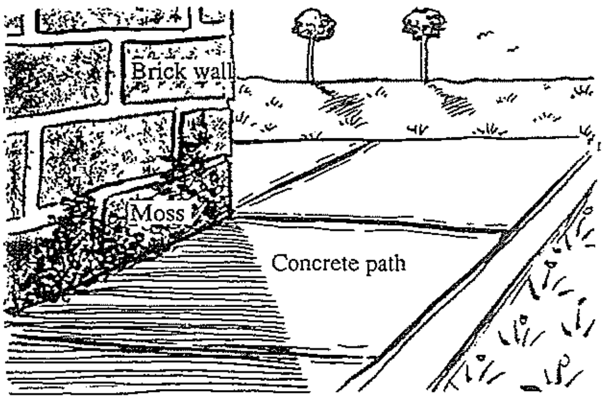


Figure 1.8

From the last activity you will have found out that even when people make the same observation they can explain it in different ways. It is possible to make many inferences from the same observation.

Often it is necessary to make more observations in order to choose the best inference.

Worked example

A student noticed moss growing on the shady side of the brick wall of her classroom but no moss growing on the concrete path next to it. The student asked her friends about this and here are the inferences they made.

1. **The path gets more sunlight than the wall.**
2. **The moss has been washed off the path by the school's cleaner.**
3. **The moss would grow on the path but it gets worn away by people walking on it.**
4. **Moss doesn't grow well on concrete because the concrete contains something that kills the moss.**

All these inferences sound reasonable. To decide which inference is the best one, the students made some more observations.

(a) Moss was found growing on a brick path.
(b) The brick wall got more sunlight than the path.
(c) The school's cleaner said it was not part of his job to clean the outside paths.
(d) No concrete had moss growing on it anywhere in the school yard.

With this information the students decided that the best inference they had made was that there was something in concrete that killed the moss.

They knew, however, that their best inference was not necessarily the right answer. They would need to investigate this problem further before they could be sure.

PART A — DEAD FISH

Dead fish are found floating in a local stream. Here are three inferences made about this.

1. The fish were dumped into the river by a local resident angry over the location of a new rubbish dump.
2. The fish were poisoned by pesticide sprays drifting into the stream from the nearby apple orchard.
3. The fish died when the water temperature increased due to the waste water released by the factories.

(a) Copy Table 1.3 into your workbook.
(b) Write down two inferences of your own in the table next to 4 and 5 that could explain the dead fish.
(c) For each inference write an observation in the table that would support or help to prove it correct.
(d) For each inference write an observation in the table that would disprove it.

The first one has been done for you as an example.

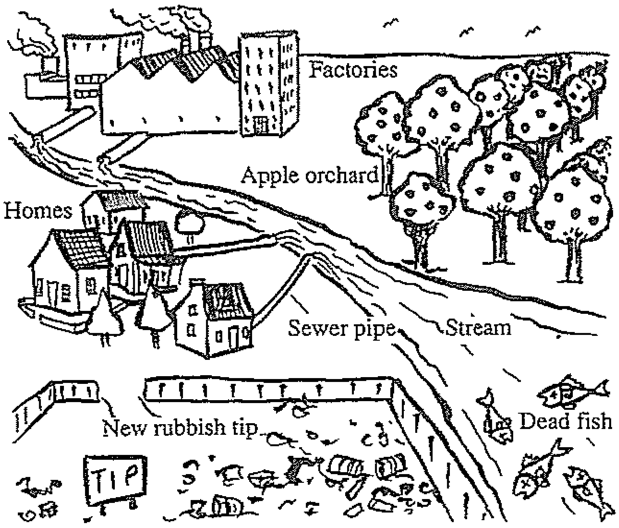


Figure 1.9

Inference	Observation to support inference	Observation to disprove inference
1 Fish have been dumped	The dead fish were not the type found naturally living in the river.	Many other water creatures were found dead and dying along the stream.
2 Fish have been poisoned by pesticide		
3 Fish have been killed by hot water		
4		
5		

Table 1.3

DISTINGUISHING BETWEEN OBSERVATIONS AND INFERENCES – AN ACCIDENT SCENE

Look carefully at Figure 1.10.

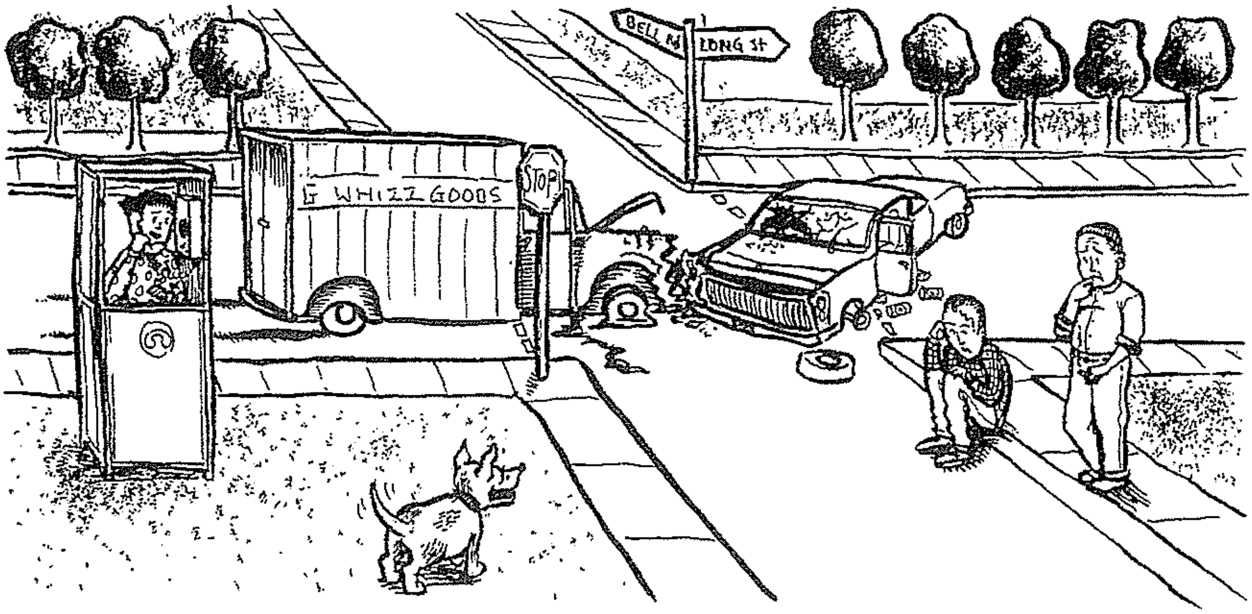


Figure 1.10

Read the following statements made about the accident scene. In your science workbook write down if the statement is an observation or an inference. Write your answers like this — 1. observation.

1 There is a stop sign on the corner of Bell Road and Long Street.
2 The truck did not come to a halt at the stop sign.
3 The car is a total write-off.
4 There are beer cans on the road next to the car.
5 The car windscreen is smashed.
6 The driver of the car has been drinking.
7 The driver cut his head on the broken windscreen.
8 The driver of the car was not wearing a seat belt.
9 There is liquid leaking from the truck onto the road.
10 The driver of the car has been speeding.
11 Petrol is leaking from the truck onto the road.
12 The truck driver is smoking.
13 The driver of the truck is worried because he knows he will lose his licence.
14 There is a woman in the telephone box.
15 The police are on their way to the scene of the accident.
16 The woman is telephoning the ambulance.
17 There is a wheel lying on the road next to the car.
18 The truck has a flat front tyre.
19 The tyre on the truck was punctured during the accident.
20 The truck driver slammed on his brakes trying to prevent the accident.

READING SCALES

Measuring instruments either display a **digital** reading, as in diagram A of Figure 2.2, or a scale with numbers and a pointer, as in diagram B. Instruments with a scale are said to be **analogue**.

Worked example

To use an analogue instrument to make a measurement, you must read the scale. This is done by judging the position of the pointer against the scale. Reading a scale is simple if you follow the four steps given below.

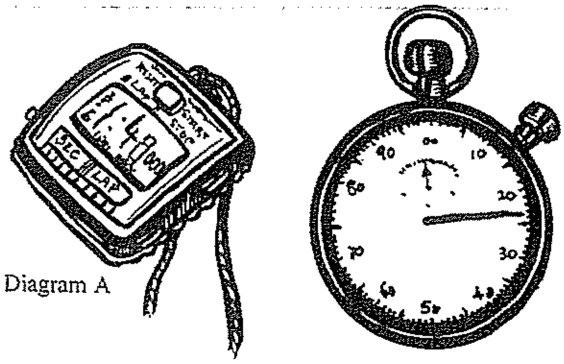
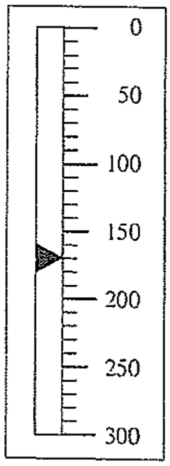


Figure 2.2

Steps	Scale	Example
1 Work out what each division on the scale stands for.		**1 In between 0 and 50 are 5 divisions. Each division must stand for 10 units.**
2 Find the closest numbered division before the pointer.		**2 Closest number before pointer is 150 units.**
3 Count up the number of divisions from the numbered division to the pointer. Calculate their value.		**3 Two extra divisions after 150 units. Each is 10 units, giving an extra 20 units.**
4 Add the value of these divisions to the numbered line.		**4 Add 150 + 20 = 170 units.**

PART A

Follow these steps to read scales 1 to 22 in Figure 2.3. Write your answers in your workbook.

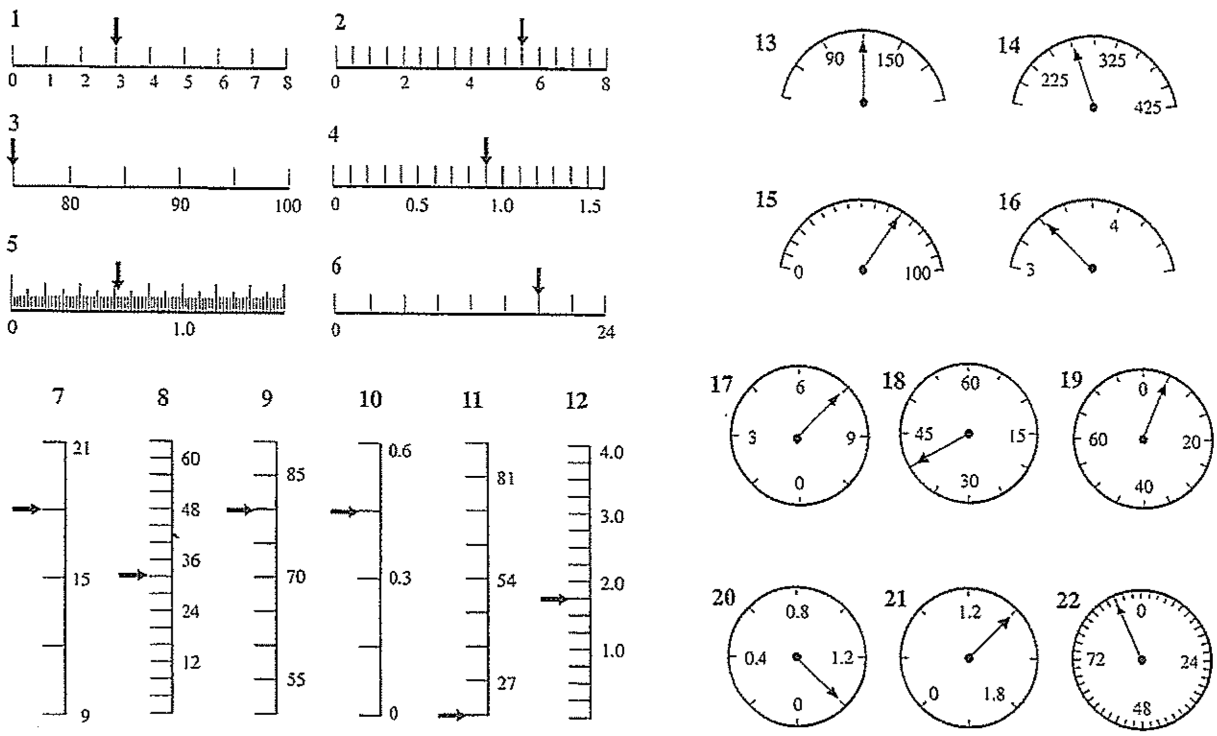


Figure 2.3

PART B

When reading a scale you will often find that the pointer may lie in between the lines. In these cases you will have to estimate the reading.

Worked example

In the following scale the pointer is between the 0.50 and the 0.60 position, but not exactly in the middle.

The reading on this scale would be more than 0.55 but less than 0.60. It could be estimated as 0.56, 0.57 or 0.58. It is not possible to be absolutely certain about this type of reading.

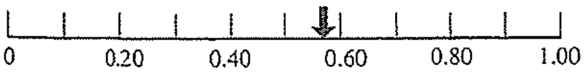


Figure 2.4

Estimate the position of the pointers on the scales in Figure 2.5. Write your answers in your workbook.

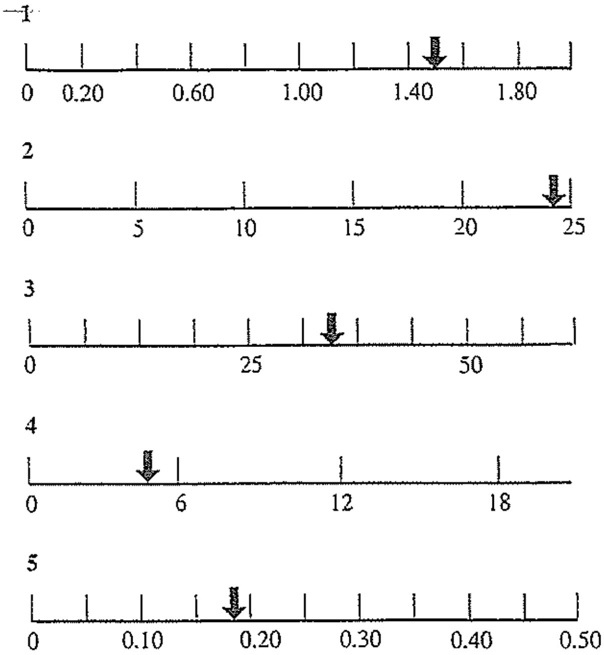


Figure 2.5

A chemistry student was asked to use a chemical data book. She had to find the melting point (m.p.) and boiling point (b.p.) temperatures of several elements. The information she collected is listed below.

Metal elements

Aluminium: m.p. 660°C, b.p. 2450°C
Barium: m.p. 714°C, b.p. 1640°C
Copper: m.p. 1083°C, b.p. 2600°C
Lead: m.p. 327°C, b.p. 1740°C

Non-metal elements

Bromine: m.p. –7°C, b.p. 58°C
Iodine: m.p. 114°C, b.p. 183°C
Phosphorus: m.p. 44°C, b.p. 280°C
Sulfur: m.p. 119°C, b.p. 445°C

Arrange this information into a table by following steps 1 to 5.

PART B

A group of students carried out a survey in their school. They asked 50 male and 50 female students in each year questions about smoking. Here is a report of their findings:

In year 7 we asked 50 girls, 45 of them had never tried smoking, three had tried smoking once or twice and two were regular smokers. With the boys in year 7, 40 had never tried smoking, six had tried it once or twice and four were regular smokers.

In year 8, 39 girls and 40 boys had never tried smoking. Seven girls and six boys had tried it once or twice. Four girls and four boys were regular smokers.

With year 9, 35 girls and 39 boys had never tried smoking. Eight girls and seven boys had tried it once or twice. Seven girls and four boys were regular smokers.

It was really hard to get the year 10 students to tell us at first but we eventually found out that 29 girls and 38 boys had never tried smoking. There were 10 girls and eight boys who had tried it once or twice. Eleven girls and four boys admitted to being regular smokers.

Arrange this information into a table then answer the following questions.

Questions

1 Which year had the greatest number of non-smokers?
2 Which year had the greatest number of male regular smokers?
3 Which year had the greatest number of people who had tried smoking once or twice?
4 What happens to the number of females who are regular smokers from year 7 to year 10?
5 What happens to the number of males who are regular smokers from year 7 to year 10?
6 Infer why there is such a big difference between the numbers of males and females who are regular smokers in year 10.

INTRODUCTION TO GRAPHS

Graphs are a way of showing a 'picture' or drawing of some information. Graphs can show important information at a glance. They make it easier to interpret results and observe patterns.

There are many types of graphs. Each type is best used to show different forms of information.
The main types of graphs used in science are explained in Table 3.5.

Type of graph	Form of information	Why they are used
Column/bar graphs	Groups of things that have been counted or measured.	Used to compare things.
Line graphs	Two quantities that have been measured measured or counted. One is usually time.	Used to show trends or changes over time.
Scatter grams	Two variables (changing quantities) that have been measured.	Used to find the relationship between variables.
Pie graph	Percentages or proportions of different things that make up a whole	Used to compare the relative sizes of things.

DRAWING LINE GRAPHS

Line graphs are probably the most common type of graph used in science. They are used when two quantities have been measured. These quantities are called variables. A variable is something that is continually changing. Often one of the variables is time.

Worked example
During an illness a child's temperature was measured every 2 hours. Draw a line graph which shows what happened to the child's temperature over the 24 hour period.

Time (hour)	Temperature (°C)
12 a.m.	39.1
2 a.m.	40.3
4 a.m.	40.6
6 a.m.	41.1
8 a.m.	40.5
10 a.m.	40.0
12 p.m.	38.8
2 p.m.	38.0
4 p.m.	37.7
6 p.m.	37.2
8 p.m.	37.0
10 p.m.	37.0

Table 3.8

Step 1 **Line graphs are best drawn on graph paper. Draw the vertical and horizontal axes on the graph paper. The variable that has been set or controlled is placed on the horizontal axis. In this case it is the time that has been controlled. The time has been measured every 2 hours. The variable that has been observed and measured is placed on the vertical axis, that is, the temperature.**

Step 2 **Choose a suitable scale for each axis.**
(a) **Horizontal axis — the time is measured every 2 hours over a 24 hour period from 12 a.m. to 10 p.m. A suitable scale in this case would be 12 divisions each equal to 2 hours.**
(b) **Vertical axis — the temperature ranges from 37.0°C to 41.1°C. A scale beginning at 36.5°C and going to 41.5°C would include all the temperatures measured. A suitable scale in this case would be 10 main divisions each equal to 0.5°C.**

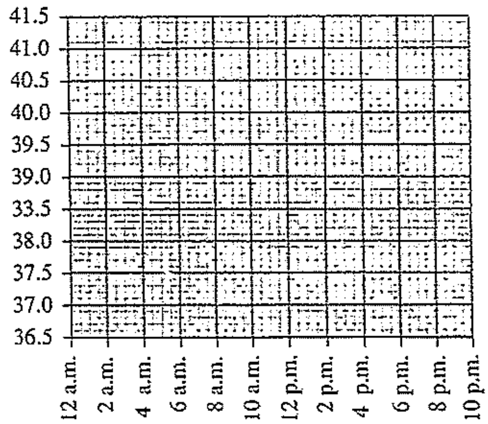


Figure 3.17

Step 3 Look at each pair of measurements in Table 3.8. Find the time on the horizontal axis and the temperature on the vertical axis. Mark the point where each pair of measurements meet on the graph paper with a small cross.

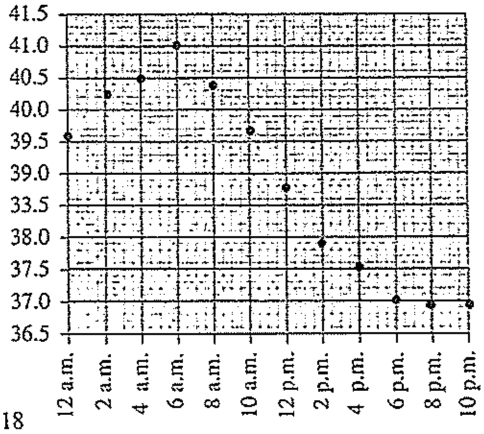


Figure 3.18

Step 4 When all the pairs of measurements have been marked on the graph use a ruler to draw a straight line from one dot to another. Label both axes with a heading and the units the measurements are made in. Write a title at the top of the graph.

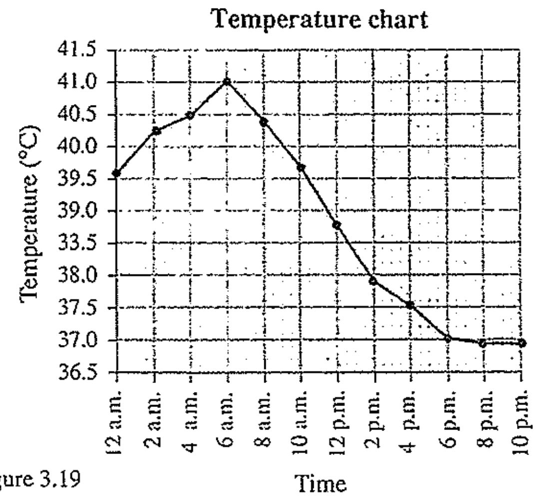


Figure 3.19

Common mistakes made with line graphs

1 **The scales used on each axis must change by even amounts.**

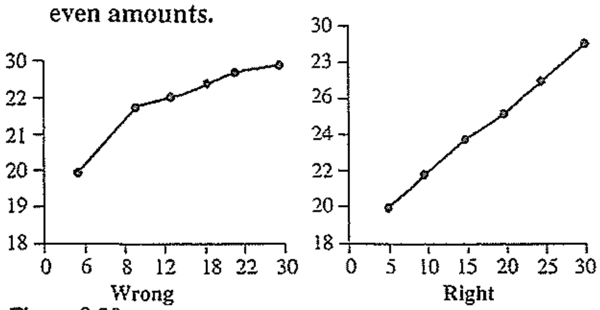


Figure 3.20

2 **The scales used on each axis should spread the measurements over the available space on the graph paper.**

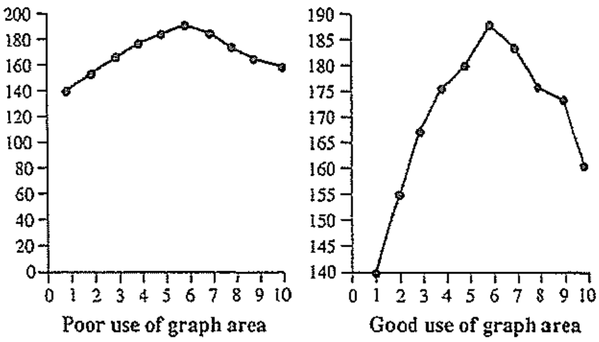


Figure 3.21

3 **The scale chosen should have major scale values fall on major grid lines. Each smaller grid line should be equal to an even subdivision of the major scale values.**

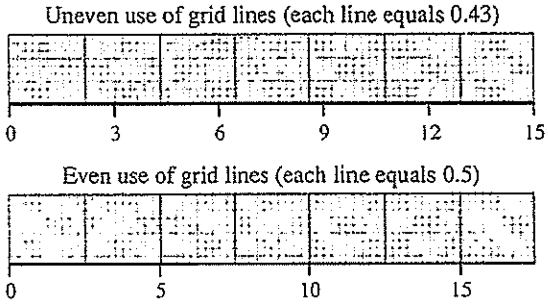


Figure 3.22

PART A

Elizabeth travelled from Sydney to her home at Moss Vale along the Hume Highway. She left Sydney at 4 p.m. When she checked her watch at 4.30 p.m. she had only travelled 25 km as the traffic was slow. By 5 p.m. she was 55 km from Sydney. At 6 p.m. she stopped to buy petrol and something for dinner. She had travelled 95 km. At 7 p.m. she was back on the road. By 7.30 p.m. she reached her home which was 145 km from Sydney.

1 Arrange this information in a table. One column should be headed time, the other distance.
2 Draw a line graph of this information.

PART B

The average stopping distance of a car travelling at various speeds on dry and wet road surfaces is shown in Table 3.9.

1 Draw a multiple line graph of this information by setting out speed on the horizontal axis and stopping distance on the vertical axis.
2 Plot both sets of measurements on the same graph. Label each line clearly showing the difference between dry and wet road surfaces.

Number of weights	Volume of air in syringe (mL)
0	50.0
1	47.5
2	45.0
3	42.5
4	40.0

Table 5.4

To find the pattern we must look at the change to the volume which occurs when each weight is added. To find the change you subtract the second volume measurement from the first. Then the third from the second and so on.

Number of weights	Volume of air in syringe (mL)	Change in volume (mL)
0	50.0	0.0
1	47.5	2.5
2	45.0	2.5
3	42.5	2.5
4	40.0	2.5

Table 5.5

Looking at the change in volume shows that each time another weight is added the volume decreases by a constant amount — 2.5 mL.

We can use this pattern to predict the volume of air in the syringe when five weights are placed on the plunger. This would be 40.0 – 2.5 = 37.5 mL.

You could continue the process to predict the volume of air for six, seven or eight weights. But how certain can you be about these predictions? The answer is: *not* absolutely certain. A prediction is a good guess using available information. The only way to be absolutely certain is to actually try the experiment and find out.

PART A

Peter was investigating the connection between the amount of force (in newtons) on a rubber band and its length (in mm). He recorded the following measurements:

0.8 N, 64.4 mm; 0.12 N, 71.6 mm; 0.0 N, 50.0 mm; 0.4 N, 57.2 mm; 0.60 N, 60.8 mm; 0.2 N, 53.6 mm; 0.1 N, 68.0 mm

1 Arrange these measurements in a table to show increasing force.
2 Calculate the change in length of the rubber band for each 0.2 N additional force.
3 Predict the length of the rubber band if 0.14 N of force were applied.
4 Predict the force needed to stretch the rubber band to a length of 78.8 mm.

PART B

Pressure can be measured in many units. Table 5.6 shows how four of these units are related. However, some of the measurements are missing. In order to complete the table you must work out what the pattern is relating to these units.

Units for pressure			
Atmosphere	Pascal	mmHg	Bar
0.5	50 650	(e)	0.5065
1.0	101 300	760	(g)
(a)	151 950	1140	1.5195
2.0	202 600	1520	2.0260
2.5	(c)	1900	2.5325
3.0	(d)	2280	(h)
3.5	354 550	2660	(i)
(b)	405 200	(f)	(j)

Table 5.6

In your workbook write down the missing measurements (a) to (j).

MAKING PREDICTIONS FROM GRAPHS – INTERPOLATING

Graphs can be used to make predictions. If the prediction is about a value between two measurements the process is called **interpolating**.

Worked example

The time it takes a pendulum to swing is measured for different lengths of string. Table 5.9 shows the measurements that were recorded.

Length of pendulum (cm)	Time (s)
10	0.851
20	0.201
30	0.451
40	0.651
50	0.802
60	0.102
70	0.252
80	0.352
90	0.452
100	0.552
110	0.602
120	0.650

Table 5.9

These measurements can then be used to draw a graph which shows the pattern connecting the length of a pendulum and the time it takes to swing.

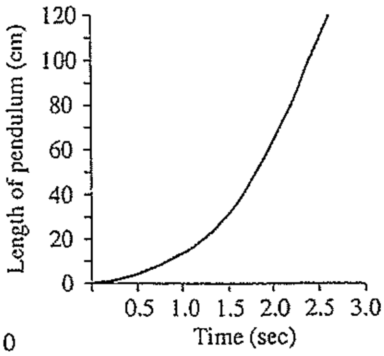


Figure 5.10

It may be necessary to find out about a value that has not been measured. Instead of actually doing the experiment again it is possible to use the graph. Because the points lie on a smooth curve it looks as if the time for each swing is changing in a regular, orderly, predictable way.

We can simply read off the graph values in between those measured. So, for a pendulum 75 cm long, we can predict it would take 2.15 seconds to swing.

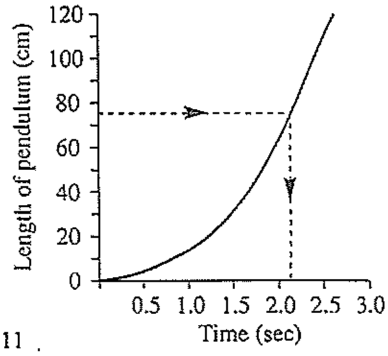


Figure 5.11

PART A

Table 5.10 shows how air temperature changed with increasing altitude (height above ground) on one day.

Altitude (m)	Air temperature (°C)
0	25
400	21
800	17
1200	13
1600	9
2000	5
2400	1

Table 5.10

1 Draw a graph of the data. Put altitude on the vertical axis and air temperature on the horizontal axis.
2 What was the air temperature at ground level?
3 Use the graph to predict the air temperature at altitudes of 200 m, 700 m, 1500 m and 2300 m.

PART B

Table 5.11 shows how the time for one orbit of the Earth changes with increasing height above the Earth.

Height above Earth (km)	Time for one orbit (min)
100	85
200	90
500	95
1 000	105
2 000	125
5 000	200
10 000	350

Table 5.11

1 Draw a line graph of the data. Put height above Earth on the vertical axis and time for one orbit on the horizontal axis.
2 Connect the points with a smooth curve.
3 Use the graph to predict the time for one orbit when the height is 1500 km, 3000 km and 8000 km.
4 Use the graph to predict the height above the Earth when the orbit time is 3 hours.

MAKING PREDICTIONS FROM GRAPHS — EXTRAPOLATING

Graphs can be used to make another type of prediction. Besides interpolating — making predictions about values in between measurements — it is possible to make predictions about values beyond the last measurement. This process is called **extrapolating**.

Worked example

Figure 5.12 shows the change in water temperature for each 30 second period as 100 mL of water is heated.

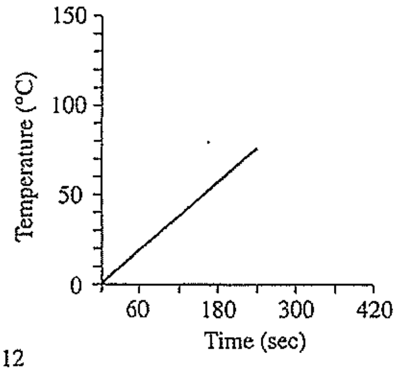


Figure 5.12

But what happens to the water temperature at 300 seconds? It would be easy to make a prediction. The water temperature has increased in a regular manner, producing a straight line. It would be logical to infer that it would continue to do so. A prediction can be made graphically by simply extending the temperature–time line a little bit further. The graph would then look like the one below. The temperature at 300 seconds can then be read from the graph. At 300 seconds we can predict that the water temperature would be 95°C.

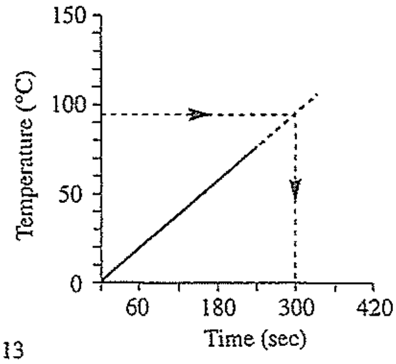


Figure 5.13

Is it possible to keep extending the temperature–time line further and further? The answer is yes, but the predictions become less reliable. We do not know if the temperature will continue on or change direction. In fact, when further measurements are made in this case, the temperature–time line does level out.

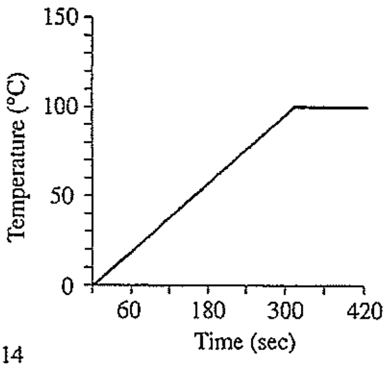


Figure 5.14

This example shows that extrapolating is not as dependable as interpolating. No one can know for sure what the future will be like. Still, many people who are involved in planning for the future must make predictions using this technique.

PART A

High-frequency sound waves called ultrasound can be used in an echo-sounding device to measure the depth of water. A burst of ultrasound sent downwards from a ship is reflected back by the sea bed. The echo time is measured. Knowing that the ultrasound waves travel at 1450 m/s in water means that the distance can be calculated using the equation distance = speed × time.

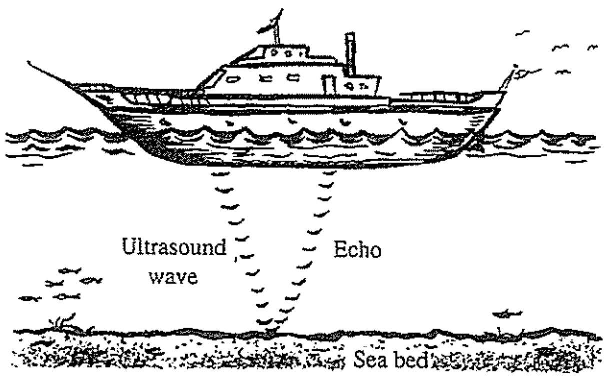


Figure 5.15

Time (s)	Distance travelled by sound waves (m)	Depth of water (m)
0.07		50
0.10	150	
0.14	200	
0.17		
0.21	300	
0.24		
0.27	400	
0.31		
0.34	500	250

Table 5.12

1 Use the equation to calculate the distance travelled by sound waves and complete the middle column of Table 5.12.
2 Calculate the depth of water. (Hint: the ultrasound wave travels down and back up.)
3 Draw a line graph of the depth of water against time. Put depth of water on the horizontal axis and time on the vertical axis (allow room for the graph to be extended).
4 Predict the depth of water if an ultrasound wave took 0.22 seconds to return.
5 Predict the time it would take for an ultrasound wave to travel down and return through water 240 m deep.
6 Predict the depth of water if an ultrasound wave took 0.40 seconds to return.
7 The speed of sound decreases as the water temperature decreases. What effect would this information have on the shape of this graph and the predictions based on it?

PART B

A ball is dropped from a cliff. The distance it falls each second is recorded in Table 5.13.

Time (s)	Distance (m)
0	0.0
1	4.9
2	19.6
3	44.1
4	78.4
5	122.5
6	176.4

Table 5.13

1 Draw a line graph of the distance the ball falls against time. Put distance on the vertical axis and time on the horizontal axis (allow room for the graph to be extended).
2 Connect the plotted points with a smooth curve.
3 Predict the distance the ball will have fallen after 7 seconds.
4 Predict how long it will take the ball to fall 314 m.

THE SCIENTIFIC METHOD

Scientists use many methods or approaches to find out information. One approach used is called the **scientific method**. It involves the following steps:

1 **Making an observation.** The scientist notices something that gets him/her thinking.
2 **Asking a question.** The observation may lead a scientist to ask questions such as 'Why did that happen ...?' or 'What would happen if ...?'.
3 **Forming a hypothesis.** Using the observations made initially and any other information collected, the scientist makes a general statement. This general statement is called a **hypothesis**. It is a possible answer to the question asked by the scientist.
4 **Making predictions.** The scientist can use the general statement to make a prediction about what should happen in a situation. This leads the scientist into designing experiments.
5 **Testing the hypothesis.** The hypothesis can be tested experimentally. If the experimental results agree with the predicted results the hypothesis is supported. More testing would then take place. If the experimental results do not agree with those that were predicted then the hypothesis must be changed.
6 **Making a conclusion.** After much testing where the experimental results repeatedly support the hypothesis a **conclusion** is made. This means that the hypothesis is accepted as a good one until it can be shown to be wrong by further experimenting. It does not mean the hypothesis is a 'proven fact'.

PART A

Copy the flow diagram into your workbook.

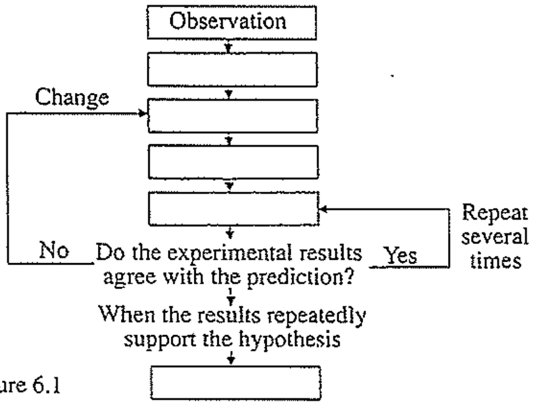


Figure 6.1

Use the written information about the scientific method to complete the flow diagram. You will need to pick out the key words from each step. The first step has been done for you.

PART B

Read the information below.

Hassib's younger sister had a birthday party. His mother asked him to help clear away after it and take down the decorations. He **noticed** that the balloons looked smaller than when he had put them around the room the night before. He **wondered why** the inflated balloons should go down. He **thought** that the air must get out of the knot at the end. Hassib knew from fixing a puncture in his bike tyre that bubbles of air can be seen easily under water. He told his mother that if he was right, he would see air bubbles coming from the knot, when he held a balloon under water.

Hassib filled a bucket with water and pushed the balloon into it. After a while he noticed that the whole balloon was covered with tiny air bubbles, but no bubbles were coming out of the knot.

He decided that his first idea was wrong, that air did not escape from the knot. But after thinking about it for a while he came up with a new idea. The air must get out of tiny holes in the balloon rubber. He decided to tell his science teacher about it at school the next day.

Write answers to the following questions in your workbook.

1 When Hassib 'noticed', 'wondered why' and 'thought', which steps of the scientific method match these actions?
2 Write down the sentence where Hassib made a prediction.
3 What knowledge did Hassib have that helped him to design an experiment to test his idea?
4 Write down the sentence that gives the results of his experiment.
5 Did the results agree or disagree with Hassib's prediction?
6 Write down the sentence that gives Hassib's new hypothesis.
7 Did Hassib make a conclusion? If yes, what is it? If no, explain why not.

PART C

Read the following, then answer the questions in your workbook.

While on holiday Mrs Ellis took her husband and two sons, Brian and Phillip, to hospital. Dr Lee could see that all were quite ill and would need treatment as soon as possible.

Mr Ellis, who suffered from a stomach ulcer, was complaining of stomach pains. Mr Ellis was a teacher and had a very stressful job. Brian, who was badly

CONTROLLING VARIABLES

Simple experiments carried out where you are working with two main variables may be suitable when you are trying to find out something to satisfy your own curiosity. If you want to carry out an experiment scientifically and be very confident in the results then you must plan a more complicated kind of experiment.

Very often in an experiment there are more than two variables (factors) that can affect the results.

Let's say that you want to find out if using soapy water from the laundry can affect the growth of plants in the garden. Obviously, this will depend on how much water the plants get, what type of plants are growing, how much soap is in the water and so on. All these variables could confuse the results; you would not be able to judge which of these variables was related to any difference in the growth of the plants.

As an experimenter you must try to limit the number of variables to the two main ones. So you try to keep other variables constant or the same during the experiment. This is called **controlling the variables.**

Worked example

To compare the heat absorbing ability of dull black metal containers with shiny silver metal containers a student set up the equipment as shown in Figure 6.3.

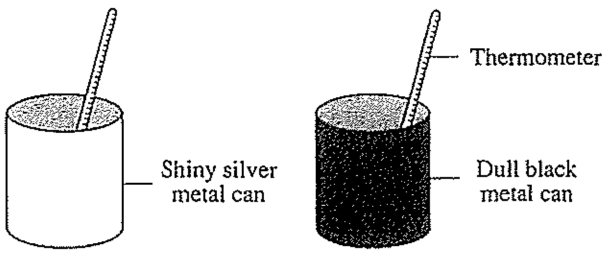


Figure 6.3

The student poured water into each container and placed them both in sunlight. The temperature of the water was then measured after several hours. The final temperature reached will depend on many variables, but the only variable the student wishes to test is the colour of the container. This means that all other variables must be the same for each can. The following variables must be controlled:

- **the size of the can**
- **the type of metal that the cans are made of**
- **the amount of water poured into each can**
- **the starting temperature of the water**
- **the amount of sunlight each can receives**
- **the time the cans sit in the sunlight.**

If these variables are not controlled the results will not be reliable.

PART A

Read the following passage and answer the questions in your workbook.

Ranjan set up an experiment on filter paper. He used four strips of filter paper. Each was the same length and width. Ranjan put the bottom 3 cm of each strip in four beakers containing 100 mL of water. He measured and recorded the temperature of the water in each beaker. After 5 minutes Ranjan removed the strips and measured the height the water had moved up the filter paper. The results are shown in Table 6.5.

Beaker	Temperature of water (°C)	Starting height of water on strip (cm)	Final height of water on strip (cm)	Distance water moved in 5 min (cm)
1	0	3	4.5	1.5
2	30	3	6.0	3.0
3	60	3	7.5	4.5
4	90	3	9.0	6.0

Table 6.5

1 What was Ranjan trying to find out by doing this experiment?
2 The temperature of the water was the independent variable. What was the dependent variable?
3 List all the variables that Ranjan controlled.
4 Draw a line graph of the temperature of water against the distance the water moved in 5 minutes.
5 Predict the distance the water would have moved up the paper strip if the temperature was 50°C and 95°C.