Isaac Essential Physics

Step into Physics

Draft Waves Excerpt

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PERIPHYSEOS
PRESS

Light sources and rays

Light enables us to see things.
Light is made by light sources.
We see a light source if its light ends up in our eyes.

1 Is it a light source? How did you decide?

(a) A TV screen,

(b) a desk,

(c) a mobile phone screen,

(d) the Sun,

(e) a sheet of paper,

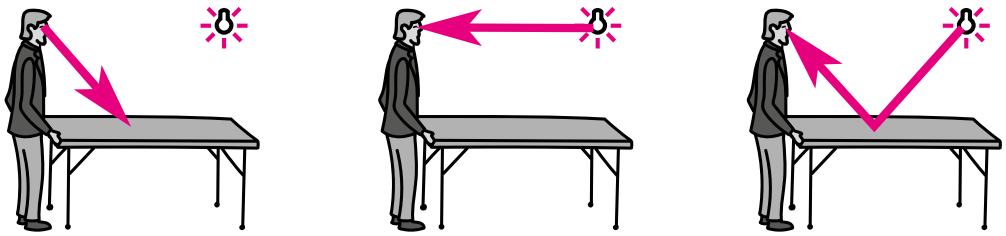
(f) a poster on a wall.

A cup is not a light source. We can see it when
- light from a light source
- travels to the cup,
- then bounces off the cup.
- The light then travels from the cup to our eyes.

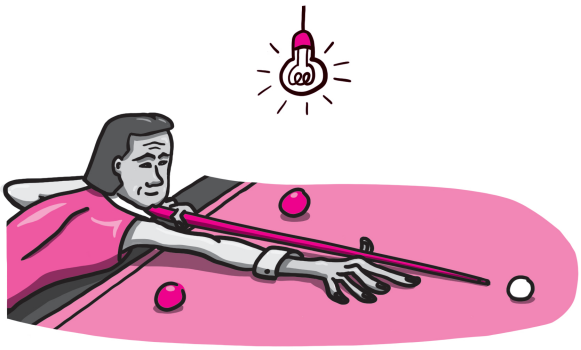
When light bounces off something, we say it reflects.

Light travels through the air in a straight line.

2 A person can see a table in a room with a light bulb. Which of the following diagrams is correct? The lines with arrows show the light travelling.



3 Draw lines with arrows to show how a snooker player is able to see a ball.



The straight lines with arrows on our diagrams are called rays.

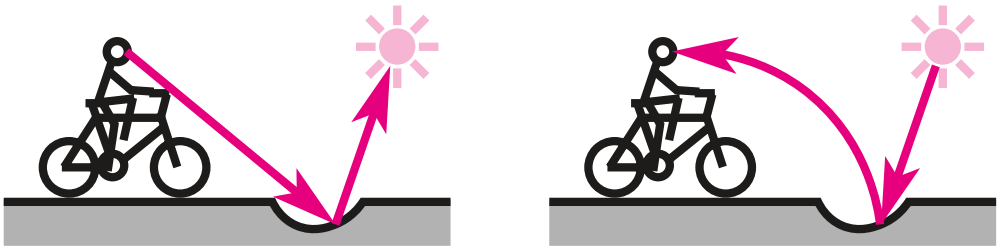
4 A lifeguard on the beach sees a swimmer in need of help. Complete the sentences using the words **reflects**, **lifeguard**, **swimmer**, **Sun**, **eyes**. You can use a word more than once.

Light from the _____ travels to the _____ and _____ off them.

Light then travels from the _____ to the _____ and ends up in their _____.

5 What is wrong with these diagrams showing a person looking at their phone?

6 What is wrong with these diagrams showing a cyclist looking at a hole in the road?

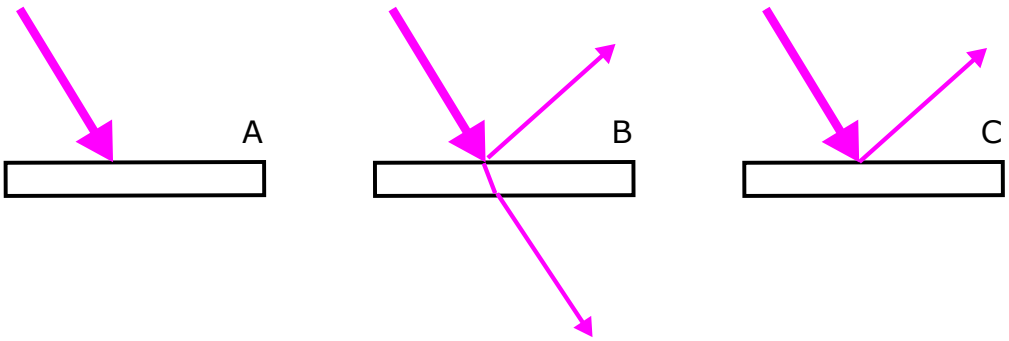


Light can not pass through an opaque material.

When light reaches an opaque object, there is reflection and absorption.

The energy from the light that is absorbed causes the material to warm up.
This increases the thermal energy store of the material.

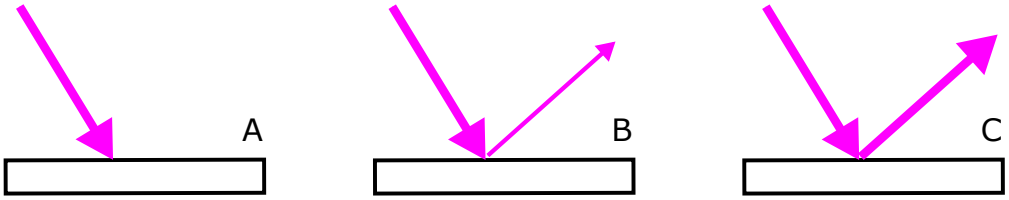
7 Which of the diagrams below shows light reaching an opaque material?



8 In these diagrams, the thickness of the line shows the brightness of the light.

(a) Which of these diagrams show reflection?

(b) Which of these diagrams show absorption?



9 Complete the sentences using the words **reflected**, **absorbed**, **some**, **no**, **warmer**, **cooler**, **slowly**, **quickly**, **bright**. You can use a word more than once. Some words are not used

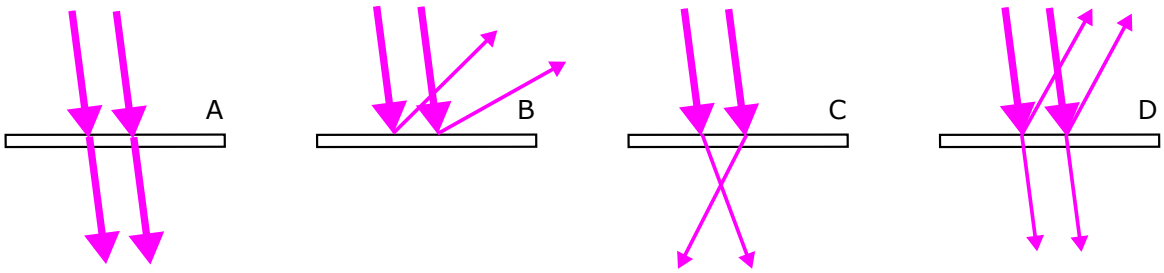
My desk is opaque and painted a pale colour. When sunlight shines on it, _____ light goes through it. I can see the desk, because most of the light is _____ by the surface. After the desk has been in sunlight for an hour, it feels much _____. This means that some sunlight was _____.

I paint my desk a darker colour. Less light will now be _____ off it, and so it won't look as _____. The desk will now warm up more _____ in the sunlight because more light is now being _____.

Light can go through a thin white sheet. Light can also go through a glass window. You can see what is on the other side of a glass window, but you can't see what is on the other side of a thin white sheet.

The glass window is transparent. The thin white sheet is translucent.

10 Match the diagrams to the words **opaque**, **translucent** and **transparent**.



11 Do we need an opaque, transparent or translucent material? Fill in the table.

Description	**Opaque, transparent or translucent?**
The lens in a camera	
The window in a bathroom	
Bedroom curtain if you need to sleep during the day	

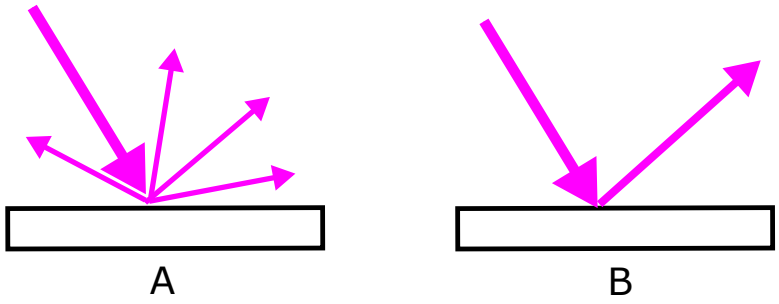
Reflection

When light bounces off something, we say it reflects.

Light travels through the air in a straight line.

Depending on the surface light can reflect in two ways.
- in specular reflection, light only leaves the surface in one direction.
- in diffuse reflection, light leaves the surface in all directions.

1 The diagrams below show the two ways light can reflect.



(a) Which diagram shows **specular reflection**?

(b) Which diagram shows **diffuse reflection**?

2 Which kind of reflection is described in each case? Fill in the table.

Description	**Specular or Diffuse?**
Reflection in a mirror	
Light bouncing off a painted wall	
Light bouncing off the inside of a window	
Light bouncing off a friend's clothes	

3 If you want to see an image of yourself, which kind of reflection do you need?

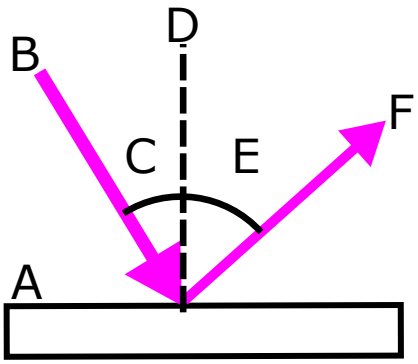
4 The brightness of reflected rays depend on the type of reflection. Complete the sentences using the words **weaker**, **energy**, **direction**, **specular**, **diffuse**.

Light from a _____ reflection can be almost as bright as the incoming ray. This is because nearly all of the _____ of the ray is going the same way.

Light going in one direction from a _____ reflection will be much _____ than the incoming ray, because only a small fraction of the energy travels in that _____.

A line drawn at right angles to the surface is called the normal.

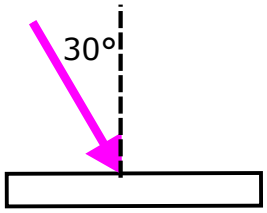
5 Which words describe the features in the diagram below? Fill in the table.



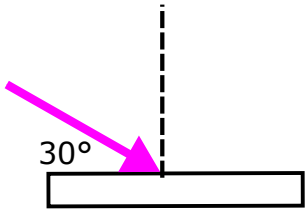
Technical term	A, B, C, D, E or F?
surface	
reflected ray	
incident ray	
angle of reflection	
angle of incidence	
normal	

6 In each diagram below, write down the angle of incidence.

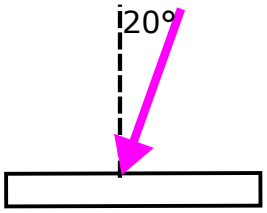
(a)



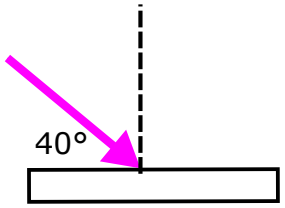
(b)



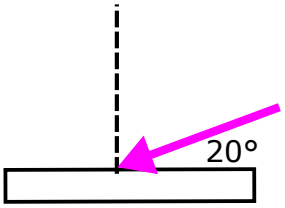
(c)



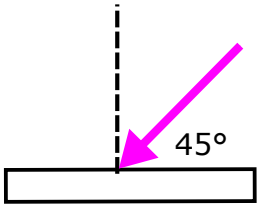
(d)



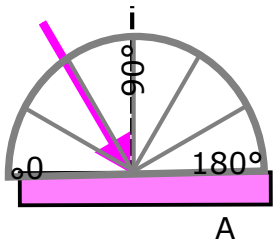
(e)

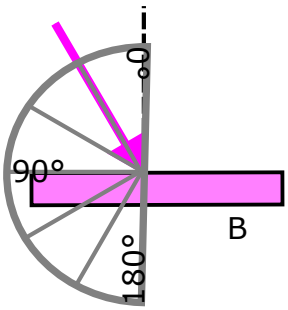


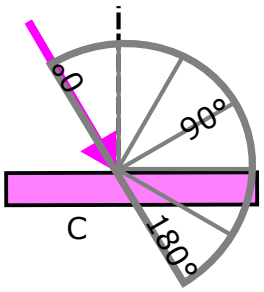
(f)



7 The diagrams below show three attempts to measure an angle of incidence.







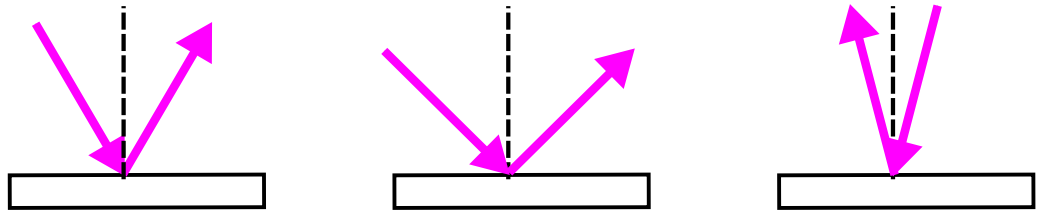
(a) From which of these protractors could we read off the correct angle?

(b) State the angle of incidence of the ray.

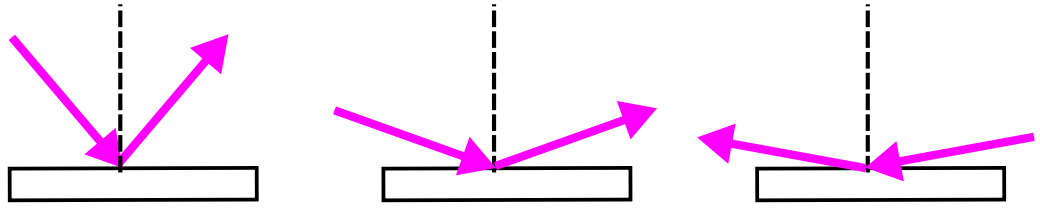
(c) What do we line the centre of the protractor up with?

8 Measure the angles of incidence and the angles of reflection using a protractor.

(a) (b) (c)

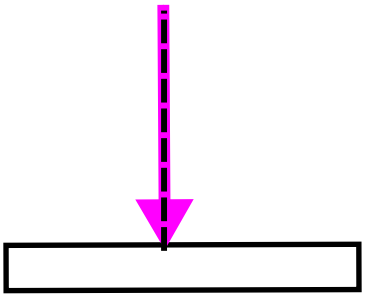


(d) (e) (f)



9 Look at your answers to question 8. How do you predict the angle of reflection if you are told the angle of incidence?

10 Look at the diagram below.

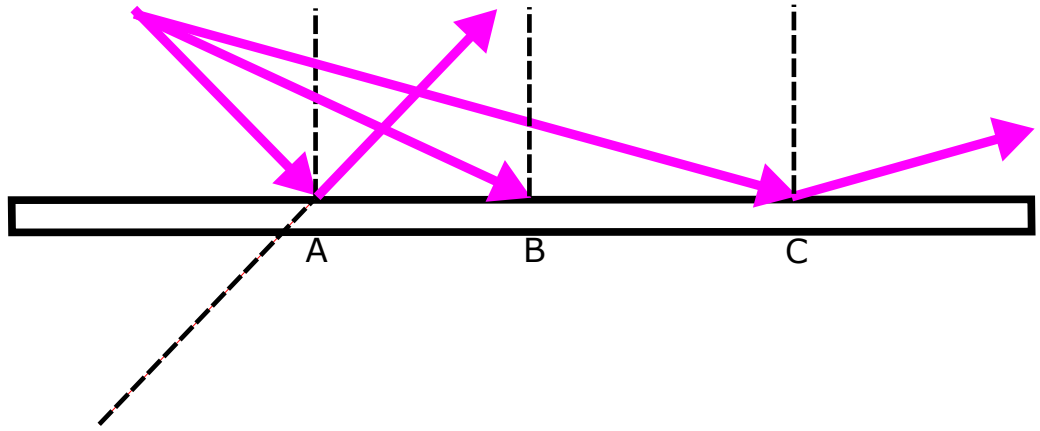


(a) State the angle of incidence.

(b) State what the angle of reflection will be.

(c) Draw the reflected ray on the diagram.

11 The diagram below shows three rays from the same point striking a mirror.



(a) Measure the angle of incidence of the ray going to B.

(b) Draw the reflected ray from B on the diagram using a protractor and ruler.

(c) Continue the reflected rays from B and C through the mirror with dashed lines. Use a ruler. The line from A has been done for you as an example.

(d) Where do the dashed lines meet? Describe the location in words.

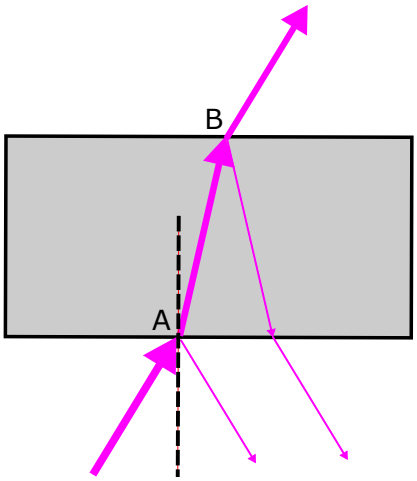
Refraction

When light travels into a transparent material, it changes speed.

This can cause it to change direction.

This is called refraction.

1 The diagram below shows a ray of light going through a glass block. Look at the diagram carefully, and then answer the questions.



(a) Draw on the diagram the path the light would take in the glass if it did not change direction at A.

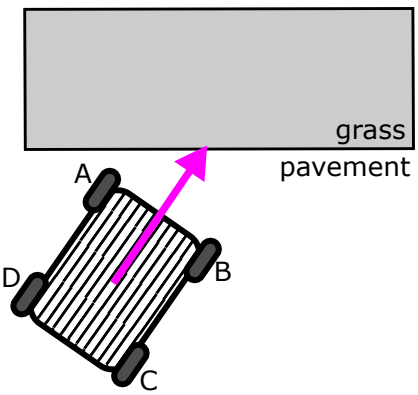
(b) Label the normal with a letter N.

(c) When the light enters the block, which way does it turn? Choose from: **towards the normal** or **away from the normal**.

(d) Describe the direction the light takes as it moves away from the block at B.

(e) Not all light enters the block. What happens to the light which does not enter the block?

2 Refraction is like a trolley being pushed off a pavement onto some grass.



(a) Which wheel on the trolley is going to go onto the grass first? A, B, C or D.

(b) Which way will the trolley turn after the first wheel goes onto the grass and slows down? **Left** or **right**?

(c) What happens after the next wheel goes onto the grass?

(d) Draw an arrow to show the direction of the trolley after two wheels are on the grass.

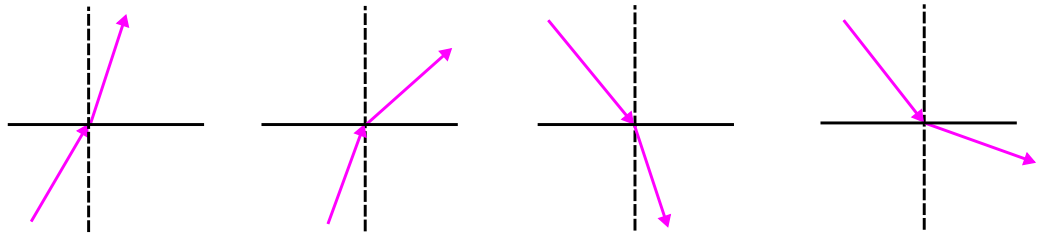
(e) Draw a normal on the diagram.

(f) When the trolley goes onto the grass, which way does it turn? Choose from: **towards the normal** or **away from the normal**.

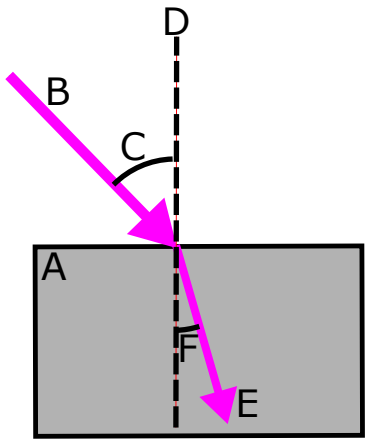
(g) Compare this diagram with the diagram in question 1. Does light slow down or speed up when it enters glass from air?

3 The diagrams below show light crossing a boundary from air into glass or glass into air. On each diagram, mark with a G the side which is glass.

(a) (b) (c) (d)

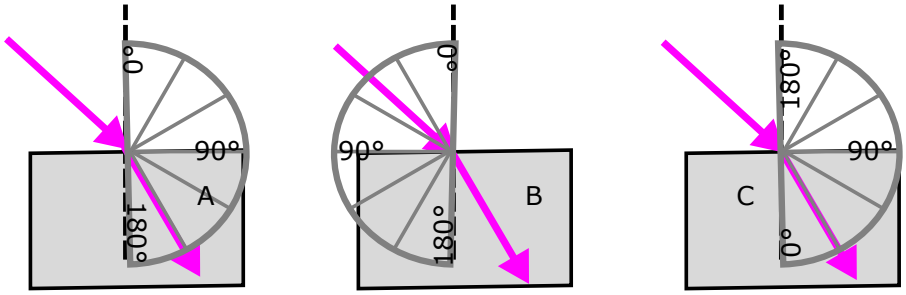


4 Which words describe the features in the diagram below? Fill in the table.



Technical term	A, B, C, D, E or F?
glass block	
refracted ray	
incident ray	
angle of refraction	
angle of incidence	
normal	

5 The diagrams below show three attempts to measure an **angle of refraction**.



(a) From which of these protractors could we read off the correct angle?

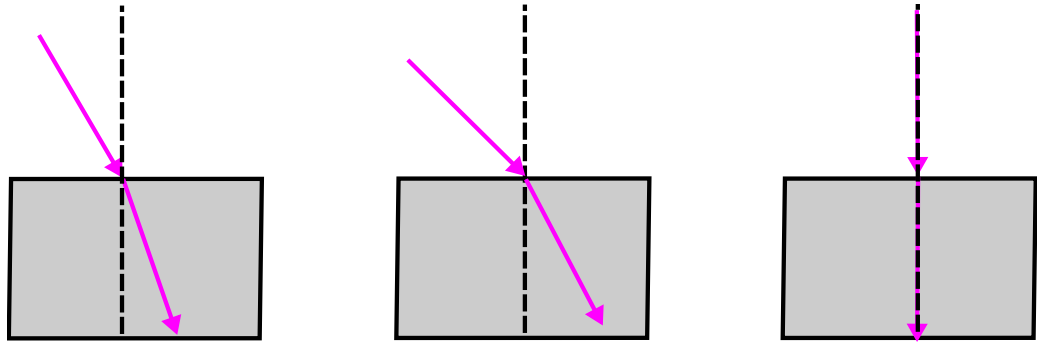
(b) State the angle of refraction of the ray.

(c) Estimate the angle of incidence of the ray. Is it $30°$, $45°$ or $60°$?

(d) Not all of the light refracts. Draw a reflected ray onto the diagram.

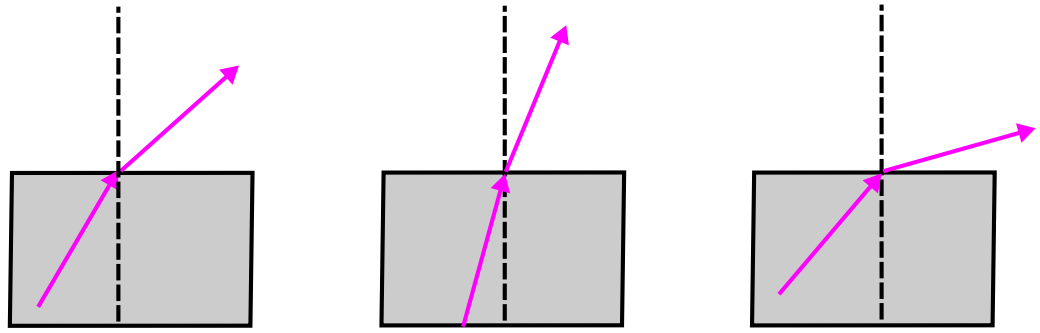
6 In each diagram below, measure and write down the angles of incidence and refraction.

(a) (b) (c)



7 In each diagram below, write down the angles of incidence and refraction. Here the angles of incidence are inside the block of glass.

(a) (b) (c)



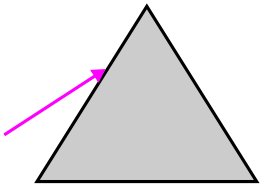
8 Complete the sentences using the phrases **will always**, **does not**, **in to**, **out from**, **incidence**, **refraction**. You do not need to use all of the phrases.

If the angle of incidence is zero, the light _____ change direction.

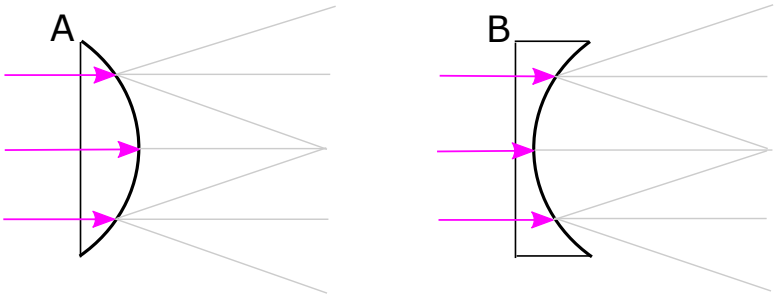
Otherwise, the angle of incidence is larger than the angle of _____ when light passes _____ a glass block.

The angle of _____ is smaller than the angle of refraction when light passes _____ a glass block.

9 Draw two further straight lines on the diagram below to show where the light might go after entering this triangular block (called a prism).



10 The diagrams below show rays passing into pieces of glass with a curved surface.



(a) Draw normals for each of the places where light reaches the curved surface.

(b) Draw the refracted rays to show how light leaves the glass. Each refracted ray follows one of the pale grey lines, but you will need to choose which one to use.

(c) These objects are called lenses. A convex lens is thicker in the middle than at the edge. Which lens is the convex lens? Write A or B.

(d) Complete the sentence: A convex lens causes a parallel beam of light to

Waves and sound

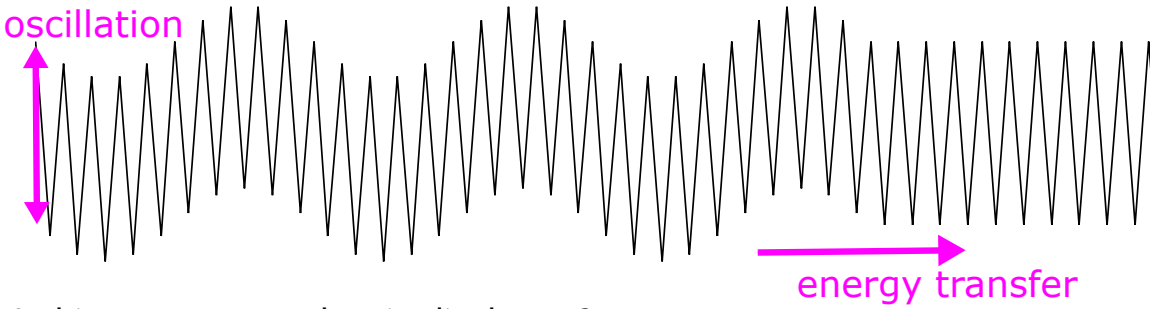
A wave carries energy and can carry information without carrying material from one place to another.

Inside a wave, each part moves one way then the other. This is called oscillation. Each part's oscillation causes the next part to oscillate as well.

In a longitudinal wave the oscillations are in the same direction as the energy transfer.

In a transverse wave the oscillations are at right angles to the energy transfer.

1 Two friends stretch a long spring between them. One of them starts moving it up and down. After a short time, it looks like this:



(a) Is this a transverse or longitudinal wave?

(b) The highest points on the wave are called peaks. Label 3 peaks with the letter P.

(c) The lowest points are called troughs. Label 3 troughs with the letter T.

2 Use a ruler to measure the distance between neighbouring peaks in question 1.

3 Use a ruler to measure the distance between neighbouring troughs in question 1.

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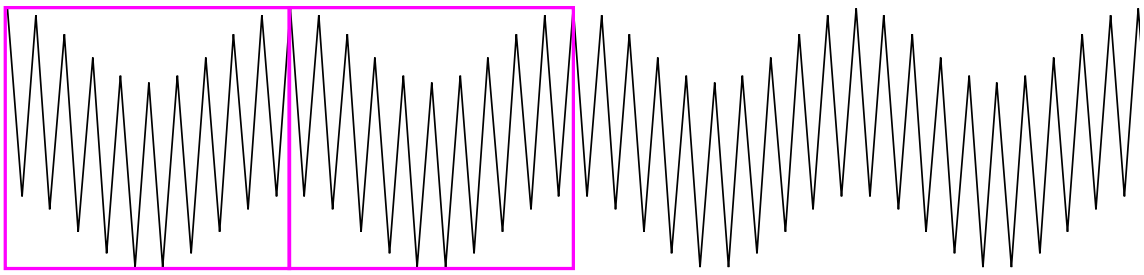
4 A short time later, the wave looks like this. Boxes have been drawn around sections of the wave.



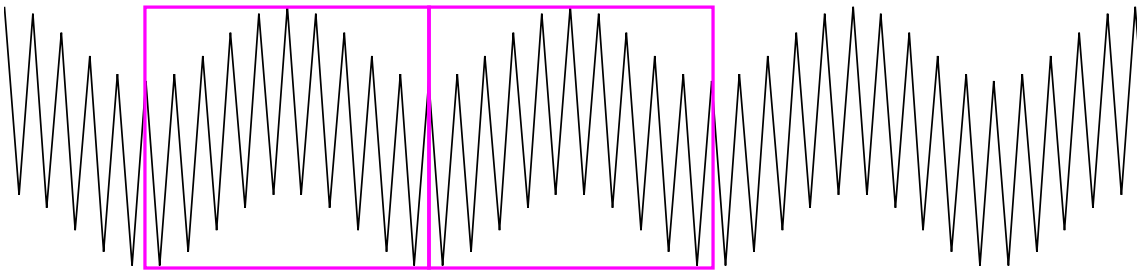
(a) Compare the contents of each box. Do they look the same?

(b) Each box contains a section of wave from one _____ to the next.

(c) Measure the length of each box.

(d) Draw the next box on the wave above.

5 The boxes can be drawn differently on the same wave.



(a) Each box contains a section of wave from one _____ to the next.

(b) Measure the length of each box.

(c) Draw the next box on the wave above.

6 The boxes in questions 4 and 5 show a repeating unit in the wave. Its width is called the wavelength of the wave.

(a) Write down the wavelength of the wave.

(b) Compare your answer to (a) with your answers to questions 2 and 3.

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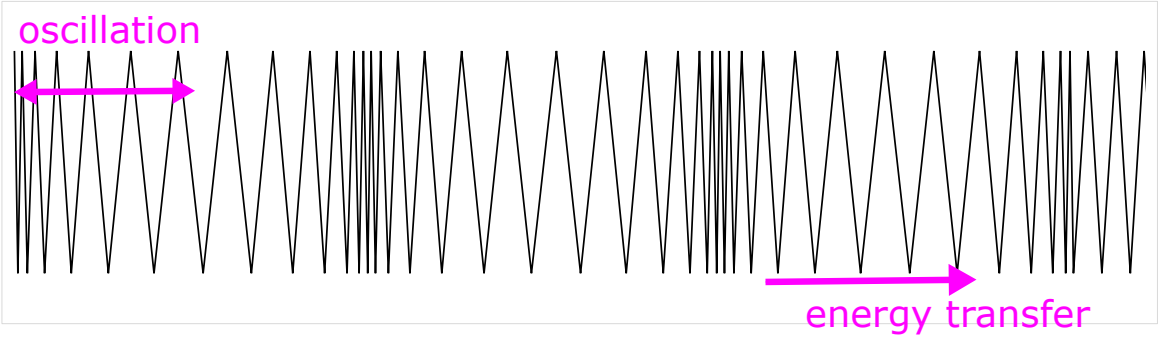
7 The two friends now push then pull the spring. After a short time, it looks like this:



(a) Is this a transverse or longitudinal wave?

(b) The places where the spring is bunched up on the wave are called compressions. Label 3 compressions with the letter C.

(c) The places where the spring is most spaced out are called rarefactions. Label 3 rarefactions with the letter R.

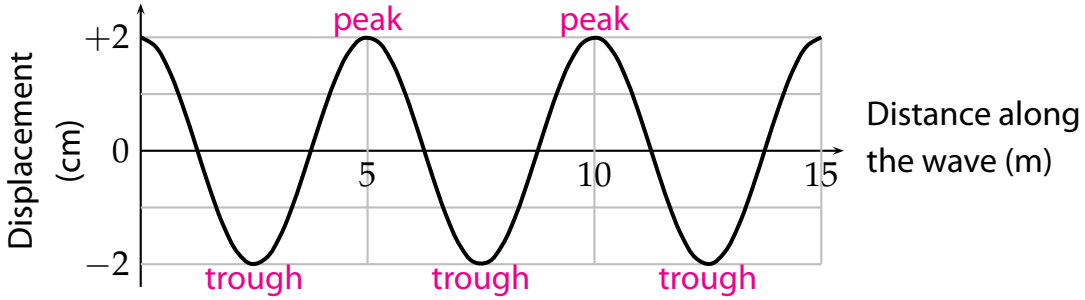
(d) Draw a box around a repeating unit on the wave.

8 Measure the wavelength of the wave in question 7.

Displacement measures how far each part of the spring is from its resting place.

When we draw a graph of a wave, we plot

- the displacement on the vertical (y) axis, and
- the distance along the wave on the horizontal (x) axis.

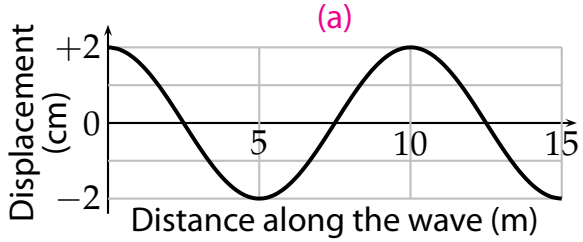


The amplitude (A) is the largest displacement on the wave. Here, the amplitude is 2 cm.

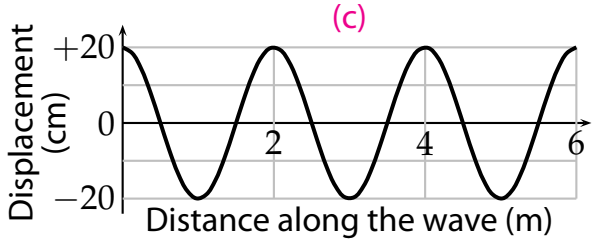
9 Using the scale on the graph, write down the wavelength of the wave above.

10 Write down the wavelength (λ) and amplitude (A) of each wave below.

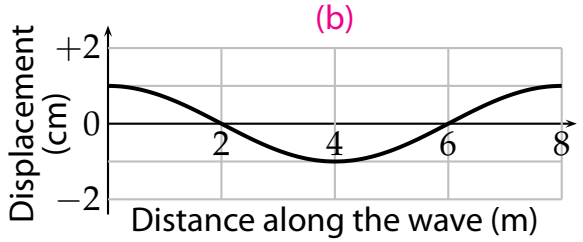
(a)



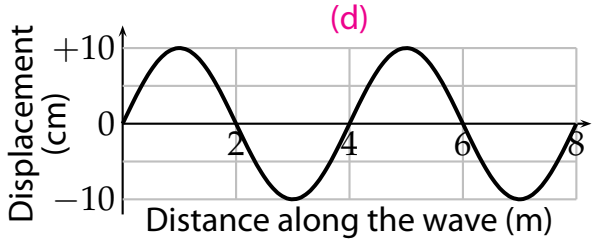
(c)



(b)



(d)



Sound is an example of a longitudinal wave.

11 A citizen listens to the news on their TV. Complete the sentences using the words or phrases **towards**, **ears**, **brain**, **sound wave**, **speaker**, **oscillates**.

The _____ in the TV _____.

This makes air molecules move away from the speaker then _____ it.

The air carries the _____ to the listener.

When the wave reaches the listener, the air makes parts of their _____ oscillate.

Nerves detect this motion, and the information reaches the listener's _____.

Sound and Waveforms

When a sound travels, the particles oscillate in the material it is travelling through. This means that they move forwards and backwards again and again.

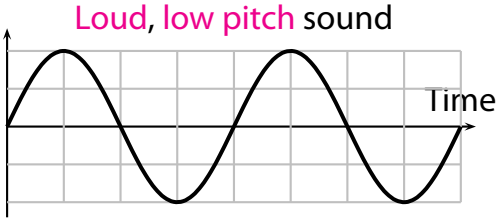
The time for each oscillation back and forth is called the time period.

When the sound reaches our ears or a microphone, it makes a sensitive surface oscillate too. This can be heard as sound.

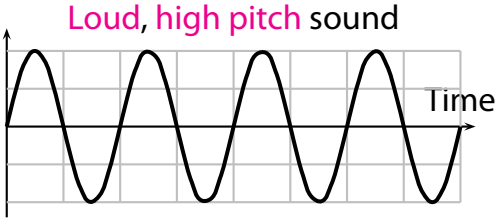
When a microphone is connected to a computer, a data-logger or an oscilloscope, the wave can be seen on a screen.

The screen shows how the displacement of the wave changes as time passes.

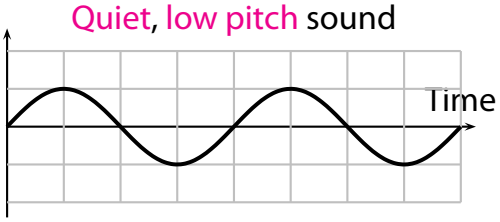
Loud, low pitch sound



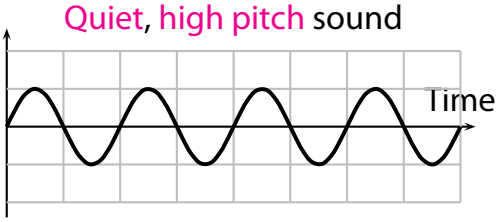
Loud, high pitch sound



Quiet, low pitch sound



Quiet, high pitch sound



1 Look at the waves shown above and answer the questions.

(a) Describe how the loud sounds' graphs differ from the quiet sounds' graphs.

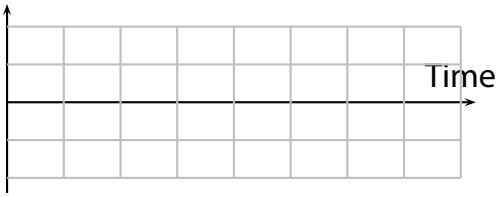
(b) Describe how the high sounds' graphs differ from the low sounds' graphs.

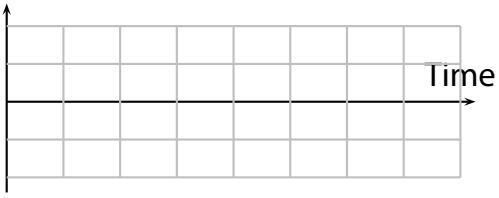
(c) Does a short time period means that the sound is high pitched or low pitched?

(d) Does a large amplitude means that the sound is loud or quiet?

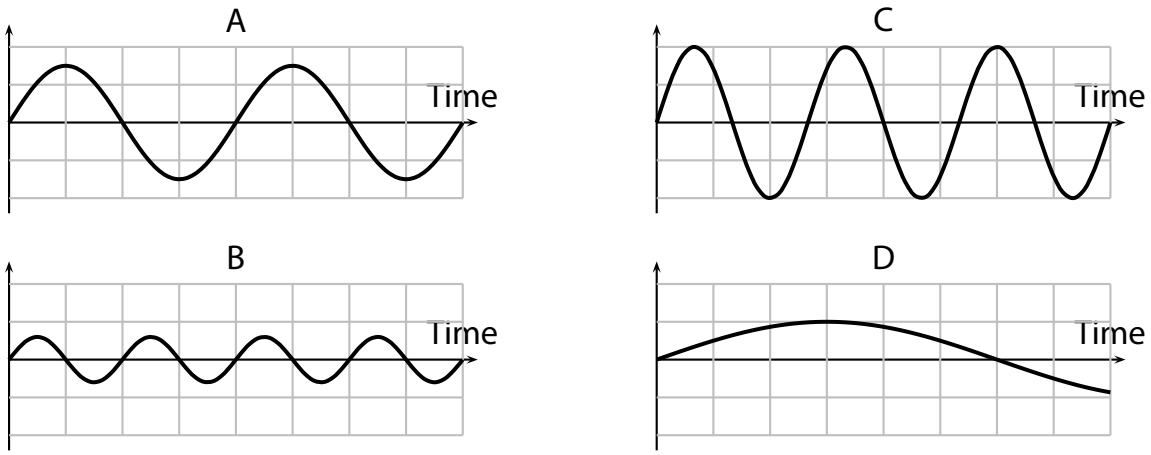
2 Draw waves on the graphs below to fit the descriptions.

(a) quieter and higher than the waves above (b) louder and lower than the waves above





3 Use these wave graphs to answer the questions below them.



(a) Put the letters ABCD in order to rank the waves from quietest to loudest.

(b) Put the letters ABCD in order to rank the waves from lowest to highest pitch.

(c) Which wave has the shortest time period?

The number of complete oscillations in one second is called the frequency of the wave.

Waves with a high frequency have a short time period and are high pitched.

4 Which wave in question 3 has the lowest frequency?

5 Complete the sentences using $20\,000$ **Hz**, **ultrasound**, **Hz**, 20 **Hz**, **hertz**.

Frequencies are measured in _____ (symbol _____).

Our ears can hear sounds with frequencies between _____ and _____.

Sounds above this range can not be heard and are called _____.

Each oscillation takes a very short time so the times are measured in milliseconds (ms).

A millisecond is one thousandth of a second. There are 1000 milliseconds in one second.

We write 1 s $=$ 1000 ms, or 1 ms $=$ 0.001 s.

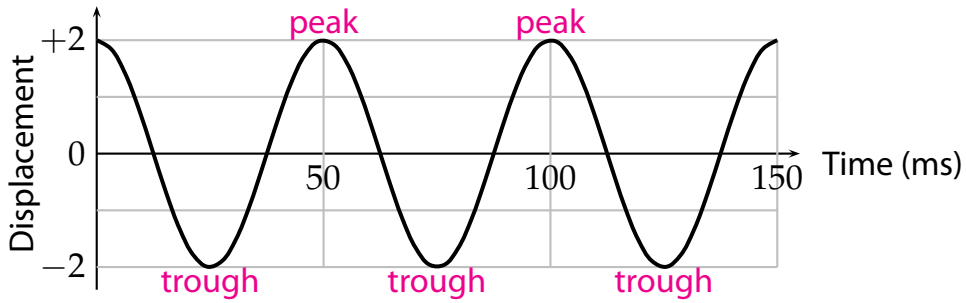
6 Write the times below in milliseconds.

(a) 0.002 s (b) 0.125 s (c) 0.02 s

7 Write the times below in seconds.

(a) 2000 ms (b) 3 ms (c) 40 ms

The **time period** of this wave is 50 ms. This is the time from one peak to the next peak.



8 What is the time period of this wave in seconds?

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9 In this question we look at the link between time period and frequency.

(a) A wave has a time period of 0.05 s. Work out how many times it oscillates each second using an equation.

1	÷	0.05	=	

(b) What is the frequency of a wave if its time period is 0.05 s?

(c) A wave has a time period of 0.002 s. Work out its frequency using an equation.

1	÷	time period (s)	=	frequency (Hz)
1	÷	0.002	=	

(d) Work out the frequency of a wave with a time period of 0.004 s using an equation.

1	÷	time period (s)	=	frequency (Hz)
1	÷	0.004	=	

10 A wave has a time period of 5 ms. Calculate its frequency.

11 Calculate the frequency of the wave in question 8?

A frequency of 4000 Hz is usually written 4 kHz. One kilohertz (1 kHz) is the same as 1000 Hz.

12 Calculate the frequencies in kHz of waves with the following time periods.

(a) 10 ms

(b) 0.5 ms

(c) 40 ms

(d) 0.1 ms