3.1 Sound waves and how they travel

2nd

1. Use the words from the box to complete the sentences below.

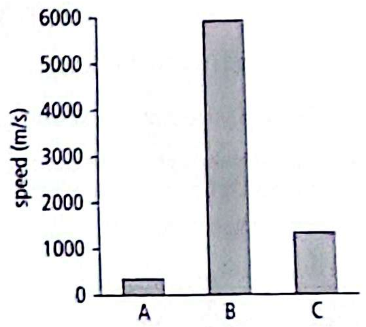
   Use each word once, more than once, or not at all.

air	compressions	waves	solids	vibrating	rarefactions	moving	vacuum	radio

   a. All sound is produced by something that is .... Sound can travel through solids, liquids, and gases but not through a ....

   b. Sound .... consist of .... (where the particles are close together) and .... (where the particles are further apart).

2. Here is a bar chart showing the speed of sound in different materials, A, B, and C. One is a solid, one is a liquid, and one is a gas.



   a. Give the letter of the material that is a solid. ....

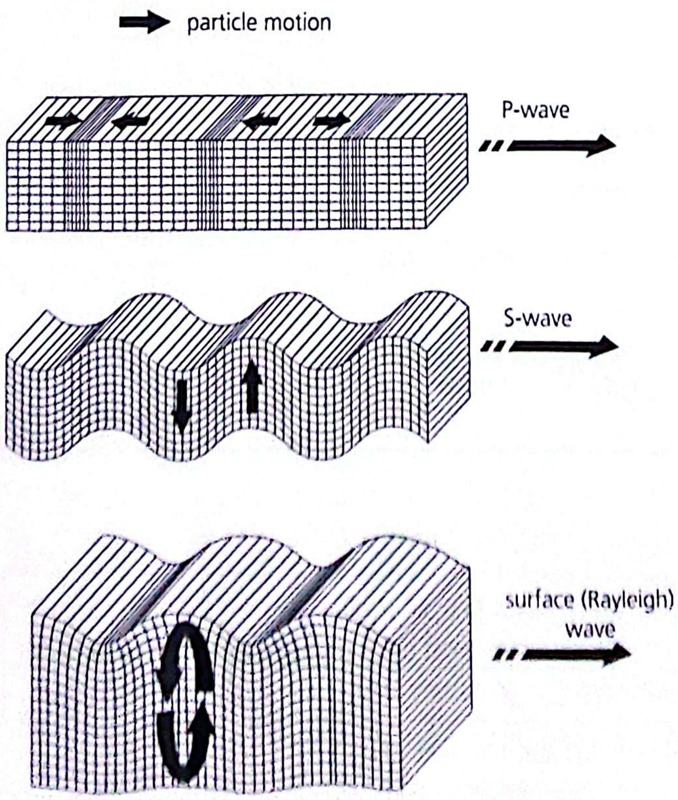
   b. Is material A a solid, a liquid, or a gas? ....

   c. How much faster, approximately, does sound travel in solids than in gases? Circle one of the answers below.

   1000 times faster **100 times faster** **10 times faster**

Extension

When there is an earthquake, waves called seismic waves are produced.



Decide which wave is a transverse wave and which is a longitudinal wave. Explain your answer.

1. The box below contains a list of words and phrases relating to the ear.

cochlea	ossicles	middle ear	oval window	inner ear	eardrum
auditory canal	auditory nerve				

a. Use the words and phrases from the box to complete the sentences below. Use each word or phrase once, more than once, or not at all.

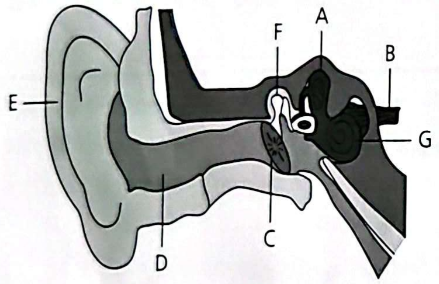
When you listen to music, a sound wave travels along your .... and makes your .... vibrate. This makes the small bones or .... vibrate. These bones make up your .... Your semi-circular canals and .... make up your .... The fluid inside the .... vibrates when the vibration is passed on by the .... Signals produced by sound-detecting cells travel down the .... to the brain.

b. Name the part of the outer ear that is *not* in the list of parts of the ear above. Describe its function.

....

....

2. Look at the diagram below. Answer the questions that follow by identifying the part in the diagram and writing down the letter.



a. This part converts the sound wave into an electrical signal. ....

b. This part consists of the smallest bones in the body. ....

c. This part can be damaged by sharp objects inserted into the ear. ....

d. These parts make up the outer ear. ....

e. This is the first thing that vibrates when we detect a sound wave. ....

Extension

Read the information in the box then answer the questions below.

> A microphone converts a sound wave into an electrical signal. Microphones have different pick-up patterns. Omni-directional microphones pick up waves that are coming from any direction. Uni-directional microphones pick up sounds from one direction only.

a. Underline the part of the text that describes what a transducer does.

b. Suggest whether singers use omni-directional or uni-directional microphones. Explain your answer.

c. Would you use an omni-directional or uni-directional microphone to measure the sound levels in a classroom? Explain your answer.

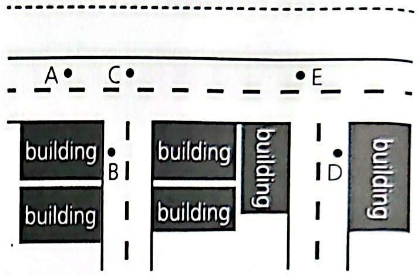
Light

7.1 Seeing things

1. Join boxes from each column to make three sentences about the way that light behaves.

You cannot see through …	… transparent materials …	… but you cannot see through them.
You can see through …	… translucent materials …	… like glass.
Light can get through …	… opaque materials …	… like concrete.

2. Here is a diagram showing some people and some buildings.



   a. Give the letters of the pairs of people who can see each other.

   ………………………………………………………………………………

   b. Explain why the other pairs of people cannot see each other.

   ………………………………………………………………………………

   ………………………………………………………………………………

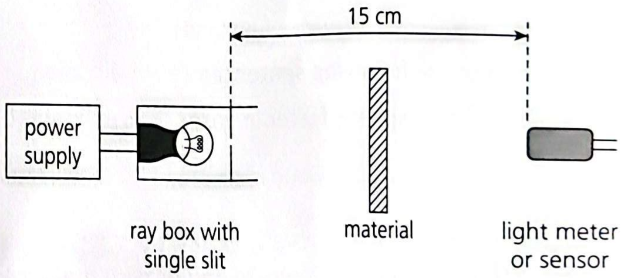
   c. Describe the journey that light takes so that a person can see the road surface. Use all of these words in your answer: reflected, emitted, absorbed. You do not need to include the colour of the road.

   ………………………………………………………………………………

   ………………………………………………………………………………

3. A student investigates the light-transmitting properties of some materials.

   First, he put the light meter on the other side of the material as shown in the diagram. He reads the light level on his light meter.



   a. Is the meter measuring how much light is transmitted or reflected?

   ………………………………………………………………………………

   b. Then he put the light meter on the same side as the ray box, pointing it at the material, and reads the light level. Is the meter measuring how much light is transmitted or reflected?

   ………………………………………………………………………………

Extension

In the experiment in question 3, the student puts sheets of transparent plastic between the ray box and the meter.

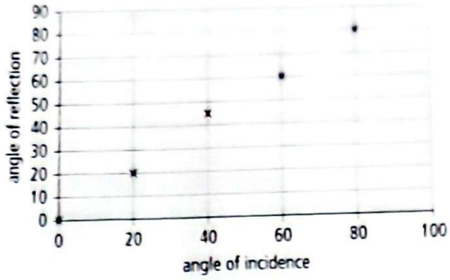
a. Suggest whether you think the meter reading will change. Explain your answer.

b. The student removes the plastic sheets. Suggest and explain what happens to the reading on the meter as they move the meter away from the ray box.

7.2 The law of reflection

1. Jamaal carried out an experiment using a mirror to investigate how light is reflected.

He measures the angle of incidence and the angle of reflection. Here are his results plotted on a graph.



a. Draw a line of best fit on the graph.

b. Give the result (or results) that does not fit the pattern.

....

c. Should the experiment be repeated? Explain your answer.

....

....

d. Explain how his results demonstrate the law of reflection.

....

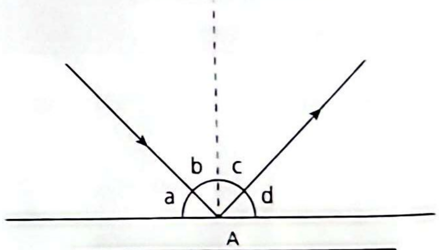
....

e. He replaces the mirror with a white screen. The reflected ray is very faint. Explain why.

....

....

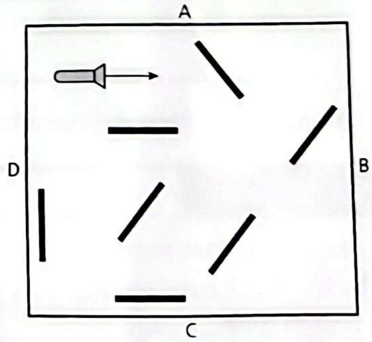
2. Look at the diagram then look at the statements in the table. Put ***T*** in the final column if the statement is true and ***F*** if the statement is false.



a.	Angle a is always equal to angle b.	....
b.	Angle b is always equal to angle c.	....
c.	Angle c is always equal to angle d.	....
d.	Angle b + angle c = 90 degrees	....
e.	Angle a + angle b = 90 degrees.	....

3. A student designs a puzzle that needs the law of reflection to be solved.

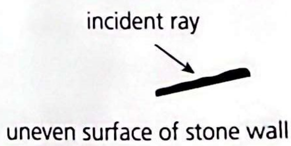
All of the mirrors reflect on both sides. Use an angle measurer to work out on which side of the box (A, B, C, or D) the ray of light will emerge after reflecting off the mirrors.



The ray will emerge on side: ....

Extension

Uneven surfaces like the surface of a stone wall reflect light.



a. On the diagram above, draw a normal at right angles to the surface where the ray hits it.

b. Draw an arrow to show the reflected ray.

c. Draw another incident ray parallel to the ray drawn above that hits a different part of the wall.

d. Draw another normal and reflected ray to show how this ray is reflected.

e. Explain why you cannot see your face in a stone wall.

7.3 Reflection and images

1. Write *T* next to the statements that are true. Write *F* next to the statements that are false.

   Then write the corrected versions of the statements that are false.

   a. The image that you see in a mirror is a real image. ....

   b. If you look in a mirror your image looks as if up and down are swapped over. ....

   c. The reflection of light that you see in a mirror is diffuse reflection. ....

   d. The image of an object in a mirror is the same size and shape as the object. ....

   e. Your mirror image appears closer to the mirror than you are. ....

   Corrected versions of false statements:

   ....

   ....

   ....

   ....

2. When you look in a mirror you see your image.

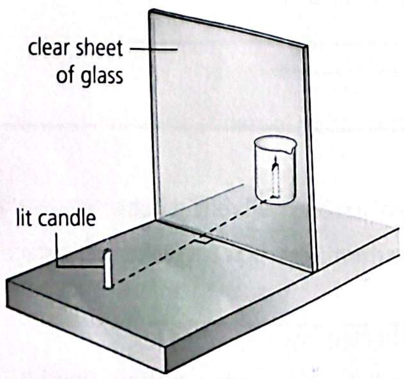
   a. Complete the table.

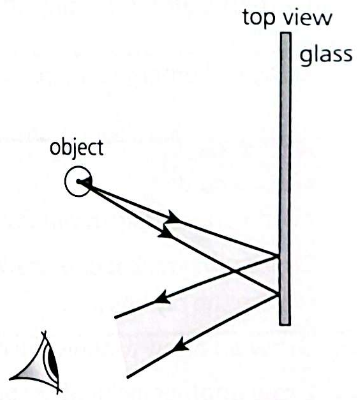
Things that are the same about you and your mirror image	Things that are different about you and your mirror image

   b. You stand 50 cm in front of a mirror. Give the distance between you and your image. ....

Extension

You can achieve magic tricks with the reflection of light. In this trick you can make it appear that a candle is burning in a beaker of water.





a. Explain why it appears that the candle is burning underwater.

b. Copy and complete the diagram to show how the image of the candle is formed in the glass.

c. Explain how you can make it look as if an unlit candle is burning. Draw a diagram and explain what you have drawn.

1. A student is finding out what happens when light goes from water into air.

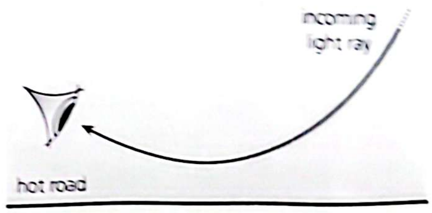
She puts a coin in the bottom of the cup and puts the cup on a table. She walks away until she cannot see the coin at the bottom of the cup.

a. Use what you know about how we see things to explain why she cannot see the coin when there is no water in the cup.

b. Her friend now pours water into the cup while she is looking at the coin. The coin appears. Use what you know about how we see things to explain why she **can** see the coin when there is water in the cup.

c. Complete the diagram of the cup filled with water showing rays from the coin in each case.

2. Mirages are very common in deserts. You see what appears to be a sheet of water a short distance ahead of you. You don't need to go to a desert to see a mirage. On a hot day you often see the same effect on a road. The road in front of you may appear wet or shiny but, however far you travel, you never reach the water because it is an optical illusion. What you are seeing is an image of the sky, which looks like water to us.



a. The brain works by assuming that light travels in straight lines. Draw a line on the diagram to show where the light appears to come from.

b. As the light travels toward the road is it moving into air that is denser or less dense?

c. Use your answer to part b to explain why the ray bends as it does.

Extension

Refractive index tells us how much light is slowed down by a medium such as air or glass.

a. Complete the table.

Material	Speed of light in a vacuum (km/s)	Speed of light in the material (km/s)	Refractive index
vacuum	300 000		1
glass	300 000	200 000	
alcohol	300 000		1.36
salt	300 000	190 000	

b. Explain why refractive index does not have a unit.

c. Is it possible to have a material with a refractive index of less than 1.0? Explain your answer.

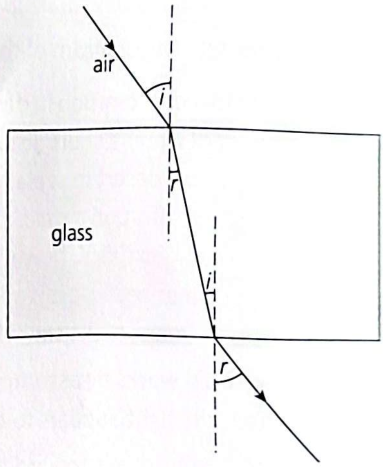
1. Complete the following sentences using the words from the list. Each word may be used once, more than once, or not at all.

denser	**direction**	**refraction**	**incidence**	**incident**	**parallel**
perpendicular	**quickly**	**refracted**	**slowly**	**straight**	

Light is .... when it passes through a glass block. The angle of .... (i) is the angle between the normal and the .... ray. The angle of .... (r) is the angle between the normal and the .... ray. The ray of light changes direction when it enters the glass block because glass is .... than air and the light travels more .... The ray of light changes direction when it leaves the glass block because light travels more .... in air than in glass. The rays entering and leaving the block are ....

2. Deepak has been studying what happens when light goes into glass. He measures the angle of incidence and angle of refraction.

Angle of incidence (°)	Angle of refraction (°)
10	7
20	13
30	37
40	25
50	31



a. Give the angle of refraction if the angle of incidence is zero.

....

b. Give the result (or results) that does not fit the pattern.

....

c. Deepak replaces the block with one that has a *lower* refractive index. Write a prediction that he could make about what will happen to the angle of refraction. Explain the prediction.

....

....

....

Extension

Light travels in straight lines but can travel around corners in an optical fibre.

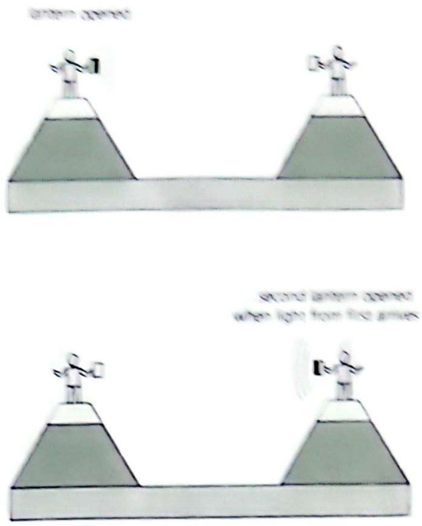
a. Explain how you can see around corners but still have the light travelling in straight lines. Draw a diagram and explain it.

b. Look at the speed of light in different materials. Write a list of the materials in order starting with the material that refracts light the most.

Material	Speed of light in the material (million km/s)
air	300
diamond	125
glass	200
plastic	187
water	225

Extension

1. In 1638, Italian scientist Galileo Galilei and his assistant performed an experiment to measure the speed of light. They stood on hills several kilometres apart. Galileo's assistant opened his lamp and when Galileo saw the light from it, he opened his own lamp.



   a. The speed of light is 300 000 km/s. The distance between the two hills is 3 km. Choose the time delay that you would expect to see in this experiment. Circle the correct answer.

   10 seconds   1 second

   $\frac{1}{1000}$ th of a second $\frac{1}{100\,000}$ th of a second

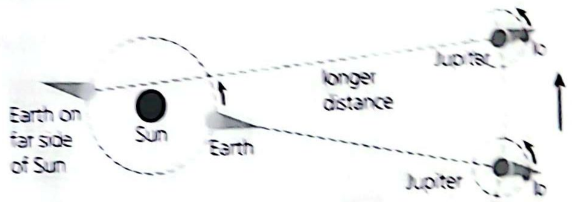
   b. Could you detect this time delay with the human eye? Explain your answer.

   ....

   c. Calculate the distance that Galileo's assistant would have to be from Galileo to have a time delay of 1 second. Suggest a problem with doing the experiment in this way.

   ....

2. a. The astronomer Rømer sometimes saw the eclipse of Io. This happens when Io moves into the shadow of Jupiter. Explain why, when Rømer saw the eclipse from Earth, it had already taken place.



   ....

   ....

   b. Sometimes Io is 6.2 million km away and sometimes it is 9.4 million km away. Convert these distances to light seconds. The speed of light is 3.0×10^8 m/s.

   ....

   ....

   c. Describe the positions of the Earth, Sun, Jupiter, and Io when Io is the furthest from the Earth.

   ....

3. The robot Perseverance landed on Mars in March 2021. Communicating with robots on Mars is difficult, but even more so if you have to take into account the fact that light takes time to travel.

   Look at the diagram of the inner planets of the Solar System in Unit 5.4 of the Student Book. Explain why there is a range of values for the distance between Mars and Earth. (Mars and Earth travel at different speeds around the Sun.)

   ....

   ....

1. Write *T* next to the statements that are true. Write *F* next to the statements that are false. Then write corrected versions of the statements that are false.

   a. The spectrum is made up of nine colours. ....

   b. Violet is refracted more than red. ....

   c. Raindrops change white light into coloured light. ....

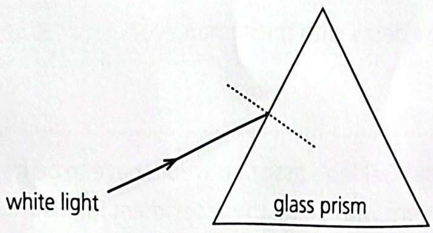
   d. Light is reflected as it goes through a prism. ....

   Corrected versions of false statements:

   ....

   ....

2. The diagram shows a beam of white light entering a prism.



   a. Complete the diagram showing how a spectrum is produced and label R where you would see red light in the spectrum and V where you would see violet light.

   b. Draw a circle around the points on the diagram that shows light being refracted.

   c. You can add another prism to recombine the light and produce white light. Describe how you can do this.

3. Rainbows can be formed wherever white light interacts with drops of water. This can happen when it rains or over waterfalls. Put the following statements in order by writing the letters in the boxes below to explain how a rainbow is formed.

   A. Different colours are refracted by different amounts as the light enters the drops.

   B. The white light enters raindrops and is refracted.

   C. The Sun emits white light, which is made up of all the different colours of light.

   D. As the light leaves, the raindrops it is refracted again spreading the colours out even more.

   E. All the colours of light are reflected from the inside surface of the drop.

Extension

Explain why you only see rainbows when the Sun is behind you.

8.1 The properties of magnets

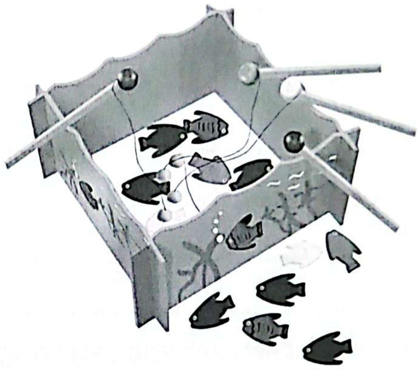
1. Use the words and phrases from the box to complete the sentences below. Use each word or phrase once, more than once, or not at all.

iron	south	attracted to	copper	north	repelled by

Magnetic materials such as .... , nickel, or steel can be magnetised. When you move a magnet near a magnetic material, the material will be .... the magnet, but it will never be .... the magnet. .... nails are .... a magnet because each one becomes a magnetised. If the pole that is touching the nail is a north pole, then the end of the nail touching the magnet has become a .... pole.

2. A child has been given a magnetic fishing game. The description says:

'This is a game based on magnetism that uses rods to pick up wooden fish from the box.'



a. Describe how you know that the 'fish' are not made of wood.

....

....

b. Here are possibilities for making the ball at the end of the rod and fish. Put a tick (√) in the blank column if you think that the game would work.

The ball at the end of the rod is a magnet and the fish are made of a magnetic material.	
The ball at the end of the rod is made from a magnetic material and the fish are made from a magnetic material.	
The ball at the end of the rod is a magnet and the fish are magnets.	

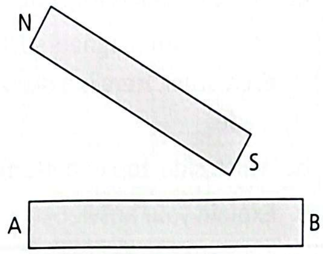
c. Explain your answer to b.

....

....

Extension

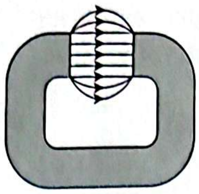
Here is a drawing of someone starting to use a magnet to magnetise a rod of metal. They repeatedly pull the south pole along the top of the rod from right to left.

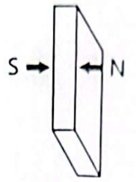


a. On the diagram:
- label the magnet
- label the rod
- draw domains inside the magnet
- draw domains inside the unmagnetised rod.

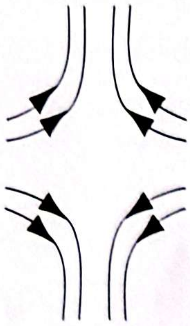
b. The rod is now magnetised. Is A the north pole or the south pole?

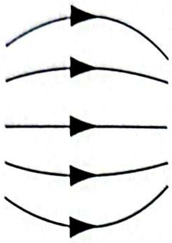
1. Magnets can be made in lots of different shapes. On each of these diagrams on the left **either** add the names of the poles *or* add the field lines to complete the patterns.

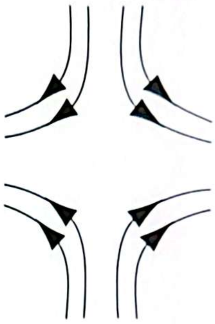




2. Draw the magnets on these diagrams to show what magnet, or combination of magnets, would create each pattern shown. Label the north and south poles.







3. A student has two magnets of different shapes.
   a. Describe how she could find the magnetic field pattern around each magnet.

   ....

   ....

   b. She uses her method to draw a diagram to show the magnetic field pattern. Describe how the pattern shows:
      i. where the field is strongest

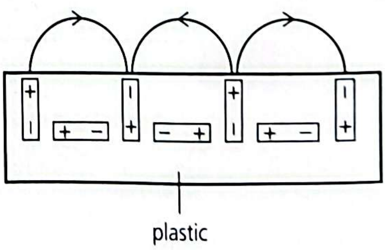
      ....

      ii. where the north pole is.

      ....

Extension

Refrigerator magnets are designed to stick to the door of your refrigerator. They are made of a plastic sheet with a picture or phrase written on it that is glued to a piece of magnetic material that has been magnetised.



a. Suggest what refrigerator doors must be made of.

Refrigerator magnets stick to the refrigerator door but not to each other. Here is a diagram of how a refrigerator magnet is made.

b. Which side, top or bottom, is attracted to the refrigerator?

c. Explain your answer.

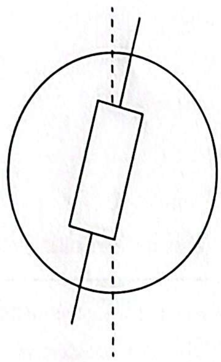
10.3 Magnetic Earth

1. Choose the words from the box to complete the sentences. You may need to use the words once, more than once, or not at all.

east	**iron**	**water**	**magnet**	**north**	**wind**	**electric**

Compass needles line up with the Earth's magnetic field because the needle is a small .... They point towards the magnetic .... pole. The shape of the Earth's magnetic field is the same as if there were a bar .... at its centre. Scientists think that the Earth may have a magnetic field because the core has a moving current of .... The Earth's magnetic field protects us from the solar ....

2. a. Sketch the shape of the Earth's magnetic field on the diagram of the Earth below. Add arrows to show the direction of the field. Label the poles of the magnet in the rectangular box. The solid line shows the Earth's axis.

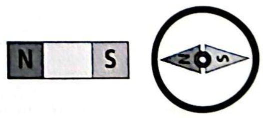


b. Describe the difference between where the solid line meets the circle and where the dashed line meets the circle on the diagram.

....

....

3. The Earth's magnetic field enables us to navigate with compasses. In this picture, a compass is shown next to a magnet. You take the compass away from the magnet and hold it in your hand. Imagine you are standing on the equator.



For each of these questions, is the north end of the compass needle pointing in front of you, behind you, to your left or to your right.

a. You face north and look down at the compass in your hand. ....

b. You turn to face west and look down at the compass again. ....

c. You turn to face south and look down at the compass again. ....

Extension

Suggest why you see auroras at the North and South poles, and not at the equator.

12.1 Hot and cold

1. Use the words from the box to complete the sentences below. Use each word once, more than once, or not at all.

energy	**longer**	**shorter**	**temperature**	**mass**	**colour**	**dissipation**

You heat a pan of water on a stove. The time it takes to heat some water depends on the

.... of water you are heating, and the .... that you want the water to reach.

It takes a .... time to heat a greater .... of water because it needs more

.... It would also need more .... to heat the same .... of water

to a higher .... Some of the energy from the stove heats the surroundings, not the water.

This is called ....

2. Explain why:

   a. It takes longer to heat a cinema to a certain temperature than a house.

   ....

   b. It takes longer to boil a pan of water than to heat a pan of water to 50 °C.

   ....

   c. Rewrite this sentence so that it is correct: 'The energy stored in the Sun is 6 million degrees C.'

   ....

3. Complete the table by ticking one or both columns for each statement.

	Energy	**Temperature**
Measured in joules.		
Does not depend on how much material there is.		
Measured in degrees Celsius.		
Increases if you heat something for longer.		

4. It takes 4200 J to raise the temperature of 1 kg of water by 1 °C.

   a. How much energy in kJ would it take to raise the temperature of 1 kg of water by 2 °C?

   ....

   b. How much energy in kJ would it take to raise the temperature of 3 kg of water by 1 °C?

   ....

Extension

It takes 4.2 kJ to raise the temperature of 1 kg of water by 1 °C, but it only takes 2.1 kJ to raise the temperature of 1 kg of cooking oil by 1 °C. Which of the statements below is true? Explain your answer.

a. It takes more energy to heat 1 kg of oil from 20 °C to 30 °C than it does to heat the same mass of water from 20 °C to 30 °C.

b. If heated for the same length of time, 1 kg of water would reach a higher temperature than 1 kg of oil. (Assume the starting temperature is the same.)

c. It takes roughly twice as much energy to raise the temperature of 1 kg of water by 10 °C as it does to raise the temperature of 1 kg of oil by 10 °C.