

02

Drawing and interpreting graphs in science

THE NATURE OF SCIENCE Investigating in Science



Objectives:

- To show students how to draw graphs correctly to communicate data
- To assist students to interpret the relationship between the shape of a graph and the data
- To help students use a graph as a source of data

Keywords in this chapter:

Scaling
Proportional
The origin
Graph
Table
Axis

2.1 Graphs are a useful way to interpret data quickly

A **graph** is a method of representing data.

When you look at a graph, you may be able to quickly notice a trend or relationship between the data. In this chapter you will learn how to draw graphs and how to interpret them. The most useful type of graph in science is a line graph. You will learn about other types of graphs in your Junior Cycle Maths course.

The number of people in a county who have been diagnosed with COVID-19 per month over a six-month period is shown in Table 2.1. Figure 2.1 shows a graph of the same information.

Month	Number of COVID-19 cases diagnosed
May	100
June	180
July	290
August	440
September	260
October	100

Table 2.1 The number of people in a county who have been diagnosed with COVID-19 over a six-month period

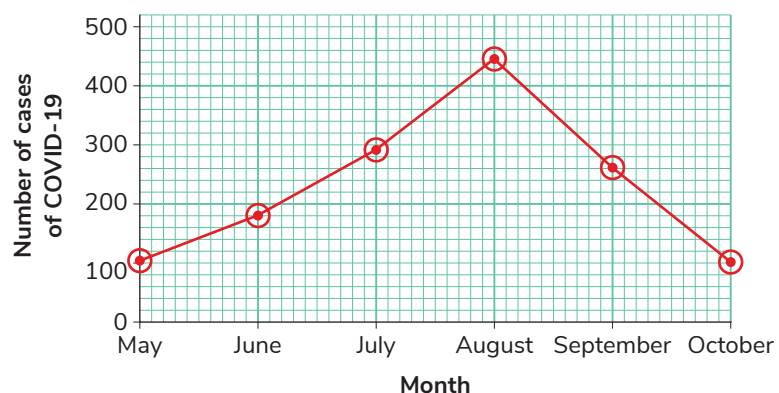


Figure 2.1 A graph showing the number of people in a county who have been diagnosed with COVID-19 over a six-month period

We can easily see from the graph that the number of diagnosed cases of COVID-19 increased over the months of May, June, July and August. We can also see that the highest number of cases occurred during August. It is clear that there was a decline in the number of cases diagnosed in September and October.

Even though we can also view the data in the table, the graph allows us to interpret the data much more quickly than reading the table. Also, the graph shows the trends more quickly than having to spend time examining the table.

There are some important terms about graphs that you need to understand (Figure 2.2).

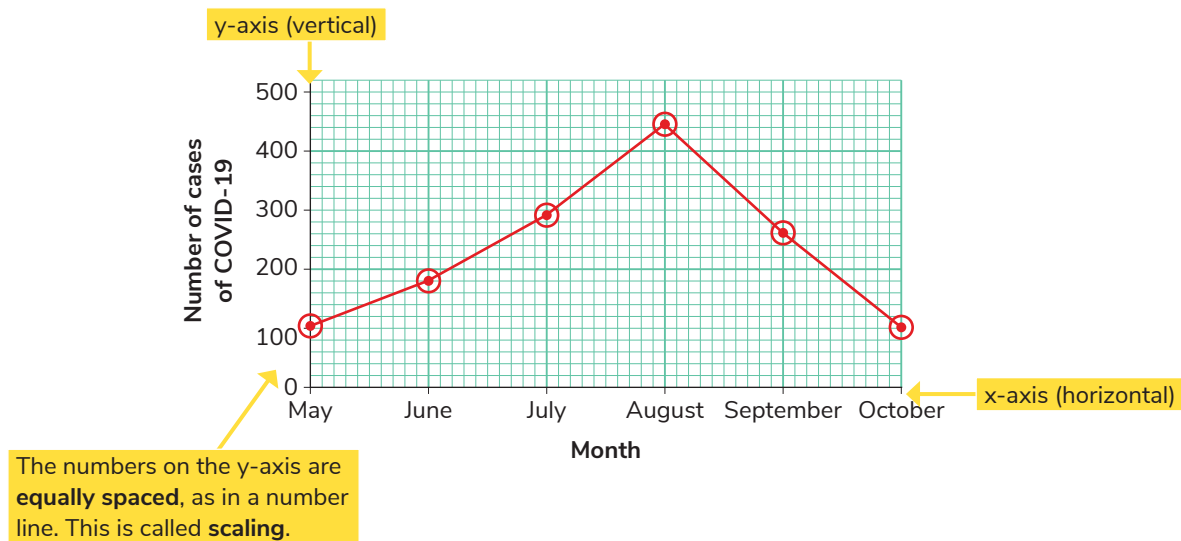


Figure 2.2 Some important terms used when drawing graphs

The horizontal line along the bottom of the graph is called the **x-axis**. Data can be represented here by a number or by a name. Where a name is used, the position of the names needs to be equally spaced.

The vertical line up the side of the graph is called the **y-axis**. Data on the y-axis are usually represented by numbers. The y-axis is drawn like a number line, where numbers are equally spaced out. This equal spacing out of numbers on the number line is known as **scaling**.

2.2 How to draw a simple graph

When drawing a graph, there are six important points to consider. We will cover these six points in worked example 2.1. You will need graph paper, a ruler and a pencil to draw graphs. Pencil is recommended for drawing graphs since mistakes can be easily corrected. The shade of graphite in the pencil must be dark black so that it is easily read when your examination paper is scanned. An HB pencil is sufficient.

In order to plot a graph accurately, it is necessary to use **graph paper**. You might have a science copybook with graph paper included or a copy containing graph paper only. This graph paper has a number of large squares (boxes). Each box is subdivided into 10 divisions, both vertically and horizontally. This is designed so that data can be plotted accurately.

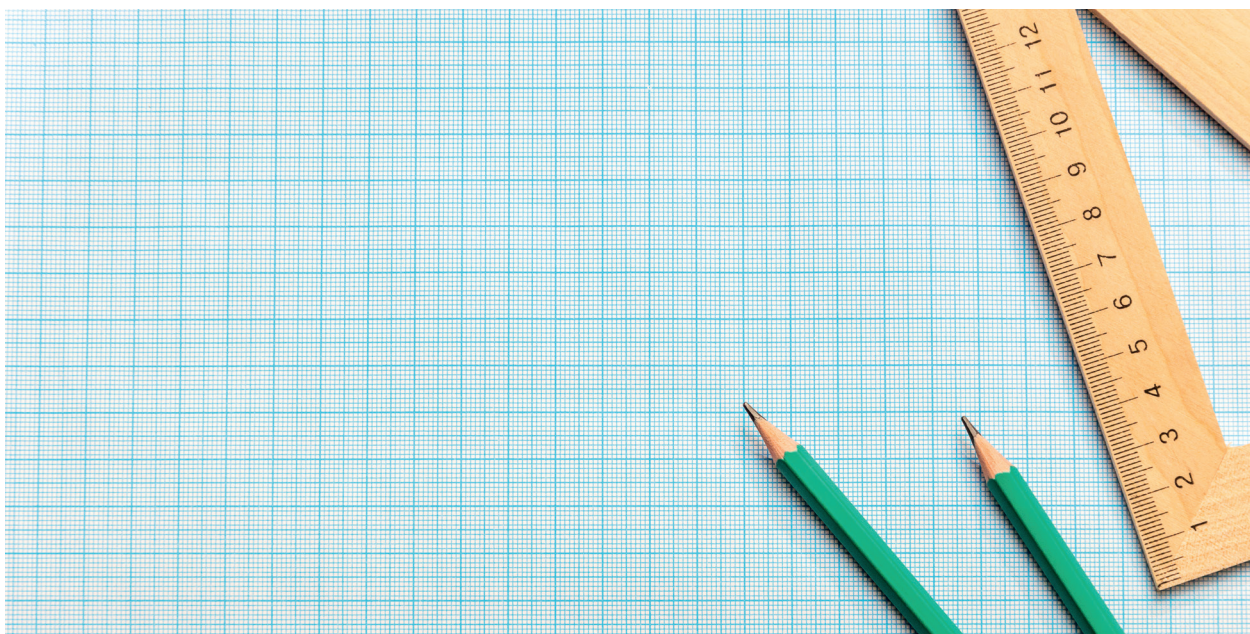


Figure 2.3 You will need graph paper, a ruler and a pencil to draw graphs.

WORKED EXAMPLE 2.1

Mary found some data on the internet about the average temperature at Cork Airport over a period of six months (Table 2.2). Represent the data on a suitable graph.

We will plot the data using the following steps:

1. **Draw the x-axis and the y-axis.** Keep the lines of each axis **on the edge of the large boxes** (Figure 2.4).
2. **Label both axes.** Each month, we are measuring the temperature. We place the variable we are changing on the x-axis. In this case, it is the month. We place the variable that we are measuring on the y-axis (vertical). In this case, it is the temperature.

A more detailed explanation of variables is given in Chapter 41.

Month	Temperature (°C)
October	11.4
November	8.3
December	6.7
January	6.0
February	6.0
March	7.4

Table 2.2 The average monthly temperature at Cork Airport over a six-month period

Where units are involved, we include the units in brackets after each variable, for example temperature (°C) (Figure 2.4).

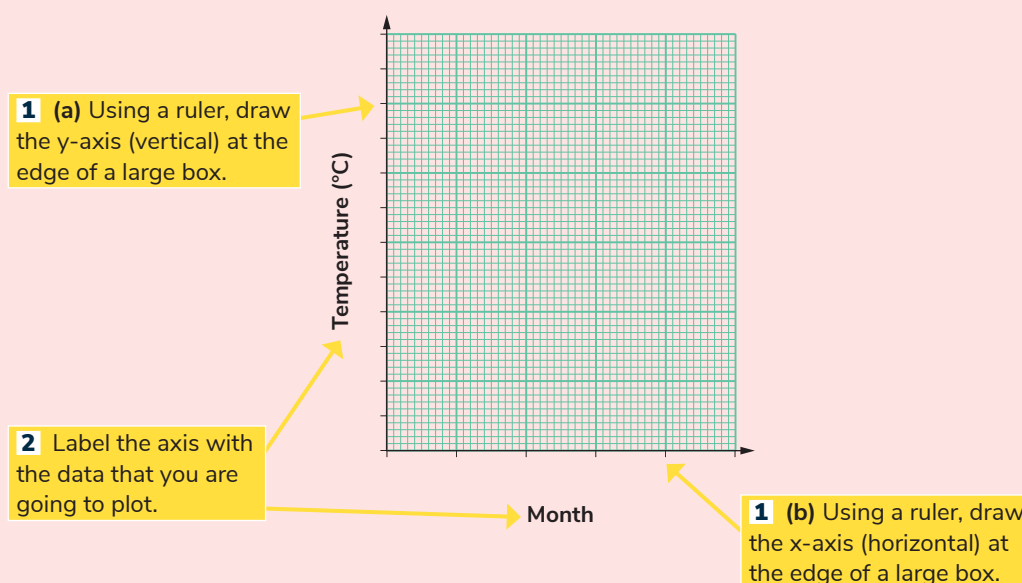


Figure 2.4 When drawing the axes of a graph: (1) Draw the axes on the edge of the large boxes. (2) Label your axes. (3) Include the unit where applicable.

3. **Put a proper scale on both axes of the graph.** We need to fill at least half of the area of the graph paper with the graph. This takes some planning before you draw the scale (Figure 2.5).
 - (a) We have six months to plot. We will fit one month at the start of each large box. Mark the beginning of each box on the axis with a small line.
 - (b) The temperature will be placed on the y-axis. For the numbers, we need to draw a number line. To do this we look at the **largest value** of temperature. In this case it is 11.4. We will round this **up** to 12. The graph paper shown in Figure 2.5 has six boxes above the x-axis. If we are to place an **even** scaling on the graph, we can let one large box stand for 2 degrees Celsius. Therefore, the large boxes are labelled 0, 2, 4, 6, 8, 10 and 12. Also, we label each half box 1, 3, 5, 7, 9 and 11, as shown in Figure 2.5.

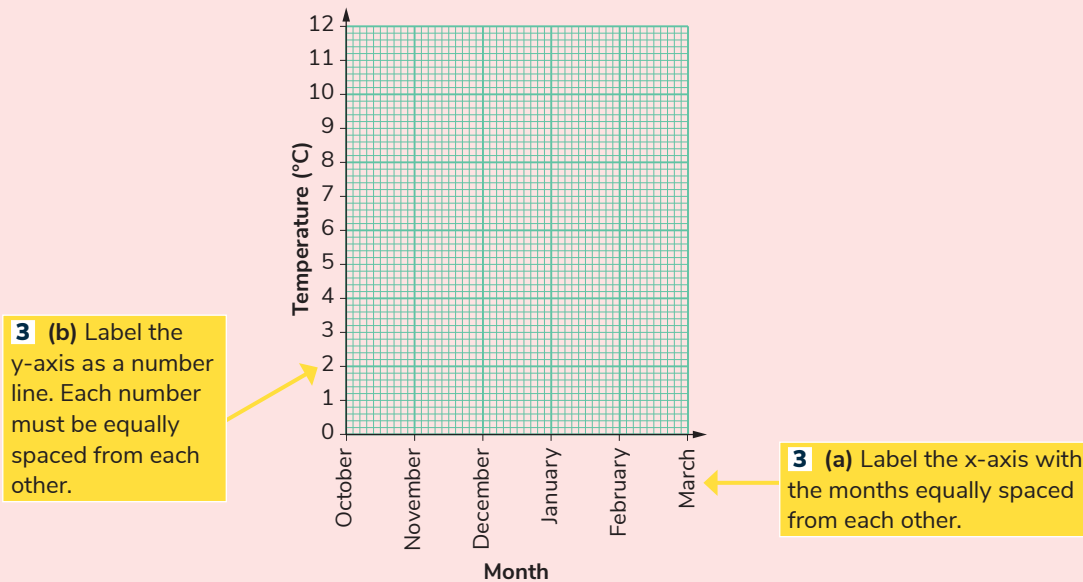


Figure 2.5 When marking a scale on a graph, it is important to leave even spacing between the numbers.

- 4. Plot the data on the graph.** Put a small dot at the correct data point and a small circle around the dot (Figure 2.6). The reason why it is good practice to put a small circle around the dot is to ensure that the examiner can see each small dot. When you connect the dots together in the next step, it can sometimes be difficult to see the original dots. In an examination, each point you have plotted on your graph will be checked for accuracy.
- 5. Join the points using a line or curve.** If the points can be joined by one straight line, use a ruler to join them. If not, connect them as accurately as you can using a hand-drawn line (Figure 2.7).

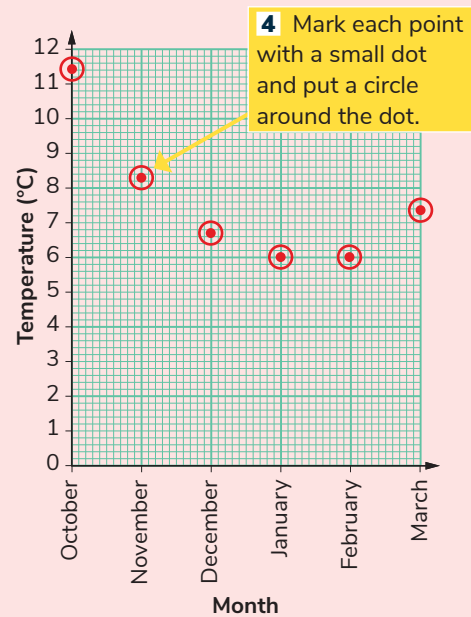


Figure 2.6 Mark your data points accurately with a dot and a small circle around each dot.

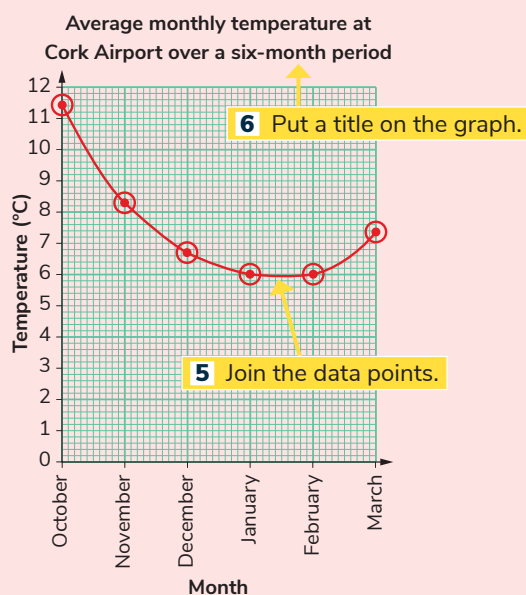


Figure 2.7 Join your points with a curve and put a title on the graph.

- 6. Give your graph a title and write this on the graph paper.** An appropriate title for this graph would be 'Average monthly temperature at Cork Airport over a six-month period'.

Test yourself: Now attempt questions 2.1–2.2 and A2.1.

2.3 Drawing more advanced graphs

In worked example 2.2 we will look at graphs that have numeric data on both the x-axis and the y-axis. These graphs are a little more advanced, as you need to pay more attention to the scaling of both axes.

WORKED EXAMPLE 2.2

The height of the bounce of a squash ball was measured when the ball was dropped from a height of 50 cm. The temperature of the ball was changed and the height of the bounce was measured. This was repeated several times. The data obtained are summarised in Table 2.3.

When carrying out an investigation of your own, you should collect enough data to plot at least six data points on a graph. Full details on how to carry out investigations of your own are given in Chapter 41.

The temperature is changed before dropping the ball. This is the independent variable and will be placed on the x-axis.

The maximum value for temperature is 75 °C. This helps to plan for the scaling of the axis.

Temperature (°C)	Bounce height (cm)
25	4
35	9
45	14
55	17
65	21
75	25

Table 2.3 The effect of temperature on the bounce height of a squash ball

The bounce height is being measured during the experiment. This is the dependent variable and will be placed on the y-axis.

The maximum value for bounce height is 25 cm. This helps in choosing the scaling for this axis.

Draw a graph to illustrate the data.

1. The axes of the graph are drawn on graph paper.
2. We are changing the temperature and we are observing the bounce height. The variable that we change (temperature) goes on the x-axis (horizontal). The variable we are observing (bounce height) goes on the y-axis (vertical). The axes are labelled and the unit is included in brackets for temperature and height (Figure 2.8).
3. Scaling:
 - (a) Temperature will be plotted on the x-axis. The highest temperature is 75 °C. We round this up to 80 °C. The x-axis has eight boxes available, so we will let each box correspond to an increase of 10 °C.
 - (b) Bounce height will be plotted on the y-axis. We have 13 boxes available for the height. We will not have enough space to let each box stand for 1 cm, so we will let one box stand for 2 cm (Figure 2.8).

A more thorough explanation of variables is given in Chapter 41.

EXAM TIP!

When choosing the scaling for the axis, examine the graph paper carefully. Note in the graph paper shown that each large box is divided into 10 subdivisions along each axis. Each subdivision is indicated by a small box. Therefore, it is far easier to read the scale if you let each large box stand for a number that divides exactly into 10. For example, if a large box is labelled 1, then each small box corresponds to 0.1. If a large box is labelled 2, then each small box corresponds to 0.2. If a large box is labelled 5, then each small box corresponds to 0.5. If a large box is labelled 10, then each small box corresponds to 1.

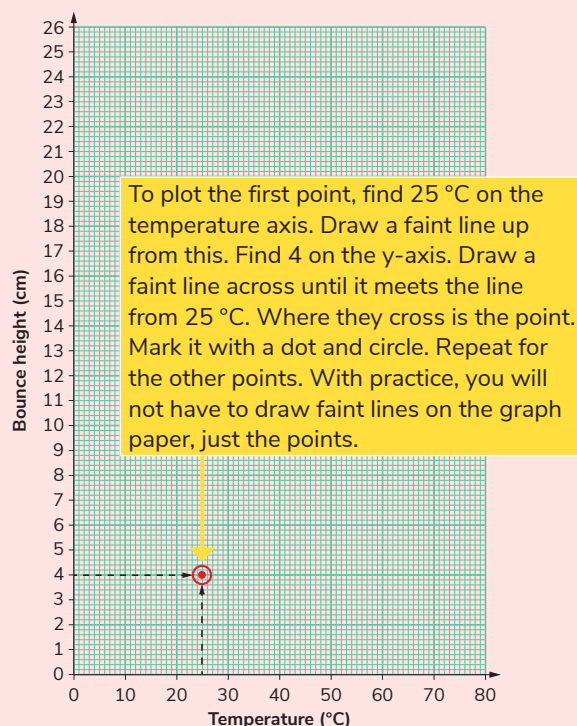


Figure 2.8 Plotting the first point on a graph

4. The first data point is marked on the graph paper shown in Figure 2.8. The remaining data points are plotted in the same way.
5. The data points must now be connected to each other. Note in Figure 2.9 that the data points almost all lie on a straight line. Therefore, we draw a line with a transparent ruler so that the line drawn is as close as possible to all the points. This is called the **line of best fit**. Since the line is close to all points and there is an equal number of close points to the right and left of the line, we call this a **good distribution** of points.
6. Place a title on the graph.

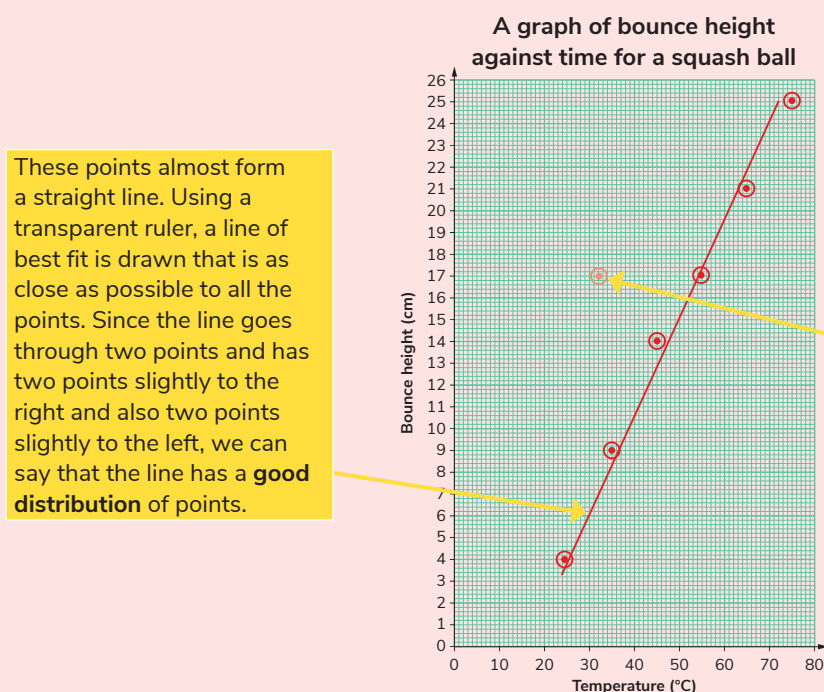


Figure 2.9 Drawing a line of best fit through the data points

EXAM TIP!

When your graph is being examined, the following points will be taken into consideration:

- ▶ Are the axes labelled?
- ▶ Is scaling of the graph accurate?
- ▶ Are the points plotted correctly?
- ▶ Are the points in the graph joined in an appropriate way?

Test yourself: Now attempt questions 2.3–2.5 and A2.2–A2.3.

2.4 Interpreting graphs

Drawing graphs is an important skill. However, interpreting graphs is an even more important one. Let's demonstrate this with an example.

Figure 2.10 shows how the life expectancy of a child born in various years since 1820 has changed. Examine the labels on the graph to help you understand some of the information you can find out from the graph.

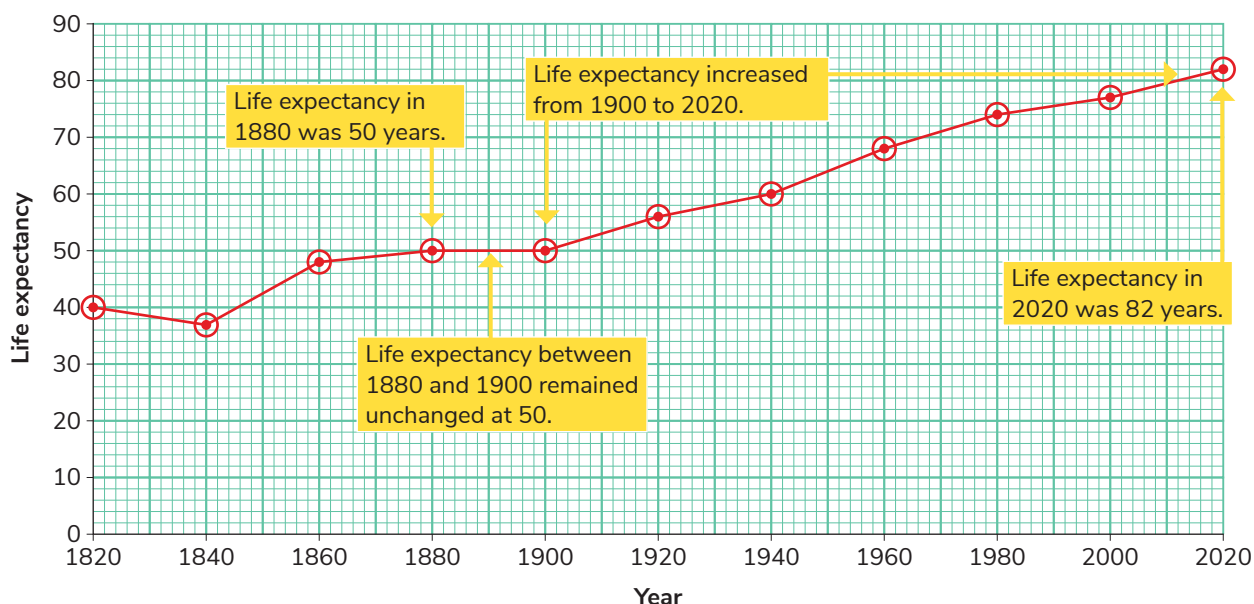


Figure 2.10 A graph of average life expectancy in Ireland over the past 200 years

WORKED EXAMPLE 2.3

State the relationship between the data in the following graphs.

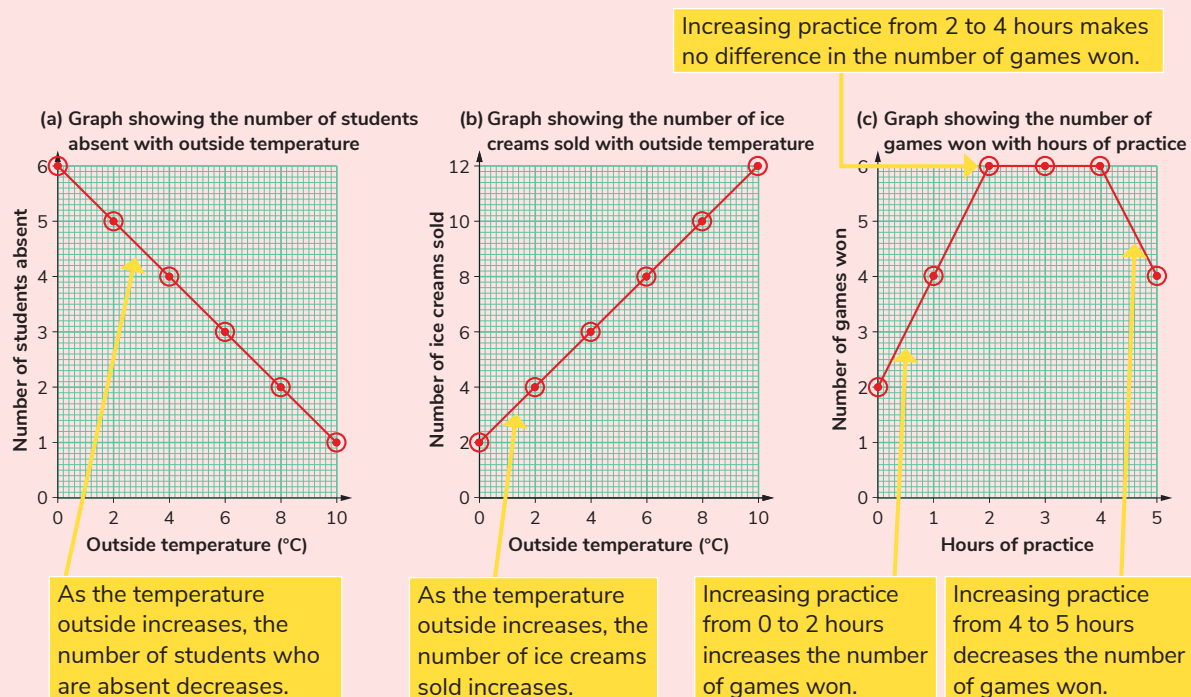


Figure 2.11 Interpreting graphs

A special type of graph – proportionality

An important relationship between two variables is shown in Figure 2.12.

- ▶ The graph shows the amount of electrical energy generated by a solar panel over time. Note that the graph **starts at the point (0, 0), called the origin**, and it is a **straight line**.
- ▶ If we compare the energy generated after 1 hour (2,000 J) with the amount of energy generated after 2 hours (4,000 J), we notice that as the time is doubled, the energy generated is also doubled.
- ▶ If you treble the time (3 hours), the amount of energy generated is also trebled.
- ▶ We summarise the above by saying that the energy generated is **directly proportional** to the time.
- ▶ You will need to be able to recognise this relationship if it arises in any graph. In particular, you will need to be able to recognise it in Hooke's law (Chapter 32) and Ohm's law (Chapter 35).

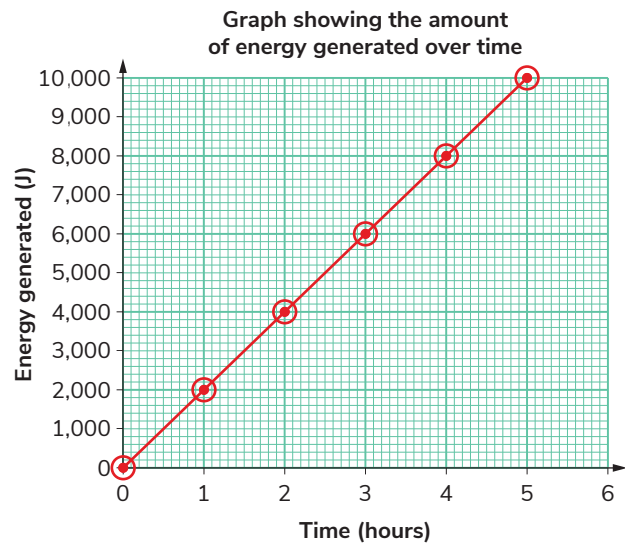


Figure 2.12 A graph of energy generated by a solar panel against time

A graph that has a straight line from the origin shows that the two variables on the graph are **directly proportional** to each other.

Test yourself: Now attempt questions 2.6 and A2.4.

2.5 Using the graph as a source of data

Graphs can be used to show trends in data.

They can also be used as a source of data.

We will use the graphs in Figure 2.13 as a source of data. The graph shows the depth of the sea over a period of time. The depth of the sea is changing because of the tide.

Figure 2.13(a) shows how to work out the depth at a time of 1.5 hours. A line is drawn straight up from 1.5 m until it hits the graph. Then a line is drawn horizontally from this point until it hits the y-axis. This gives a value for the depth (5.6 m).

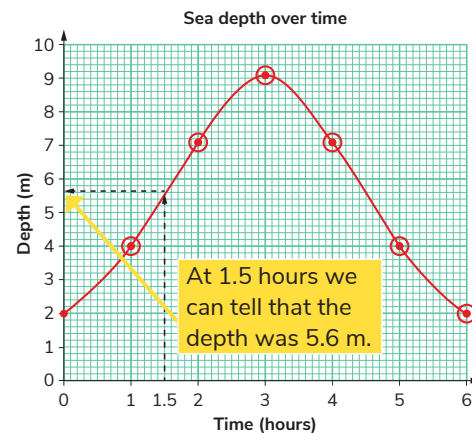


Figure 2.13 (a) Working out the depths at a specific time

EXAM TIP!

In an exam, **do not erase the dashed lines**, as they are evidence that you knew what to do. If an error is made at a later stage, you may obtain some marks for these.

Figure 2.13(b) shows how to calculate the length of time that the depth was greater than or equal to 8 m. A line is drawn from 8 m horizontally until it hits the graph. Note that it hits the graph at two points. Vertical lines are drawn from these points until they hit the x-axis. These values are read (2.3 hours and 3.7 hours). Between these times, the height of the water was at or above 8 m. The height of the sea was equal to or greater than 8 m for $3.7 - 2.3 = 1.4$ hours. Again, **do not rub out these lines**.

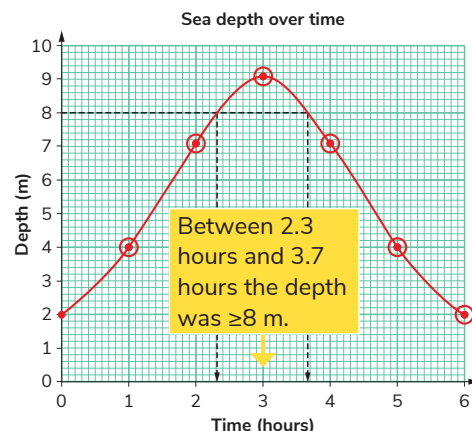


Figure 2.13 (b) Working out how long the depth was 8 m or greater

Test yourself: Now attempt questions 2.7 and A2.5.