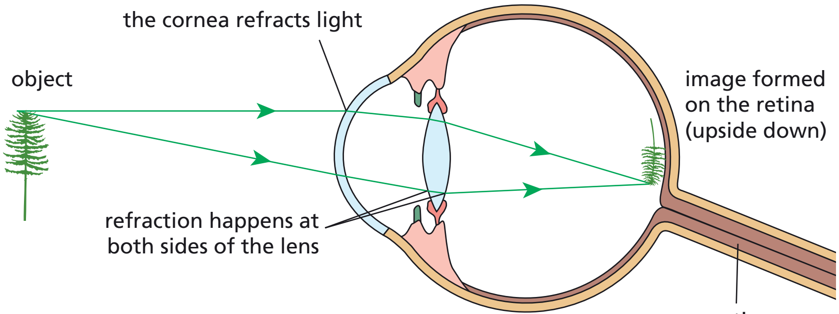


FIGURE 1.4.7f: How the eye works

5. Name the parts of an eye that refract light.
6. Explain what the lens does to the rays of light.
7. Explain why the image formed on the retina is upside down.

Did you know…?

A pinhole camera works in much the same way as a human eye. You can make a working pinhole camera from a cardboard box, greaseproof paper and sticky tape using nothing more than a pin and a pair of scissors.

Know this vocabulary

incident ray
reflected ray
normal line
angle of reflection
angle of incidence
ray model
refraction
cornea
lens
retina
convex lens
concave lens

Bending light

We are learning how to:

- Compare lenses.
- Construct explanation as to how lenses work.
- Explain how lenses can be used to correct defects in vision.

We usually think of light travelling in straight lines and usually it does. However we can make it bend and the way of doing this is to make it pass through something which is either denser or less dense.

Is this going to be a photo or redrawn as an illustration? KVGD

FIGURE 1.4.8a: A convex lens

Is this going to be a photo or redrawn as an illustration? KVGD

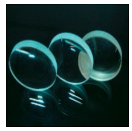


FIGURE 1.4.8b: A concave lens

Types of lens

Lens are used in many everyday objects such as cameras and projectors, and also in specialist equipment such as microscopes and telescopes. They come in many different shapes and sizes but there are two main types: convex and concave.

Convex lens bulge outwards in the middle. They gather light and focus it into one place. A magnifying glass or a hand lens is a common example of a convex lens.

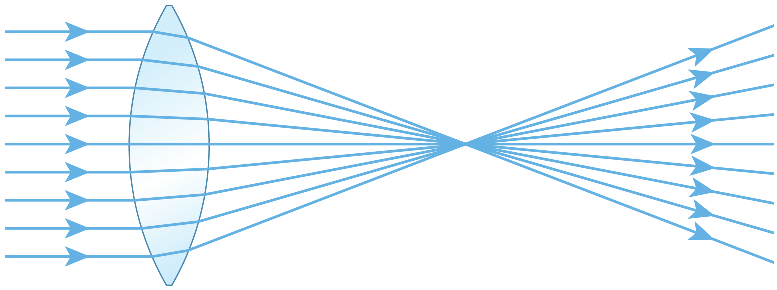


FIGURE 1.4.8c: Xxxxxxxxxxxxx

If we shine parallel light rays into a convex lens, they will meet each other and cross over. We sometimes call this a converging lens.

Concave lenses are thicker around the edge and curve inwards in the middle. They make light rays spread out.

If we shine parallel rays into a concave lens they will travel away from each other. These are sometimes called diverging lenses.

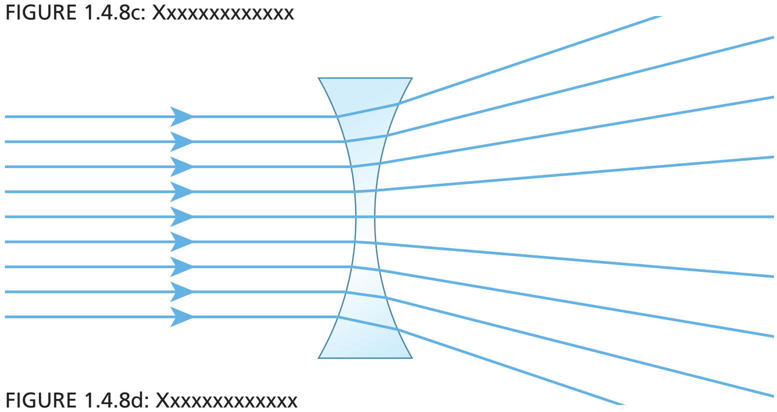


FIGURE 1.4.8d: Xxxxxxxxxxxxx

1. Suggest what a hand lens does with the light it gathers from the object you are looking at.

2. Suggest why the lens in the human eye is a convex lens.

2. Explain why:

a) A convex lens is called a converging lens

b) A concave lens is called a diverging lens

Did you know…?

xxxxxx

Explaining how lenses work

We can use ideas about refraction and prism to explain how a lens works. Firstly, remember what happens when light is refracted – if it enters a denser medium it is refracted towards the normal and if it enters a less dense medium it will be refracted away from the normal. Secondly we can apply this to a triangular prism. See what happens when light enters it and when it leaves it.

Now think about the shape of a convex lens. We can think of it as being two prisms and a block. It's not a perfect model but it's close enough.

Now think about three parallel rays approaching. The upper one will be refracted downwards and the lower one upwards. The middle one will come through the middle and the three of them will meet.

4. Unless there's an object at the point where the rays meet, they won't stop there. Sketch where they will go next.

5. What difference do you think it will make if the convex lens is thinner? Show your ideas on a diagram.

6. Try constructing a corresponding model for a concave lens.

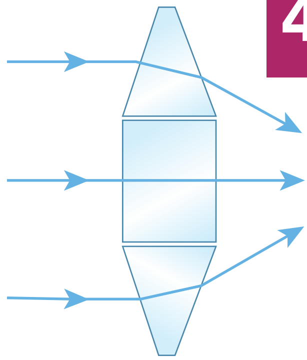


FIGURE 1.4.8e: xxxxx

Correcting vision

Some people have eyes that won't focus properly on objects a certain distance away. What the lens in the eye should do is to focus rays on the back of the eye (on the retina). We're going to be looking at two common defects.

One of these conditions is nearsighted; the lens in the eye makes the rays meet too soon. The remedy is for spectacles to be fitted with concave lenses, which compensate by making the light rays diverge.

The other condition is farsightedness. This is the opposite situation; the lens in the eye doesn't make the rays close in sharply enough, so a convex lens is used instead.

7. How else could the vision be corrected, other than by using spectacles?

8. These diagrams show the rays coming into the eye as parallel, which is correct for a distant object. However, for an object close to, the nearsighted person might not need to use their spectacles. Draw a diagram to suggest why not.

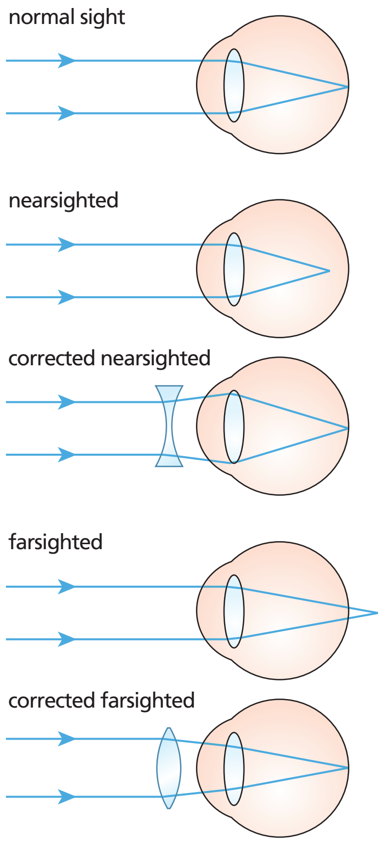


FIGURE 1.4.8f: xxxxx

Know this vocabulary

refract
medium
normal
lens
prism
convex
concave

Exploring coloured light

We are learning how to:

- Describe how a spectrum can be produced from white light.
- Compare the properties of light at different frequencies.
- Explain how light of different wavelengths can be split and recombined.

Some days it can be raining and, at the same time, the Sun can be shining. This is when a rainbow can often be seen. To make a rainbow, sunlight and droplets of water are needed.

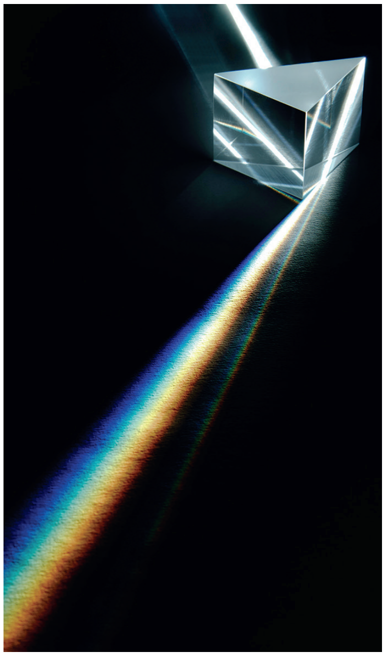


FIGURE 1.4.9a: A prism produces a spectrum from white light.

Spectrum from white light

Sunlight is made up of light waves of different **wavelengths**. The range of wavelengths that the human eye can detect as different colours is called the visible **spectrum**. Seen together they make what is called white light. This white light can be split up to produce the colours of the spectrum. For example, if sunlight is shone through a prism (triangular-shaped block of glass), it is refracted into different colours.

1. Describe the shape of a prism.
2. Describe the spectrum obtained when white light passes through a prism.
3. Which colours appear at each edge of a rainbow?

Different wavelengths

Light waves travel at the same speed in the same medium. The longer the wavelength, the fewer the crests that pass a fixed point every second and, therefore, the lower the **frequency**.

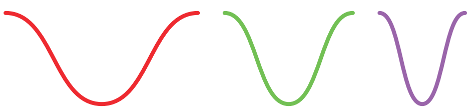


FIGURE 1.4.9b: In the visible spectrum, waves of red light have the longest wavelengths and waves of violet light, the shortest.

When a light wave passes into and out of a glass prism, the wave is refracted. The shorter its wavelength, the more it is refracted – so violet light is refracted more than red light. The 'white light' is split up and spreads out to form a spectrum.

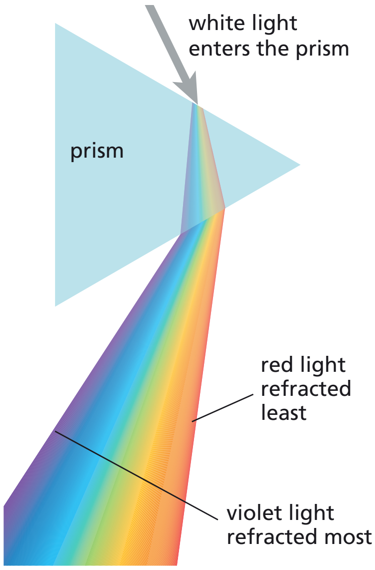


FIGURE 1.4.9c: The white light is split up by refraction.

Waves with different wavelengths can be combined – this is additive colour mixing. It is different to mixing paints. Mixing red, blue and green light produces white light. Mixing red, blue and green paint produces muddy brown paint.

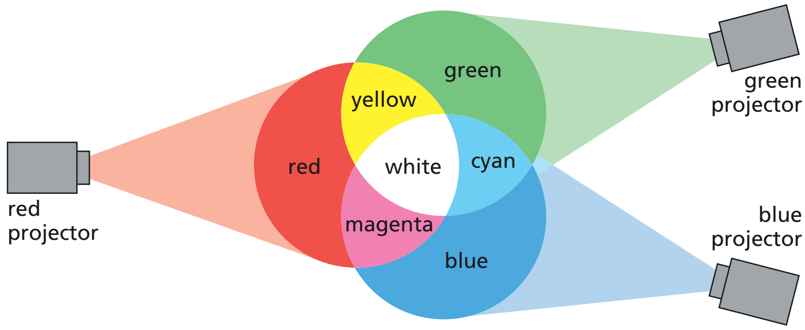


FIGURE 1.4.9d: Recombining waves to make white light

4. Explain the relationship between the wavelength and the frequency of a wave.
5. Which has the longest wavelength – red light or blue light?
6. Explain why white light spreads out to produce a visible spectrum when it passes through a prism.

Frequency and behaviour

Some materials are coloured, but can still be seen through, such as coloured plastic sheets and solutions of food dyes. They only absorb light waves of certain frequencies. The light that passes through consists of light with frequencies that were not absorbed.

Some opaque materials are coloured. This is because light waves of certain frequencies are absorbed by the material, but the light with other frequencies is reflected.

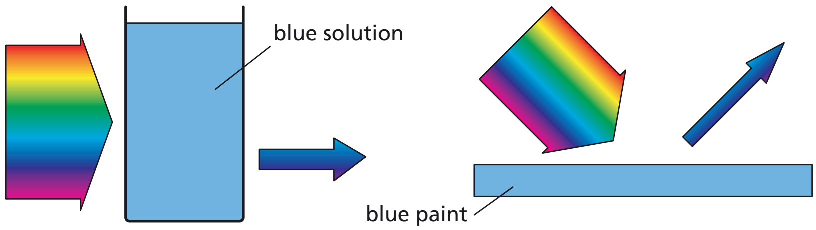


FIGURE 1.4.9e: A blue solution absorbs wavelengths of light other than blue. Only blue light passes through. Blue paint absorbs wavelengths of light other than blue. Blue light is reflected. No light passes through.

7. Explain why a solution of red food colouring is red, but also transparent.
8. Explain why green paint appears green.

Did you know...?

Light with frequencies lower and higher than those at the extremes of the visible spectrum cannot be seen by the human eye. Infrared radiation has frequencies lower than that of red light. Ultraviolet radiation has frequencies higher than that of violet light.

Know this vocabulary

wavelength
spectrum
frequency

Checking your progress

To make good progress in understanding science you need to focus on these ideas and skills.

☐ Recognise that sound energy is transferred by waves and describe how sound waves are made in different situations.	☐ Explain how longitudinal waves carry sound. Relate the terms frequency, wavelength and amplitude to sounds.	☐ Interpret and devise wave diagrams to represent different sounds of different wavelength and amplitude.
☐ Know that sound consists of vibrations in a medium.	☐ Know that sound travels faster in some media than others.	☐ Understand that the denser the medium, the faster the sound travels.
☐ Recognise that some materials are good at reflecting sound and others can absorb it.	☐ Recognise an echo as a reflection of sound.	☐ Explain what is meant by reflection and absorption of sound.
☐ Know that sound can be represented by a waveform.	☐ Explain how the waveform represents the amplitude and wavelength of the sound.	☐ Compare waveforms for different musical instruments.
☐ Understand that we hear sound because of vibrations travelling through a medium.	☐ Explain that we can hear a certain range of frequencies.	☐ Suggest how various ear problems might affect a person's hearing.

☐ Recognise that light can be reflected by some materials and absorbed by others.	☐ Explain the differences between transparent, translucent and opaque materials.	☐ Use diagrams to explain the difference between diffuse and specular reflection.
☐ Describe the ray model of light, using the idea that light travels in straight lines.	☐ Explain the difference between reflection and refraction, and describe what happens when light waves are refracted.	☐ Use ray diagrams to explain reflection and refraction, and to explain why eclipses appear different to observers in different places.
☐ Use the conventions of a ray diagram correctly.	☐ Use a ray diagram to show what happens when light is reflected.	☐ Use a ray diagram to show what happens when light is refracted.
☐ Recognise convex and concave lenses.	☐ Explain how convex and concave lenses affect light.	☐ Explain how lenses can be used to correct defects of vision.
☐ Describe the formation of a spectrum from white light.	☐ Explain how white light can be split into a continuous spectrum of colours, called the visible spectrum.	☐ Use the concepts of reflection and absorption of light to explain why some materials (transparent, translucent and opaque) are coloured.

Questions

Questions 1–4

See how well you have understood the ideas in this chapter.

1. What is the frequency range of ultrasound? [1]

a) below 20 Hz
b) between 20 and 20 000 Hz
c) above 20 000 Hz
d) there is no range

2. Draw a waveform which represents a loud, low pitched (i.e. deep) note. Label it to show how you have represented those qualities. [2]

3. A light ray approaches a glass block at 30° to the normal. When it enters the block, does the ray: [1]

a) Bend towards the normal?
b) Continue travelling in the same direction as before?
c) Bend away from the normal?
d) Travel along the normal?

4. In which of the following materials does light travel the fastest? [1]

a) water
b) glass
c) air
d) transparent plastic

Questions 5–9

See how well you can apply the ideas in this chapter to new situations.

5. Look at the different waves shown in 1.4.11a. Wave (a) represents a note played in the middle of a piano. Which wave best represents a siren? [1]

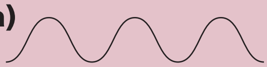
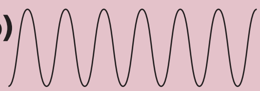
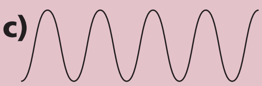
a)  **b)**  **c)**  **d)** 

FIGURE 1.4.11a

6. Emily's family are moving house. Their lounge is empty, with no curtains, carpets or furniture, and it sounds 'echoey'. Which of these statements is correct? [1]

a) Hard surfaces are good at absorbing sound.
b) Sound travels faster than light.
c) Sound travels faster in an empty room.
d) Soft surfaces such as curtains are good at absorbing sound.

7. Think about what happens to sunlight when it passes through transparent materials, and then explain why we see different colours in stained glass windows. [2]

8. Describe and explain what you would see if transparent red sticky tape were put on a piece of frosted glass. [1]

9. Explain whether you would expect sound to travel through water faster, slower or the same speed as in air, and why. [2]

Questions 10–12

See how well you can understand and explain new ideas and evidence.

10. A bat sends out an ultrasound signal. It receives an echo just 0.5 seconds later. How far away is its prey? (distance = speed × time; the speed of sound in air is 330 m/s) [2]

11. Imagine looking at a small object through a block of glass. Complete a copy of Figure 1.4.11b to show where the object appears to be (its image). [1]

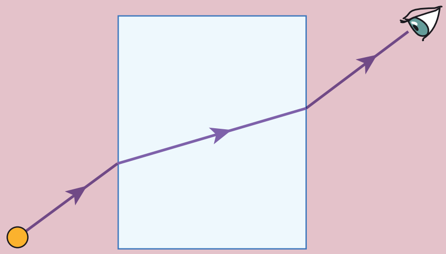


FIGURE 1.4.11b

12. A periscope has an arrangement of mirrors to enable the user to see around obstacles. Complete the diagram to show
   a) how light rays travel from the object to the user
   b) that the object does not appear upside down. [3]

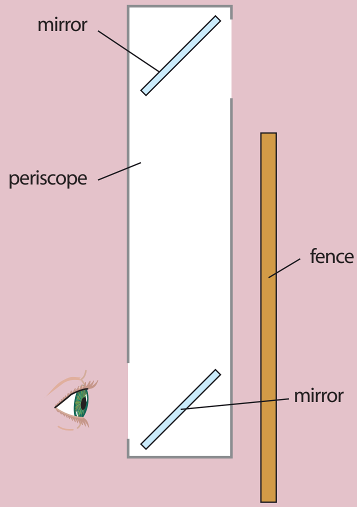


FIGURE 1.4.11c