2 Science skills

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Essential Learnings for Chapter 2

Essential Learnings	References		
	Student book (page number)	Workbook (page number)	Teacher Edition CD (Assessment task)
Ways of working Identify problems and issues, formulate scientific questions and design investigations	Investigate 4 page 26 page 39 Experiment page 40	page 21 Exercise 10	
Select and use scientific equipment and technologies to enhance the reliability and accuracy of data collected in investigations	pages 29–36 Skillbuilder page 29 Investigate 5 pages 31–34	page 18	Assessment task 2 Measuring

QSA *Science Essential Learnings by the end of Year 9*

Vocabulary

accuracy
dependent
displacement
electronic
experiment
graph
inference
independent
instrument
meniscus
parallax
pendulum
prediction
qualitative
quantitative
temperature
thermometer

Focus for learning

Make observations of the Moon and use these observations to make inferences and predictions (page 23).

Equipment and chemicals (per group)

Investigate 4 page 26 stand and clamp, string (about 50 cm), large paperclip, blank piece of A4 paper and adhesive tape, a weight (for example a steel nut), ruler, stop watch

Investigate 5 pages 31–34 ruler, thermometer, cup of crushed ice, salt, 100 mL beaker, 100 mL measuring cylinder, electronic balance, objects for weighing, burner, matches, tripod, gauze mat, heatproof mat, stand and clamp

Experiment page 40 metre ruler, stop watch or watch with a second hand

2 Science skills

Getting Started

You and your group time travel thousands of years back in time.

Each night you look up in the sky and notice a white shining object that people call the Moon. You observe that it changes shape from a round object to a thin crescent then back to a round object.

- Work in your group and write as many inferences as you can to explain your observations.
- Is there any way to test your inferences?
- On a particular night you notice that the Moon has a very thin crescent shape. Predict the shape of the Moon 5 days later. How did you arrive at your answer?

Starting point

Summarise what has been taught to date:

- safety
- laboratory rules
- equipment
- drawing scientific diagrams
- report writing.

Use the Getting Started to encourage students to make as many inferences as they can to account for their observations.

The students may like to read the definition of an inference in the glossary at the back of the textbook or have a class discussion to come up with an explanation of what one is.

After the Getting Started discussion, have the students scan the chapter in their textbooks. Then ask them to work in groups to write a very brief, dot point summary of what the chapter is all about.

Hints and tips: developing skills

The aim of Chapters 1 and 2 is for students to develop the skills they need to become independent thinkers and to gain an objective scientific approach to the world in which they live. To become scientific thinkers, students not only need to investigate by doing, but they must also be shown how and why it is important to accurately measure and collect data, infer from observations, predict, draw conclusions, and evaluate their results. These skills lead them to become open thinkers.

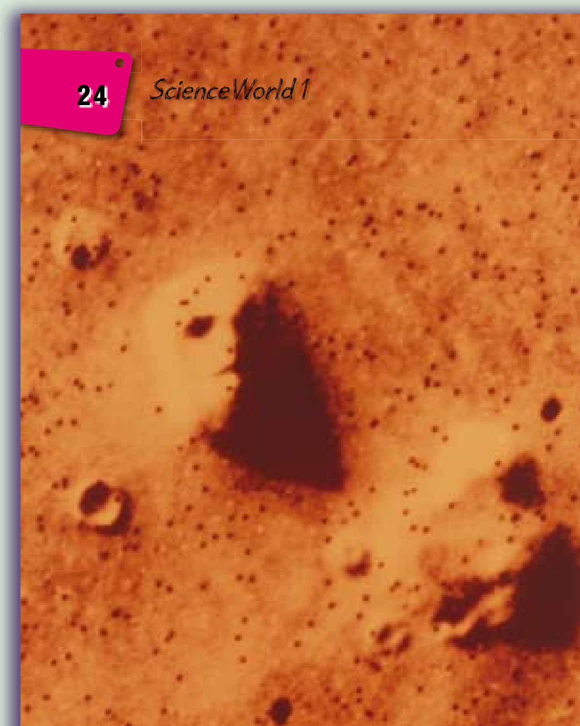


Fig 2a The 'face' on Mars taken by the Viking spacecraft in 1976. The dots corresond to areas where data was lost during transmission from Viking to Earth.

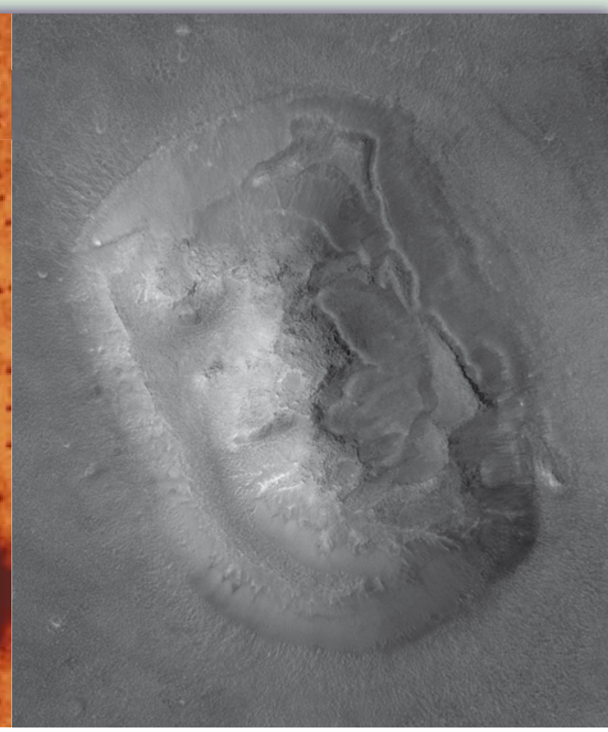


Fig 2b The 'face' on Mars taken by the Mars Global Surveyor in 2001. If you half close your eyes, you can still make out the 'eyes' and 'nose' of the 'face'.

Hints and tips

Ask students to give examples of situations that they have been in when an inference has been made correctly or incorrectly about something they have said or done. For those students who cannot think of their own examples, ask them to make up a scenario or recall a story from a television program or movie.

2.1 Inferring and predicting

Look at Figs 2a and 2b. Both are photos of the same structure on the surface of the planet Mars. Fig 2a was taken in the late afternoon in 1976. Fig 2b was taken 25 years later in 2001.

In 1976 scientists wondered about the origin of the 'face'. People thought the massive structure may have been carved by an ancient Martian civilisation. Or maybe it was formed from erosion of the Martian surface, and the face is an optical illusion.

These two statements are called **inferences**. An inference is an explanation of an observation. In 1976 these two inferences were made to explain the face, and one of them was almost certainly wrong. The photo taken in 2001 showed that the 'face' was simply a geological structure, more than likely formed by erosion. So the first inference was wrong.

Inferring is an important skill in science, and you need to remember three things about it.

Making inferences

1. You can usually make several different inferences from the same observation.
2. Observations are correct, provided the observer has been careful and honest in reporting the observations. However, inferences made from these observations can be incorrect. They can be tested by further observations.
3. It is important not to confuse observations and inferences. Otherwise you may think something is a 'fact' when it is only an 'educated guess'.

Learning experience

Ask students to work in a small group to produce a short role play for the class in which no dialogue is used when first performed. After watching the performance, ask the class to say what was happening or to suggest the possible dialogue that may have been exchanged between the characters. The group then performs the role play again, with the dialogue.

Ask the class what happens when a group of people observes the same events. Will they all make the same inference?

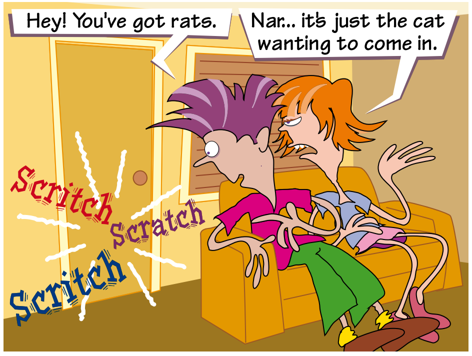


Fig 3 Different inferences from the same observation

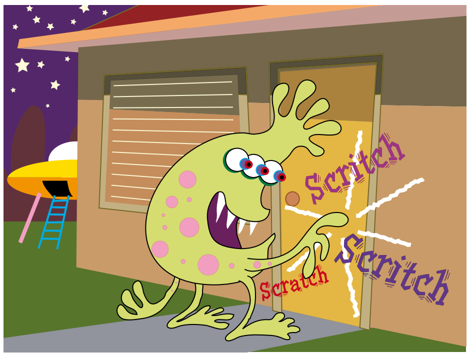


Fig 4 Inferences can be wrong.

Making predictions

Another important skill is **predicting**. This is making a forecast of what a future observation may be.

Predictions are based on your observations and what you already know. For example, if you have been observing the Moon for a number of nights you can confidently predict whether there will be a full Moon tonight. Otherwise you can only guess, and you will probably be wrong.

Skillbuilder

Averaging

In the next investigation you are going to repeat measurements and average your results. Repeating measurements improves the accuracy of observations.

For example, suppose you timed how long a model car took to go down a ramp four times: 5 seconds, 7 seconds, 8 seconds and 8 seconds. You only want one measurement, so you calculate the average.

To do this you:

- add all the measurements together, and
- divide this total by the number of measurements.The average is more accurate than if you had taken the first measurement of 5 seconds.

$$5 + 7 + 8 + 8 = 28 \qquad \text{average} = \frac{28}{4} = 7$$

The average is more accurate than if you had taken the first measurement of 5 seconds.

Science in action

Predicting planet Pluto

In the last eight years of his life, the American astronomer Percival Lowell (born in Boston 1855, died 1916) searched the night skies for Planet X—the planet he predicted had to be beyond Neptune.

Lowell based his predictions on calculations he had made observing the positions of the two planets Neptune and Uranus. He reasoned that the movement of the two planets was influenced by another planet. The predicted planet he called Planet X, since the actual name of the planet couldn't be given until the planet was discovered.

Pluto was finally discovered by Clyde Tombaugh at the Lowell Observatory in Arizona on 18 February 1930 after he studied photos of the star patterns taken in January.

Hints and tips

Reinforce the concept that predictions are based on observations as well as previous knowledge.

Homework

Further research can be done on the observations and predictions that led to the discovery of Pluto and the difficulty of observing this faraway object.

Learning experience

Allow students in small groups to count the number of small coins, washers or counters that can cover a small circle (approximately 10 cm diameter).

Collect the data from the groups, enter these in a table and calculate the average.

Ask students: 'Is the average consistent with the majority of group results?'

Learning experience

Ask students to write predictions regarding weekend weather or sporting events, eg football outcomes. Then ask them what they need to know before they make these predictions.

Discuss the differences between a prediction and a guess, and the difficulty of making predictions about events that they have no knowledge or understanding of.

Lab notes

- Steel nuts (or other objects) are used in this investigation instead of lead sinkers because of the safety issues associated with handling lead metal.
- Place a book, brick or pencil case on the base of the stand to make it more stable.

Part A

Step 4: make sure that students 'let the weight go', rather than push it.

Investigate

4 PENDULUM PREDICTIONS

Aim

Does the distance of swing or the length affect the time it takes for a pendulum to make one swing?

Materials

- stand and clamp
- string (about 50 cm)
- large paperclip
- blank piece of A4 paper and adhesive tape
- a weight, for example a steel nut
- ruler
- stop watch

Planning and Safety Check

You need to work in a small group of at least three people. Read through the method and design data tables for your results. The data tables are a very important part of this investigation. Don't start without them!

PART A
Changing the distance of swing

Method

1 Set up the apparatus as shown in the diagram.

2 Draw a line on the paper directly under the hanging pendulum. This is the *zero mark*.

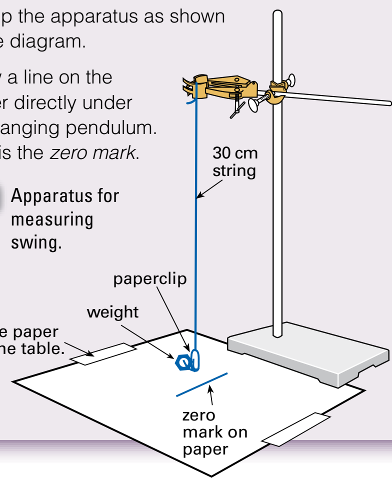


Fig 7 Apparatus for measuring swing.

3 Measure 5 cm from the zero mark and draw a line parallel with it. Hold the ruler vertically on this line.

4 Now pull the weight out so that it touches the ruler. Let the weight go and pull the ruler away. Have another person time how long it takes to swing out and back to the 5 cm mark.
Record the time in your data table.

5 Repeat this another three times.
(You can get more accurate results if you time four swings and divide by four to get the average time.)

6 Repeat Steps 3 to 5, but this time pull the weight out 10 cm.
Record your results and find the average time for a swing.
Predict what will happen if you pull the weight out 15 cm or 20 cm. Test your prediction.

Discussion

1 Suggest why you used the zero mark on the paper.

2 Why did you hold the ruler vertically just before you let the weight go?

3 Write a report of your investigation using the headings on page 13.

4 Why did you time *two* distances of swing before you made your prediction? Why not make a prediction after the first distance?

PART B
Changing the length

In this part of the investigation, keep the swing distance the same (say 5 cm), and the mass the same but change the length of the pendulum.

Shorten the string length by 5 cm. Time the swings. Then shorten the length by another 5 cm. Time the swings.

Use the results to predict what will happen if you shorten the string by another 5 cm.

Learning experience

Lead students through the following *inquire*, *respond* and *reflect* steps.

Inquire: What is a pendulum?
Where could we find or see a pendulum?
Why does it slow down?

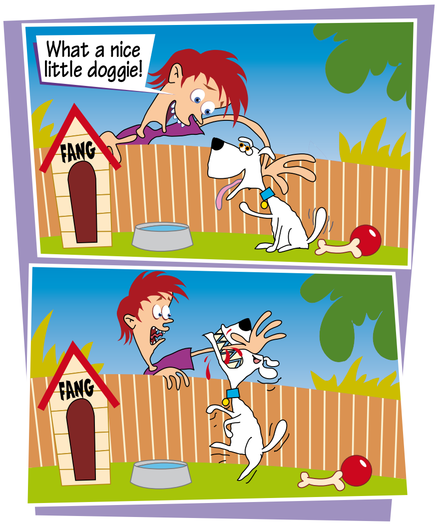
Respond: Allow students to perform the experiment (Parts A and B) and respond to the Discussion questions.

Reflect: Students should reflect on the results, coming up with inferences to explain the results. What was the effect of shortening the string?

As an extension the results for Part B could be graphed.

Check!

1 Look at the cartoon below.
   a What was the boy's inference?
   b On what observations did he base his inference?
   c Was his inference correct?



2 Explain, in your own words, the difference between an inference and a prediction.

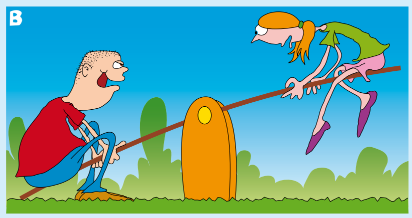
3 Which of the following are observations, and which are inferences?
   a The leaves of this plant are drooping.
   b I think this is a sugar solution.
   c The inside of the Earth is molten rock.
   d The temperature of the water is 23 °C.
   e This toy must have a magnet in it.

4 When Sven saw the burning candle below he made the following inference: that the candle must be in a draught. What observations made him think this? Use his inference to predict what might happen to the candle if it keeps burning.

5 For each situation below (A–D) decide which statement is an observation, which is an inference, and which is a prediction.

A

B



   a The left-hand end of the see-saw is lower than the right-hand end.
   b If the person on the left-hand end gets off, the right-hand end will fall.
   c One person is heavier than the other.

C
   a In 2 seconds he will drop the bar.
   b The bar is very heavy.
   c He is lifting the bar.

D
   a The minute hand is on the 6 and the hour hand is between 8 and 9.
   b The time is 8.30 am.
   c In half an hour the bell will ring.

Check! solutions

1 Here are some suggestions:
   a The boy's inferences were that the dog was friendly and that it was safe to give him a pat.
   b He observed that the dog's tail was wagging.
   c Obviously not!

2 An inference is what you think on the basis of an observation, whereas a prediction is a forecast of what you think a future observation might be.

3 a This statement is an observation.
   b This statement is an inference.
   c This statement is an inference.
   d This statement is an observation.
   e This statement is an inference.

4 The observations were that the flame, and therefore the smoke and wax, were all to the right-hand side. He could infer that the draught was coming from the left.

5A a The shaking is an observation.
   b A suggested cause is an inference.
   c That it might erupt is a prediction.

5B a This statement is an observation.
   b This statement is a prediction.
   c This statement is an inference.

5C a This statement is a prediction.
   b This statement is an inference.
   c This statement is an observation.

5D a This statement is an observation.
   b This statement is an inference.
   c This statement is a prediction.

6 a The man has observed that the object is broken.
b Two inferences are that it was broken by the boy or by the dog.

7 a An approximate prediction for day 4 would be 200.
b We can make this prediction because the counter has measured approximately 50 for each of the first 3 days.

6 Look at the cartoon below.
a What observations has the adult made?
b What two inferences could he make?

7 Cameron has a mouse in a cage. The mouse has an exercise wheel with a counter on it. Cameron wrote down the counter reading each morning, but his little brother tore the corner off his data table.
a Predict what the counter reading for day 4 should be (approximately).
b Explain how you made your prediction.

	Counter
Day 1	49
Day 2	100
Day 3	152
Day 4	

challenge

1 Make up your own example (as in Check 5) to show the differences between an observation, an inference and a prediction.
2 The weather bureau's predictions about the week's weather are sometimes wrong. Suggest a reason for this.
3 Five students were discussing the results of an experiment.
Duncan: The plants in pot C are the tallest.
Rohan: Yes, that's because we watered them more often than the others.
Cameron: No, pot C must have better soil, because we gave all the pots the same amount of water.
Jess: That could be, but I noticed that pot C was closer to the window than the others.
Gavin: Anyway, the plants in pot D certainly didn't grow very well.
Draw up a table and put the students' observations in one column and their inferences in another.
4 You look up your star sign information in the newspaper. Today it says that you will meet a dark-haired person. You will travel overseas soon, and your lucky numbers are 2, 5, 11 and 21.
Would you class this information as scientific predictions. Give a reason for your answer.
5 Look at these tracks made on the beach.

a Infer what made the tracks.
b Infer the order in which the tracks were made. Discuss your answers with others.
6 a What observations can you make about the surface of Mars on page 24?
b Is the Sun shining from the left or the right of the photo taken in 1976? Is your answer an observation or an inference?
c Which inference about the face do you think is correct? Why?

Challenge solutions

1 One example could be observing that your bicycle tyre is flat and an inference is that you could have a puncture in the tube. You could predict that if you repair the tube and pump up the tyre it will not go flat again.

2 A possible reason is:
People who work at the weather bureau are able to make very accurate observations about changes in the atmosphere. They can then use these observations to make inferences and predictions. These are not as accurate because the factors can change suddenly, and different people can make different inferences about the same data.

3 A table would look like this:

Name	Observation	Inference
Duncan	✓	
Rohan		✓
Cameron		✓
Jean	✓	
Gavan	✓	

4 No, it certainly is not a scientific prediction. A scientific prediction must be based on careful observations and inferences, not on 'star signs' (or tarot cards or tea leaves in a cup).

5 Here are some suggestions:
a From the left it can be inferred that the tracks have been made by a car tyre, a barefoot person, a bird and a person wearing large shoes.
b It is important to observe which tracks are over other tracks. On this basis the likely order is tyre, bare foot, shoes and bird.

6 Here are some suggestions:
a The surface of Mars is a red–brown colour and shows a number of small and large craters which are usually circular in shape.
b From our observations of the shadows we can infer that the Sun is shining from the top left of the photo.
c On page 24 there are two possible inferences given to explain the observation about the 'face' on the surface of Mars. In view of the detailed photo taken by 'Surveyor' in 2001 it can now be seen that the second inference is correct and that the formation has been caused by erosion rather than some ancient civilisation.

2.2 Measuring

There are two different types of observations. One is a description in words, such as the colour of a car or the smell of a flower. These observations are said to be **qualitative** (KWAL-i-tate-ive). The other type of observation involves measurements, eg a 70 kg person or the 9 cm tail of a mouse. These measurements involve numbers, and are said to be **quantitative** (KWONT-i-tate-ive).

Note that measurements are made up of a number and a unit. For example, your height might be 167 centimetres. Centimetres are the units used. Without the units the number has no meaning. A friend may tell you she has 1000 in the bank. You may think she is rich, until she says it is 1000 cents. So the unit is just as important as the number.

Some measuring instruments have digital readouts, eg digital watches. Other instruments have a scale with numbers on it and a pointer which moves along the scale. To read these instruments you must estimate the position of the pointer against the scale.

Reading a scale is simple if you follow the five steps below.

Quantity	Instrument	Common units
length	metre rule or tape measure	millimetre mm (1/1000 m) centimetre cm (1/100 m) metre m kilometre km (1000 m)
mass	balance	gram g (1/1000 kg) kilogram kg tonne t (1000 kg)
time	watch or clock	second s minute min hour h
temperature	thermometer	degree Celsius °C
volume (liquids)	measuring cylinder	millilitre mL (1/1000 L) litre L

Notes on the table

1 Use these prefixes for smaller and larger units:
- micro (μ) = one millionth
- milli (m) = one thousandth
- centi (c) = one hundredth
- kilo (k) = a thousand
- mega (M) = a million

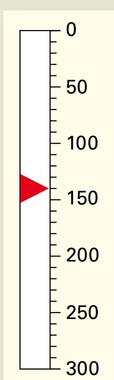
2 The volume of solids is more commonly measured in cubic centimetres (cm^3) or cubic metres (m^3). One cubic centimetre is the volume of a cube with a side of 1 cm.

3 When measuring the volumes of liquids and gases, 1 cm^3 is the same as 1 mL.

Skillbuilder

How to read a scale

1 Decide which way the scale reads—up, down, or left to right.
2 Work out what each division on the scale stands for.
3 Find the closest numbered division before the pointer.
4 Count the number of divisions from the numbered division to the pointer. Calculate their value.
5 Add the value of these divisions to the numbered division.



Example

1 The scale reads from top to bottom.
2 In between 0 and 50 there are five divisions. So each division represents 10 units.
3 The closest numbered division before the pointer is 100.
4 There are four extra divisions after the 100. Each is 10 units, which gives an extra 40 units.
5 So the scale reading is 100 + 40 = 140

Hints and tips

It is very important to emphasise the need for accurate measurements and descriptions in laboratory work.

Skillbuilder note

Ask students to use their rulers to find the sizes of different objects in centimetres and millimetres.

Learning experience

Set up different pieces of measuring equipment at stations around the laboratory. The equipment can include measuring cylinders (various sizes), beakers, scales, electronic scales, beam balances, tape measures, rulers and thermometers. Ask students to measure predetermined volumes, masses and temperatures, and to summarise what is measured with each piece of equipment.

Homework

Ask students to devise a list of everyday items that can be best measured using units that contain the following prefixes: *micro*, *kilo*, *mega*.

For example, the capacity of a water tank in a house can be measured in kilolitres.

What items are measured in cubic measurements?

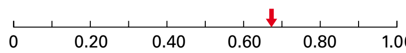
What does the prefix *nano* mean? What would you be measuring if you used a unit containing this prefix?

Hints and tips

- Explain the importance of scales.
- Explain how errors occur.
- Relate the work here to what students have been taught in maths, eg graphing skills (axis, scale).
- Relate the concepts of accuracy, estimation and errors to the students' work in maths. Ask what these terms mean in maths or other subjects. Students will see a commonality that exists between them. Students need to be aware that the skills they develop in science can be used in other subjects, and vice versa.
- When students write up their practical reports you could encourage them to include a section called 'error statement' in which they list, in point form, any possible errors that may have contributed to experimental data inaccuracies.

Estimating readings

When reading a scale you will often find that the pointer lies between two lines. In these cases you have to estimate the reading. For example, on the scale below the pointer is between the 0.6 and the 0.7 position, but not exactly in the middle. The reading is more than 0.65 but less than 0.7. It can be estimated as 0.67.



Accuracy

Remember—you cannot get a better measurement than your measuring instrument allows. All measuring instruments are accurate only within limits. Scales used on any instrument are marked off into smaller and smaller divisions. The smallest division determines the accuracy of the instrument. For example, in Fig 15 (bottom left), thermometer B can measure the temperature of the water more accurately than thermometer A.

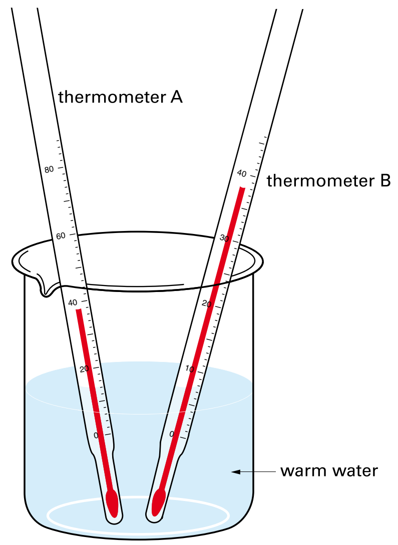


Fig 15 Why does thermometer B give a more accurate reading than thermometer A?

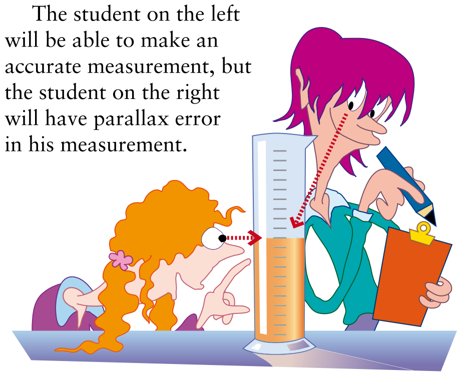
Errors

It is difficult to say any measurement is exact. Mistakes or errors occur in all measurements. These errors can occur when you make a mistake reading a scale or writing down the measurement. They can occur because an instrument is not working properly or because you are not using it correctly.

Parallax error

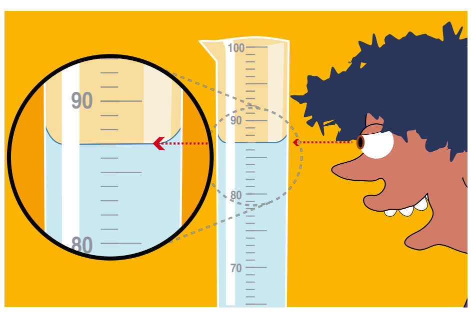
Parallax error occurs when you don't look straight over the pointer. You need to look square on to a measuring instrument.

The student on the left will be able to make an accurate measurement, but the student on the right will have parallax error in his measurement.



Reading the bottom of the meniscus

To avoid errors when measuring liquids in measuring cylinders, always read the bottom of the **meniscus** (men-IS-cus)—the curved water surface. Keep your eye level with the meniscus. The volume of water below is 87 mL, not 88 mL.



Learning experience

After discussing the concepts on this page, allow groups or the whole class to come up with some basic rules to eliminate errors, for example:

- Always measure liquids at eye level.
- Keep the bulb of the thermometer in the liquid when you are measuring temperature.

Once the group or class has agreed on a set of rules, make A4 posters to hang around the room.

Investigate

5 MEASURING THINGS

Aim

To measure length, temperature, mass, time and volume accurately.

Planning and Safety Check

Make a list of the equipment you will need for each part of the investigation. You will need to design data tables for some parts.

PART A Length

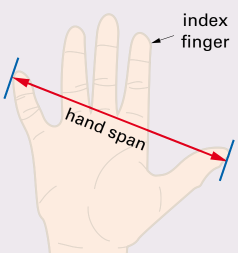
Is the length of the index finger and the hand span of your right hand the same as for your left hand?

Your data table should look something like this:

	length of index finger	hand span
left hand		
right hand		

Suggest how you could improve the accuracy of your results.

Are your hands smaller, larger or about the same size as the average for the hands of other people in the class? (Give measurements.)



PART B Temperature

What is the temperature of the following?

- **a** the air—in the shade and in the sun
- **b** water—from cold and hot water taps
- **c** crushed ice
- **d** crushed ice with several spoonfuls of salt mixed with it
- **e** inside a refrigerator and inside a freezer
- **f** under your armpit

Record your measurements in a data table like the one below.

Location/object	Temperature (°C)

Compare your measurements with those made by other students. If there are any differences it may be wise to check for errors.

Hints for using thermometers

1. Thermometers break easily, so take special care with them. Do not roll them or drop them. When putting them away, place them in their special tube or box. If you break a thermometer, report it to your teacher immediately.
2. The bulb of the thermometer has to be put into the substance whose temperature you are measuring, and left there while you read the scale.
3. Don't hold the bulb of the thermometer, as this changes the temperature.
4. You can't get a reading straight away. Wait until the red alcohol (or silver mercury) column stops moving.
5. Before reading the thermometer, turn it so that the scale is facing you.

Hints and tips

Ensure that students have read all parts of the investigation before they start. Students should also have prepared data tables. This will allow for easier recording of information and less error.

Lab notes

Recall safety and laboratory rules from Chapter 1. Also recall how to write up investigations using the standard headings.

Make sure all students read the Planning and Safety Check. Check their lists of equipment and data tables for each part.

Part A

- This is a good opportunity to introduce new technology if possible, eg infra-red thermometers, ultrasonic tape measure.
- Emphasise the need to reduce error here, eg by carefully measuring from the base of the index finger to the tip.

Part B

- There are significant health risks in using mercury thermometers and school policies on this will vary.
- Make sure that the thermometer has at least a minute to reach a steady temperature. Emphasise the need to view it horizontally to avoid parallax error.

Group data can also be collected. Ask students to share their answers and devise another table where all data can be shown.

Homework

Ask students to go home and use their kitchen scales to measure the masses of some items in the pantry. How different are the measured masses from what the labelling says? If any item is different, they should try to explain why. Can they work out the difference as a percentage?

Lab note

Part D

There is still a place for using displacement cans to measure the volume of large or irregular solids by displacement. Don't forget to discuss sources of error and accuracy.

Hints and tips

Sometimes measuring liquids in a measuring cylinder is difficult for students, particularly as this may be their first experience in using one. Adding a few drops of food colouring to the water will not only make it easier to see the meniscus but will also make it more interesting for students.

Remind students that it is best to measure the volume in a beaker or measuring cylinder by leaving it on the bench. Students should bend down to get their eyes level with the meniscus. This will allow for a more accurate reading and reduce spillage.

After they become more experienced at reading the scales, students can hold the beaker or measuring cylinder up to eye level in their hand.

PART C
Volume of a liquid

How can you accurately measure the volume of a liquid?

1 Use a beaker with graduations on the side to measure exactly 50 mL of water.

2 Pour the water into a 100 mL measuring cylinder.

Record the volume as accurately as you can. (Remember to read the volume at the botttom of the meniscus.)

Are the two readings the same? Suggest reasons for any differences.

Why are your volume measurements more accurate when using a measuring cylinder than when using a graduated beaker?

PART D
Volume of a solid

How can you measure the volume of an irregular solid?

For regular solids like cubes and spheres, you can find the volume by measuring the sides or diameter and using a maths formula.

For irregular solids like a stone, you can find the volume using a method called *displacement*.

The diagrams below show you how to do it.

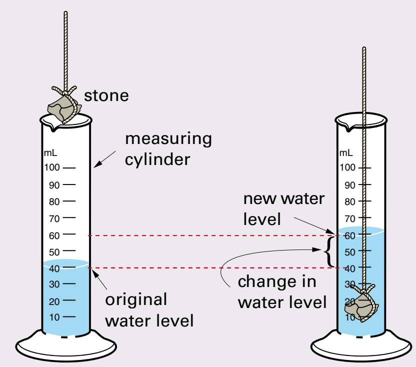


Fig 20 The volume of an object can be measured by submerging it in water in a measuring cylinder. What is the volume of this stone?

Find a stone or other irregular solid and find its volume.

try this

Try to solve these two problems:

- How would you find the volume of a large stone that will not fit into a measuring cylinder?
- How would you find the volume of an irregular piece of styrofoam? (Styrofoam floats in water!)

PART E
Mass

How can you measure the mass of an object? The most common balance in school laboratories is the electronic balance with a digital readout.

Method

1 Make sure the balance is on a firm surface such as a lab bench. The reading can be affected if the balance is unsteady.

2 Turn on the balance and wait until the screen reads 0.00 g. If it doesn't, press the zero key.

3 Place an object on the pan and wait until the reading is steady.
Record the mass of the object.

4 Weigh two or three other objects.
Record the mass each time.

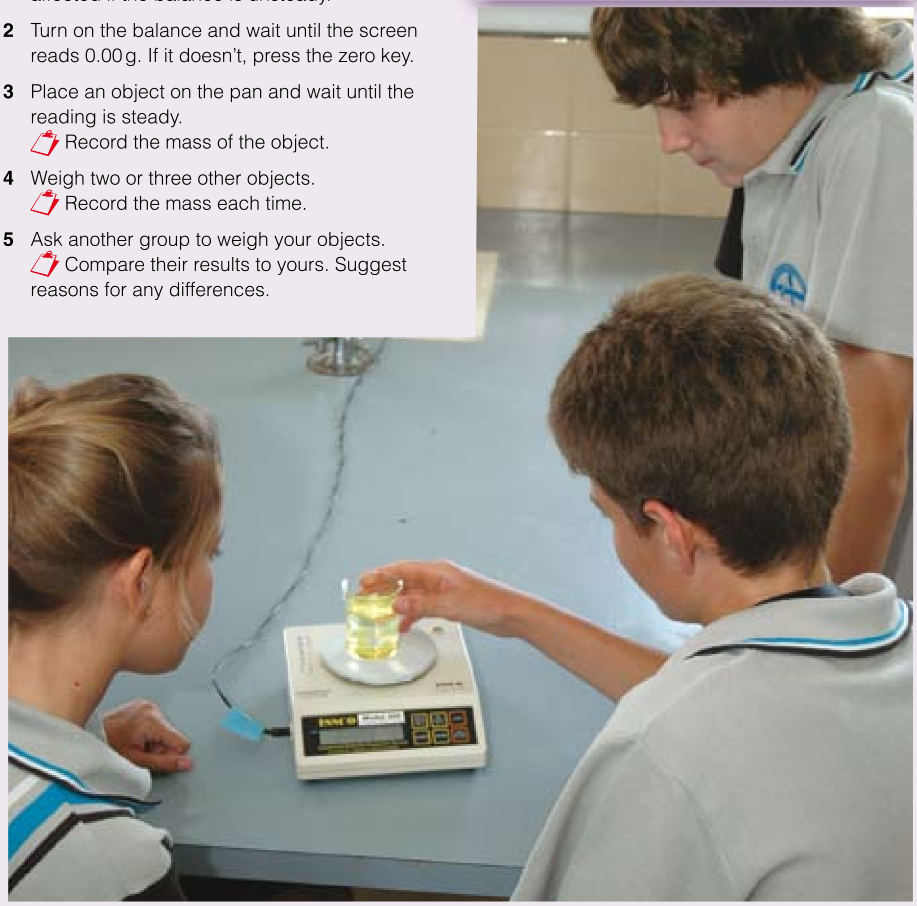
5 Ask another group to weigh your objects.
Compare their results to yours. Suggest reasons for any differences.

try this

When measuring the masses of laboratory chemicals, you should always use a container. Knowing this, solve the following measurement problems.

1 How can you use a beaker and measuring cylinder to find the mass of 100 mL of water?

2 How can you measure out exactly 1 g of a white powder?



Lab note

Part E

Some balances will have a 'tare' key. If they do, it is worth teaching students how to use it when they measure the mass of liquids, or powdered or crystalline solids such as sugar or salt.

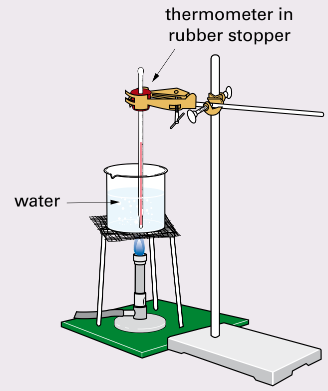
Hints and tips

Small movements around the bench or leaning on the bench may cause errors in the balances. Minimise movement around the room where possible when using electronic and beam balances.

PART F
Time and temperature

How hot does water get when you boil it?
Collect the equipment you need to set up the apparatus shown. Add 100 mL of water to the beaker.
Light the burner. Heat the water and measure the temperature every minute.

- Record your results in the data table you designed in the Planning and safety check.
- What pattern can you see in the results?
- Keep your results. You will use them on page 38.



Check!

1 Copy and complete the following sentences:
- **a** Every quantity has a ______ of measurement.
- **b** An instrument for measuring mass is called a ______.
- **c** The curved surface of a liquid is called a ______.
- **d** For measuring volumes, a measuring cylinder is more ______ than a beaker.
- **e** Measurements made during an investigation should be recorded in a ______ table.
- **f** An observation which does not contain a measurement is said to be ______.
- **g** Parallax ______ occurs when you don't look straight over the pointer on a measuring instrument.

2 Write five correct sentences by joining words from each of the columns in the table—large lengths are measured in kilometres.

Very large Large Small Very small	lengths volumes	are measured in	mega kilo milli micro	metres litres

3 What unit does each of these symbols represent?
- **a** mm
- **b** m
- **c** s
- **d** mL
- **e** cm^3
- **f** kL

4 Which of the following observations are quantitative?
- **a** The gas has an odour like rotten eggs.
- **b** This soft drink can contains 375 mL.
- **c** The ant has six legs.
- **d** This rock contains large pink crystals.
- **e** The magnet did not attract the nails.
- **f** The maximum temperature was 28 °C.
- **g** The water froze overnight.
- **h** The fizzing lasted about 2 minutes.

Lab notes

Part F
- Make sure you start with water at room temperature.
- Ensure that the tip of the thermometer is about 1 cm from the bottom of the beaker.

Hints and tips

As an extension, students can graph their results using different axis scales to understand the relationship between axis scale and the size of the graph. They could also look at the way scales are marked on equipment.

Assessment task

Assessment task 2: Measuring can be completed at the end of this section.

Check! solutions

1 Check your answers:
- a Every quantity has a **unit** of measurement.
- b An instrument for measuring mass is called a **balance**.
- c The curved surface of a liquid is called a **meniscus**.
- d For measuring volumes, a measuring cylinder is more **accurate** than a beaker.
- e Measurements made during an experiment should be recorded in a **data** table.
- f An observation which does not contain a measurement is said to be **qualitative**.
- g Parallax **error** occurs when you don't look straight over the pointer on a measuring instrument.

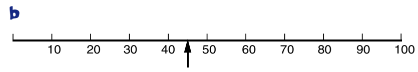
2
- a Very large lengths are measured in kilometres.
- b Large lengths are measured in metres.
- c Small lengths are measured in millimetres.
- d Very small lengths are measured in micrometres.
- e Very large volumes are measured in megalitres.

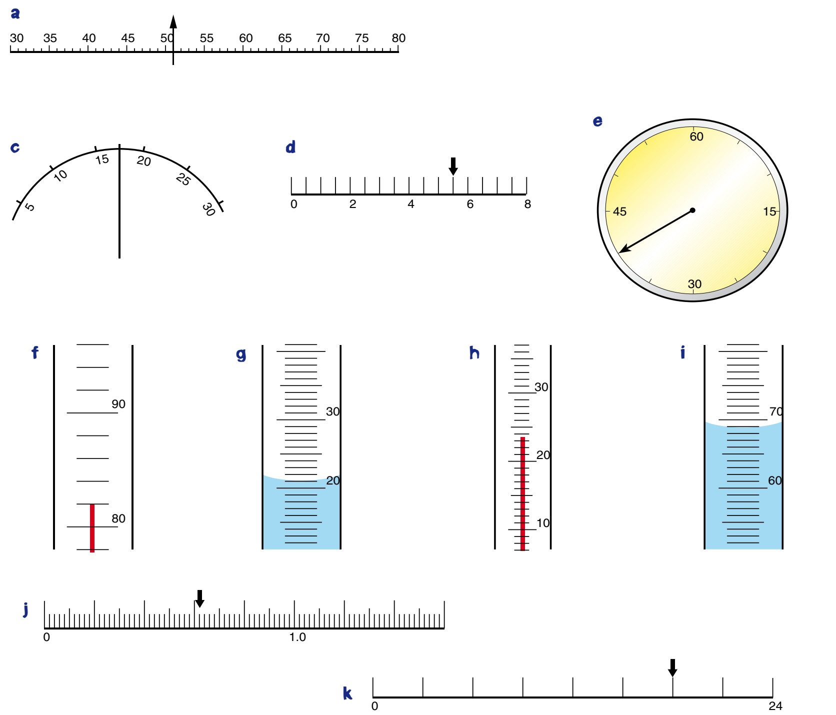
You can probably think of a few more.

3
- a millimetres
- b metres
- c seconds
- d millilitres
- e cubic centimetres
- f kilolitres

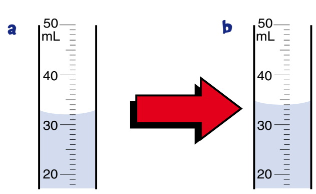
4 A quantitative observation is really a measurement and will usually include numbers and units. The following are quantitative: **b, c, f, h**.

5 Reading a scale is a skill that requires a lot of practice. Read the scales on this page. Some you will need to estimate.

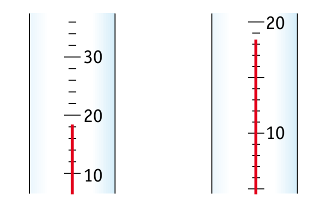




6 A measuring cylinder is filled with water to the level shown in **a**. A small object is then dropped into the cylinder and the water level rises to that in **b**. What is the volume of the object?



7 The two thermometers below were used to measure the temperature of tap water. Which one would give a more accurate measurement? Why?



5 The correct readings (without any units) are:
- a 51
- b 45
- c 17
- d 5.5
- e 40
- f 82
- g 21
- h 23.5
- i 69
- j 0.62
- k 18

6 The difference in the volume of water is 2 (34 – 32) and the units are likely to be millilitres (mL).

7 Thermometer B is more accurate because each mark represents 1 degree, whereas with thermometer A each mark represents 2 degrees.

8 a The mass of the water is the difference between these two figures: 306 g
b The total mass would be the sum of the beaker and the water: 212 g

9 The conversions are:

a	0.25 m	e	10 800 s
b	3500 mL	f	7 min 10 s
c	3.6 km	g	3500 W
d	24.5 cm	h	20 microseconds (μs)

10 The main errors are:
a The boy is holding the bulb of the thermometer.
b The girl with the mouse is missing out on measuring part of the tail and should hold its tail on the measuring scale.
c The girl is not looking at the level of the top of the water and has made a parallax error (see page 30 of the textbook).
d The tape should be stretched out tightly and held closer to the plant.

8 Scott found the mass of a beaker of water. He then tipped out the water and found the mass of the empty dry beaker. Here are his results:

full beaker 418 g

empty beaker 112 g

a What was the mass of water in the beaker?
b What would the total mass be if Scott added 100 mL of water to the empty beaker?
(Hint: 1 mL of water has a mass of 1 g.)

9 Convert the following from one unit to another.
a 250 cm to m
b 3.5 L to mL
c 3600 m to km
d 0.245 m to cm
e 3 h to s
f 430 s to min
g 3.5 kW to W
h 0.00002 s to μs

10 Look at the cartoons below. For each case say what error in measurement the student has made.

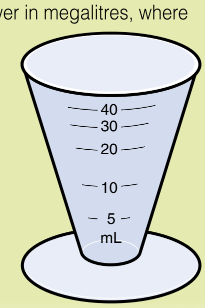
challenge

1 Ann and Peter are driving to the coast. Ann is driving and Peter (in the passenger's seat) says she should slow down because she is doing more than 100 km/h. Ann says he has made a parallax error and she is doing less than 100 km/h. What does she mean?

2 At the delicatessen section of the supermarket, you order a large container of olives. The sales assistant places the plastic container on the electronic balance, presses the TARE button, fills the container full of olives and weighs the container again.
What does the TARE button do? Were you charged for the mass of the container?

3 A swimming pool is 50 m long, 20 m wide, 1 m deep at the shallow end and 2 m deep at the deep end. What volume of water is needed to fill it? (Give your answer in megalitres, where 1 mL = 1000 m^3.)

4 Suggest why some medicine glasses are this shape.



Challenge solutions

1 Because Peter is looking at the speedometer at an angle, he gets a higher reading than Ann who is looking straight on.

2 The word 'tare' means that the scales have been re-set to zero even though there may be an empty container on them. This means that if it is then filled with food like olives it will only record the weight of the olives, which is called the nett weight.

3 The volume is 50 m × 20 m × 1.5 m = 1500 m^3. The usual way to express volumes of liquids is as litres, so it would be 1.5 million litres or 1.5 megalitres (1 m^3 = 1000 L).

4 One suggestion is that the narrower the glass at the bottom, the further apart the graduations will be so the more accurately the medicine can be measured, particularly with smaller volumes.

2.3 Displaying data

So far in this book you have learned and practised a number of science skills. For example, you have:

- made and recorded observations
- devised data tables for these observations
- made inferences from observations
- made predictions from observations, inferences and your experience.

As well as these skills, you have learned how to use laboratory equipment, read a scale, calculate averages and reduce errors.

Another important part of an investigation is displaying your data in a graph, diagram or chart.

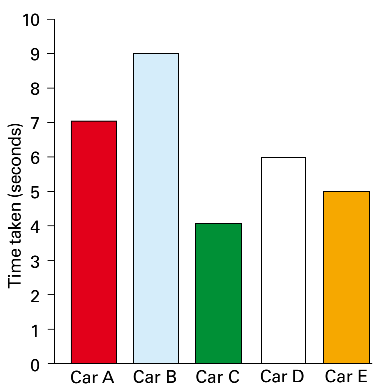
Bar graphs

Suppose you were investigating how long it took different model cars to travel down a wooden ramp. Here are the results:

Model car	A	B	C	D	E
Average time to travel down ramp (seconds)	7	9	4	6	5

A very useful way of comparing data is to draw a *bar graph* (sometimes called a bar chart). In this case, the time (in seconds) is on the vertical or *y*-axis of the graph, and the type of car on the horizontal or *x*-axis.

Time taken for cars to travel down ramp



Line graphs

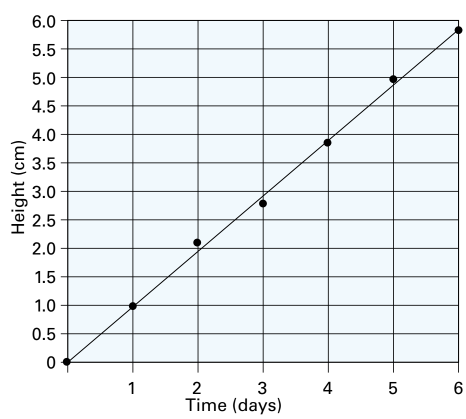
Sometimes you want to show the relationship between two things being measured. In this case you would draw a line graph of the data. For example, a group of students was investigating the growth of seedlings. They measured the height of the seedlings every day. Here are their results:

Time (days)	Height (cm)
0	0
1	1.0
2	2.1
3	2.8
4	3.8
5	5.0
6	5.8

Before you start on your line graph, you have to decide which measurement goes on which axis. On a line graph the *independent* measurement goes on the horizontal axis. The *dependent* measurement goes on the vertical axis.

In this case, time is the independent measurement, and height is the dependent measurement. Height is dependent because the height the seedlings grow **depends** on how many days (time) you let them grow.

Seedling growth over six days



Computer programs such as Microsoft Excel can be used for drawing graphs. Open the ICT skillsheets on the CD to see how this can be done.

Working with technology

Hints and tips

Before starting the last two sections, it may be a good idea to quiz students on all that has been taught on investigations, observations, inferences, predictions and scientific report writing. Test their understanding of concepts as well as the spelling of words.

At this point you may want to explain what a line of best fit is using the **Seedling growth** graph as an example. Alternatively, you may prefer to wait and cover this with the Skillbuilder on page 85 in Chapter 4.

Recall the rules for drawing graphs:

1. Select a suitable scale and make sure the markings on the axes are evenly spaced.
2. Label the axes.
3. Mark each point in pencil and draw the line in pencil.
4. Give the graph a suitable title.

Homework

Ask students to collect various types of graphs from magazines, newspapers, reports and pamphlets. Explain why a particular graph was used to display the data and suggest how another type of graph could have been used instead.

Check! solutions

1 a The aim of the experiment was to compare the melting points of several solids.

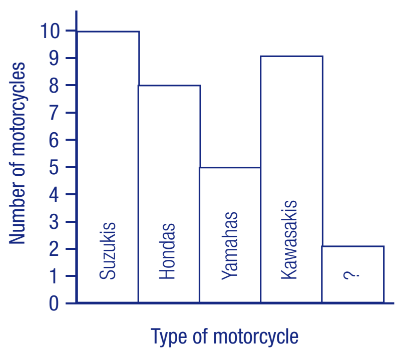
b The experiment was done by putting each of the solids into a beaker with a thermometer and measuring the temperature when the solid melted to form a liquid.

c From the results of this experiment we can conclude that the ascending order of melting points is: ice, wax, hypo and mothballs.

2 The data table could be constructed like this:

Mouse number	1	2	3	4	5
Mass (grams)	155	163	180	135	149

3



4 a 141 cm

b 146 cm

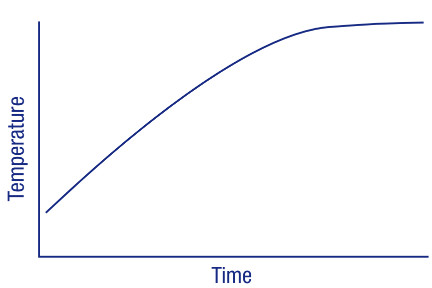
c 143.6 cm

d Duncan, Darryl and Vanessa.

e We can conclude that on average, in this group, boys are about 5 cm taller than the girls.

5 Ella has to decide whether the independent variable is continuous, in other words whether she could predict a value for a point in between the groups. In the examples in the book (page 37), the answer for the cars would be NO and for the growing plant would be YES.

6 a The graph should look something like this.



Obviously the times and the temperatures will be different for different people.

b The independent variable is the time, since you deliberately change it and the temperature of the water depends on it.

Check!

1 The results of an investigation are shown in the data table below.
   a Write down an aim for the investigation.
   b Say how you think the investigation was done.
   c Write a conclusion for the investigation.

Solid	Melting point (°C)
ice	0
mothballs	80
wax	44
hypo (photographic fixer)	48

2 Philippa wrote this in her science notebook:

We measured the mass of five mice. The first mouse had a mass of 155 grams. The second mouse measured 163 grams. The third mouse measured 180 grams; the fourth 135 grams; and the fifth mouse had a mass of 149 grams.

Record this information in a data table.

3 Adam and Duncan observed the motorbikes passing the school in one hour. They saw 10 Suzukis, 8 Hondas, 5 Yamahas, 9 Kawasakis, and 2 which they could not identify. Draw a bar graph of this data.

4 Use the data table to answer the questions below.

Student	Height in cm	Student	Height in cm
Belinda	133	Emma	136
Robert	138	Paul	142
Duncan	157	Vanessa	156
Darryl	160	Chadi	135
Katherine	140	Annalissa	139

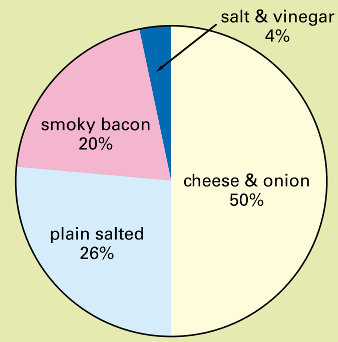
   a What is the average height of the girls?
   b What is the average height of the boys?
   c What is the average height of the 10 students?
   d Which students are taller than the average?
   e What conclusion can you make from these results?

5 Ella recorded data from an investigation. She is unsure whether to draw a bar graph or a line graph. Explain what she should do and why.

6 Look at your results in Investigate 5 Part F.
   a Use your results to plot a line gragh.
   b Which measurement is the independent variable? Give a reason for your answer.

challenge

1 Fifty students were asked: what is your favourite flavour of potato crisps? The results were recorded in a pie chart (sector graph) as shown. Convert the pie chart to a bar graph, showing how many students preferred each flavour. Suggest a reason for collecting this data.

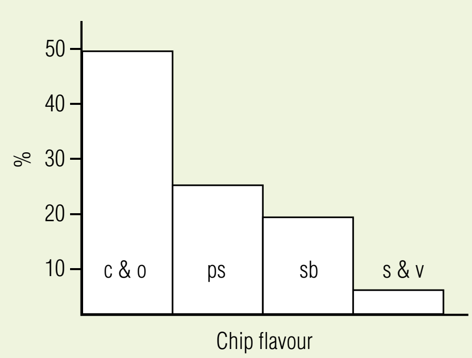


2 The table below shows the times of high tide at a beach.

	Mon	Tue	Wed	Thurs	Fri
am	6:10	7:00	7:50	8:40	
pm	6:35	7:25	8:15	9:05	

   a What pattern can you see linking the times of the high tides?
   b Predict the times of the two high tides on Friday.

Challenge solutions



1 A reason for collecting this data might be so that the school canteen will know what to order.

2 a The pattern is that the high tides are 50 minutes later every day and that the evening high tide is 12 hours and 25 minutes after the morning tide.

b The predicted high tides for Friday are 9.30 am and 9.55 pm.

2.4 Experimenting

You have probably heard about scientists doing experiments and then wondered what the difference is between an *experiment* and an *investigation*. These terms mean much the same thing—scientists carefully planning laboratory or field work to show that something is true (or not true).

An **experiment** always involves designing tests to answer a question or solve a problem. For example, when you cut an apple and leave it for a few hours, the white flesh inside starts to turn brown. You have an idea that it is something in the air that causes the apple to go brown. So your aim might be: ***If a cut apple is covered to exclude air, it won't go brown.*** You then design tests to show whether this is true or untrue.

Designing experiments

The important thing to remember about designing experiments is that your aim must be a statement or question that is able to be tested. For example, the statement ***Plants grow better in white light than blue light***, is easy to design tests for.

When planning experiments and writing reports, you use the same headings as you did for the report on page 13. In other words, you start with a *title*. Then write an *aim*, list the *materials* you will need and write the *method* so that others can follow it. You then collect *results*, write your *discussion* and finally your *conclusion*.

On the next page you can practise designing an experiment.

Activity

For each of the parts below, write an aim that could be tested in an experiment.

- **a** Dark coloured clothes seem hotter in summer than light coloured clothes.
- **b** My bike's brakes seems to work better on a dry day than on a rainy day.
- **c** When you pull the plug out of the bath, water rushes down the hole and creates a whirlpool motion. Does it always go in the same direction (ie clockwise or anti-clockwise)?
- **d** My hot chocolate drink in a glass cup seemed to stay hotter longer than my friend's hot chocolate drink in a paper take-away cup.
- **e** Seeds seem to germinate faster on hot days in summer than cooler days during winter.
- **f** I find that raw sugar takes longer to dissolve in a cup of tea than white sugar.

Homework

Ask students to find out who, other than scientists in laboratories, conducts experiments. What sort of experiments are carried out? Why is it important that these experiments are carried out?

Hints and tips

Remind students of the main headings when writing up an experiment:

- Title
- Aim
- Method
- Material
- Results
- Conclusion

See Chapter 1 page 13.

Review the rules for drawing diagrams of scientific equipment.

- Use a pencil and a ruler.
- Draw the equipment in two dimensions.
- Draw the equipment to scale.
- Do not use shading.

See Chapter 1 page 4.

Activity note

To extend this activity, students could hold a group discussion and then write a brief plan of how an experiment for any of the six statements could be carried out.

Hints and tips

Students may have trouble with the meaning of the terms *experiment* and *investigation*. Throughout the *ScienceWorld* series, experiments are usually open-ended laboratory activities in which students have to plan how they will test a particular problem or question. In most investigations, on the other hand, the aim, method and discussion are given for students to follow.

Lab notes

- Reaction time is a term not well understood, especially in newspaper and other media reports. Make sure that students understand that it means the time between a stimulus and a response.
- The distance fallen (d in cm) can be converted to a time using the formula $t = 0.045 \times \sqrt{d}$
- Another method of measuring reaction time is to start two stopwatches by touching the buttons together and then using the stop sound of one as the stimulus to turn the other one off. Subtracting the times will give a very accurate reaction time.
- There are also websites that can be used to measure reaction time, but this is not really 'measuring' as intended in this activity.

Hints and tips

Students can use the CD in their textbook to access the ICT skillsheet *Getting started with Microsoft Excel*. This tutorial will help them draw graphs using the computer.

Experiment

TESTING REACTION TIME

The problem to be solved

How quickly can you catch a falling ruler?

When a person holds a ruler between their thumb and fingers and lets it go, they see it fall and then their fingers quickly try to catch it. You can measure a person's reaction time by finding out how far the ruler fell before it was caught.

The problem in this experiment is to find out which of your senses—sight, hearing or touch—reacts fastest to catch a falling ruler.

Designing your experiment

1 **Setting up the test**
Have one person hold a metre ruler (a 50 cm one can be used) between another person's thumb and fingers. Make sure the 0 cm mark is level with the top of their thumb and fingers.

2 **Testing the senses**
Drop the ruler and measure how far it fell before it was caught. Do this 4 times and average the results.
Repeat the test but this time blindfold the person or ask them to shut their eyes. They have to catch the ruler after they hear you shout NOW or GO. To test a person's touch reaction, tap them on their arm or hand.

3 **Designing tests**
Work in a small group and design the tests to solve the problem. Make sure you write a draft of your method, list the materials needed and discuss safety issues. *Show this to your teacher before you start.*

4 **Plotting graphs**
Include bar graphs of the results in the Results section of your report.

5 **Writing your report**
Write a full report of the experiment. Include diagrams where appropriate. You could also take a digital photo of the test to include in your report.

Working with technology

You could write your report using a word processor program like Microsoft Word. You can also draw data tables and plot graphs using this computer software. Open the ICT skillsheets on the CD to see how this can be done.

Learning experience

Students may need some ideas on how to get started in this experiment. A class brainstorming session may be useful. Make sure all groups show their draft plan to you before they start.

As an extension for fast finishers, ask them to suggest another problem which can be tested using their senses.

MAIN IDEAS

Copy and complete these statements to make a summary of this chapter. The missing words are on the right.

1 An inference is an ______ of an observation. The inference may or may not be correct.
2 It is important not to confuse observations and ______.
3 ______ is making a forecast of what a future observation will be, based on past observations.
4 Measurements are ______ observations, and are made up of a number and a ______.
5 The results of an experiment can be recorded in a ______, and displayed in graphs.
6 An ______ is an investigation that involves designing tests to answer a question or solve a problem.
7 A good report of an experiment has the following headings: ______, aim, method, results, discussion and ______.

conclusion
data table
experiment
explanation
inferences
predicting
quantitative
title
unit

Try doing the Chapter 2 crossword on the CD. Working with technology

REVIEW

1 Maria walked into her bedroom. This is what she saw.

Which of the following are observations, and which are inferences?
a My new coat has been ripped.
b The flower vase has been broken.
c That awful dog has done this.
d Oh! Marks on my bedspread!

2 For each statement below, decide whether it is an aim, a conclusion, an observation or a prediction.
a Which magnet is stronger?
b Magnet B will pick up more iron filings than magnet A because it is bigger.
c Magnet A picked up 10 paperclips, and magnet B picked up 15.
d Magnet B is stronger than magnet A.

Main ideas solutions

1 explanation
2 inferences
3 predicting
4 quantitative, unit
5 data table
6 experiment
7 title, conclusion

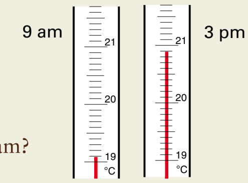
Review solutions

1 a observation
b observation
c inference, since she didn't actually see the dog do it
d observation

2 a aim
b prediction
c observation
d conclusion

REVIEW

3 The temperature was measured at 9 am and at 3 pm, as shown.

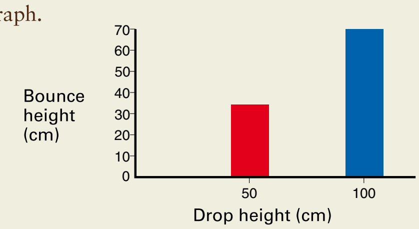


a What was the temperature at 9 am?
b What was the temperature at 3 pm?
c What was the difference in temperature between 9 am and 3 pm?
d What was the average of the two temperatures?

4 Six students each measured how long it took a tablet to dissolve in water. They used water at different temperatures. The table below shows their results.
a Sort out the data, and see if you can see a pattern in it. Write a generalisation (see page 13) for the results.
b Draw a graph of their results. Why is it better to draw a line graph for these results?

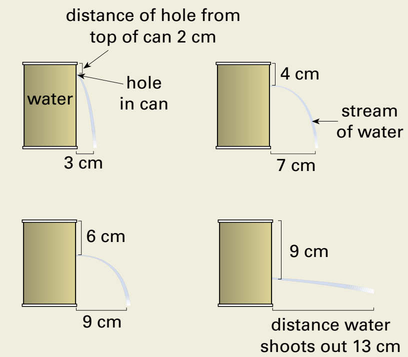
Student	Temperature of water (°C)	Dissolving time (seconds)
Cory	30	22
Katherine	25	24
Darryl	35	20
Duncan	40	18
Emma	20	27
Belinda	45	16

5 Heidi has dropped a ball from two different heights, and measured how high it bounced each time. She recorded her results in a bar graph.



a Predict how high the ball will bounce if she drops it from 75 cm onto the same surface.
b Predict the bounce height for a drop height of 200 cm.

6 Brent did an experiment and made these sketches to show his results.



a Write a report of Brent's experiment. Make sure you include the title, aim, materials, method, results (including a data table), discussion and conclusion.
b Would it be better to draw a bar graph or a line graph of the results? Explain the reasons for your choice.
c Predict what would happen to the stream of water if the hole was 12 cm from the top of the can.

LAB REVIEW

Do this in pairs, with your partner checking your results. Discuss reasons for any differences in the measurements, and repeat them if necessary.
1 Measure the temperature inside and outside the laboratory. What is the difference?
2 Work out an accurate way of measuring the volume of a drop of water from a dropper. Then do it.

Check your answers on pages 299.

3 a 19.1 °C
b 20.9 °C
c 20.9 – 19.1 = 1.8 °C
d average temperature $= \frac{19.1 + 20.9}{2}$

$= \frac{40.0}{2} = 20\,°C$

4 The pattern is more obvious if you reorganise the data table as shown below:

Temperature of water (°C)	Dissolving time (seconds)
20	27
25	24
30	22
35	20
40	18
45	16

As the temperature increases, the dissolving time decreases, or tablets dissolve more quickly at higher temperatures.

5 a Just over 50 cm, halfway between 35 cm (for a drop height of 50 cm) and 70 cm (for a drop height of 100 cm).
b 140 cm (If you double the drop height, the bounce height will probably double also.)

6 a *Leaking can*

Aim: To find out what effect the depth of water above the hole has on how far the water shoots out from the can.

Materials: 4 cans, 1 nail to punch holes

Method: I used four identical cans, and punched a hole in each one a certain distance from the top. I then filled each can with water and measured how far the stream of water shot out of each hole.

Results:

Distance of hole from top of can (cm)	Distance water shoots out of hole (cm)
2	3
4	7
6	9
9	13

Discussion: The results are about what you would expect.

Conclusion: As the distance of the hole from the top of the can increases, so does the distance the water shoots out.

b A line graph is better because you want to show the relationship between the distance of the hole from the top of the can and the distance the water shoots out.

c About 17 cm (If the water shoots out an extra 4 cm going from a 6 cm hole to a 9 cm one, then you might expect another 4 cm increase going from a 9 cm hole to a 12 cm one.)

Lab review

Temperature—see page 31 Part B
Volume of drop—use a small measuring cylinder to find the volume of 10 drops. Then divide by 10 to find the volume of 1 drop.