Chapter 1

Making measurements

THE INVESTIGATIONS IN THIS CHAPTER WILL:

- allow you to measure length, volume and time using a variety of instruments, as a scientist would do in a lab
- allow you to use techniques to measure short periods of time, or distance and appreciate the methods used to ensure these measurements are accurate. Accurate timing is important in sports such as Formula 1®.

Practical investigation 1.1: Estimating measurements

KEY WORDS

circumference: the distance around the outside of a circle

diameter: the length of a straight line that goes from one side of a circle to the other and passes through the centre of the circle

estimate: use information available to decide on a value that is appropriate

IN THIS INVESTIGATION YOU WILL:

- take accurate measurements of mass, time and distance using appropriate equipment
- calculate average values.

YOU WILL NEED:

- metre ruler
- stopwatch
- top-pan balance
- newton scale
- 30 cm ruler (for analysis section)

Safety

- Before you start recording the time for star jumps, check that the surrounding area is clear of objects.
- Make sure the person performing star jumps is wearing footwear suitable for this task.

Getting started

Familiarise yourself with the names of the equipment and what they measure from the skills section at the start of this book. Fill in the table provided to show which piece of equipment you will use for each type of measurement.

Measurement	Equipment
length	
volume	
mass	
time	

Use this table to help you during your investigation.

Method

1 Look at everything you are going to measure. Estimate each value and record your estimates in the table that has been provided.

2 Take measurements of:

- the height of the person sitting next to you (in cm)
- how long it takes a student to perform ten star jumps
- the length, width and thickness of a glass block
- the diameter of a piece of wire
- the mass of a bag of sugar.

Take each measurement three times.

Recording data

1 Record your measurements in the table. Remember to include the appropriate units.

Measurement type	Estimated value	Measured value			Average measurement
		1	2	3	

TIP

Make sure you record all measurements to the same number of significant figures or decimal places.

Handling data

2 Review your table. Are all of the measurements to the same number of decimal places or significant figures? Correct any that are not.

3 Calculate the average value for each measurement. Write the average values in the table.

Analysis

4 Compare your estimated and measured values. Comment on the values. Make reference to the data in your table to support your comments.

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5 Calculate the volume of the glass block, based on the measurements you have taken.

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Evaluation

6 Were the measuring instruments that you chose suitable in each case? Explain your answer and suggest what other instruments you could have used.

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7 List three of the instruments you used and give the precision of these instruments.

TIP

The precision of an instrument is the smallest scale division on the instrument.

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Practical investigation 1.2: The simple pendulum

KEY WORDS

mean: the mathematical term for the average of a range of numbers

meniscus: the lowest point of the top of a liquid

oscillation: the movement of an object from its start point to its furthest point and back again to the start

time period: the time taken for one complete oscillation

KEY EQUATION

average: the average of 12, 15 and 16 is 14.3: $\frac{12 + 15 + 16}{3} = 14.3$

IN THIS INVESTIGATION YOU WILL:

- use multiple measurements to calculate the average value for the time period of a pendulum
- determine if there is a relationship between the length of a pendulum and its time period.

YOU WILL NEED:

• pendulum bob • string • two small rectangular pieces of wood or cork board
• clamp stand • clamp • boss • stopwatch • ruler • C-clamp

Safety

Clamp the stand to the bench to ensure it is stable and cannot fall over and cause injury.

Getting started

Take a pendulum. Hold it between your fingers and look at how the pendulum moves.

Think about the things that you will need to consider in order to time the oscillation of the pendulum accurately. Write them down here.

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Now, working with a partner, think of ways in which you could adapt your method to make your measurements more accurate. Write them down here.

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Method

1 Tie the string to the pendulum bob to make a pendulum.

2 Hang the pendulum from the clamp stand and wait for it to come to rest (stop moving).

3 Use the ruler to measure the length of the pendulum from where the pendulum is held to the centre of its bob (its centre of gravity).

4 Keeping the string straight, move the pendulum bob to one side and release it, allowing it to swing at a steady pace. Use the stopwatch to time ten complete oscillations.

5 Repeat twice more and take an average of the results.

6 Repeat for four different lengths of pendulum.

Recording data

1 Record your measurements in the table.

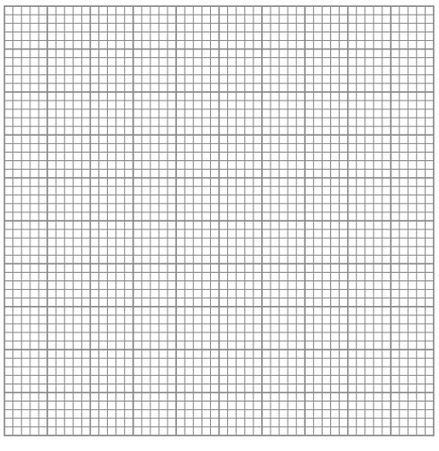
Length of pendulum / cm	Time taken for ten oscillations / s				Time period (time taken for one oscillation) / s
	1	2	3	Average (mean)	

Handling data

2 Calculate the time period for each pendulum length. Write the values in the table.

Analysis

3 Draw a graph of pendulum length against time period.



4 State and explain whether the length of the pendulum has an effect on the time period of an oscillation. Use your results to support your answer.

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Evaluation

5 Suggest another variable that might affect the time period of an oscillation.

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REFLECTION

How did you find recording the oscillations of your pendulum? With your partner, discuss one way in which you could have improved this investigation to make it easier to record the oscillations.

Practical investigation 1.3: Calculating the density of liquids

IN THIS INVESTIGATION YOU WILL:

- determine the densities of three common liquids by taking measurements of volume and mass.

YOU WILL NEED:

- 100 cm^3 measuring cylinder
- oil
- saltwater solution
- water
- balance
- safety goggles

Safety

- Some of the fluids in this investigation can cause mild irritation to the eyes. Use safety goggles at all times.
- Clear any spills immediately to prevent slipping.

Getting started

With your partner, discuss why knowing the density of a fluid is important. Write some ideas down in the space provided.

TIP

Think about convection and the weather.

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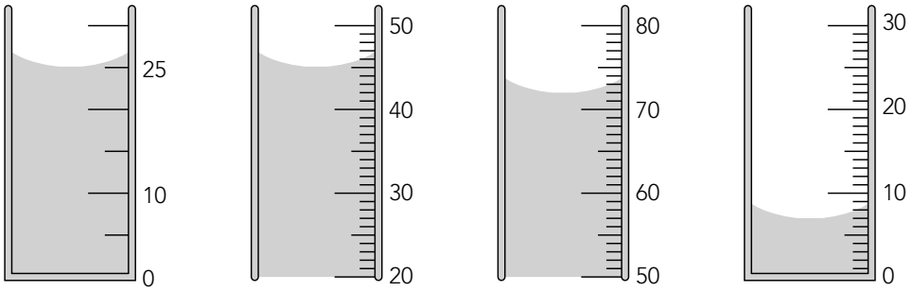
When you measure the volume of a liquid, it is important to ensure that the reading is taken correctly. The reading should always be taken at eye level, and using the meniscus of the liquid. Look at the example in Figure 1.1 and then try to read the volume of the remaining three measuring cylinders.



25 cm³ …… …… …… ……

Figure 1.1: Taking a reading from a measuring cylinder.

Method

1 Place the measuring cylinder on the balance. Set the balance to zero.

2 Add 50 cm³ of water to the measuring cylinder. Record the volume and mass of the water in the table on the next page.

3 Repeat for 60 cm³, 70 cm³, 80 cm³, 90 cm³ and 100 cm³. Record the volume and mass of the water in the table on the next page.

4 Empty and dry the measuring cylinder. Repeat steps **1–3** for the saltwater solution and the oil.

Recording data

1 Record your measurements in the tables.

Water	
Volume / cm^3	Mass / g

Saltwater solution	
Volume / cm^3	Mass / g

Oil	
Volume / cm^3	Mass / g

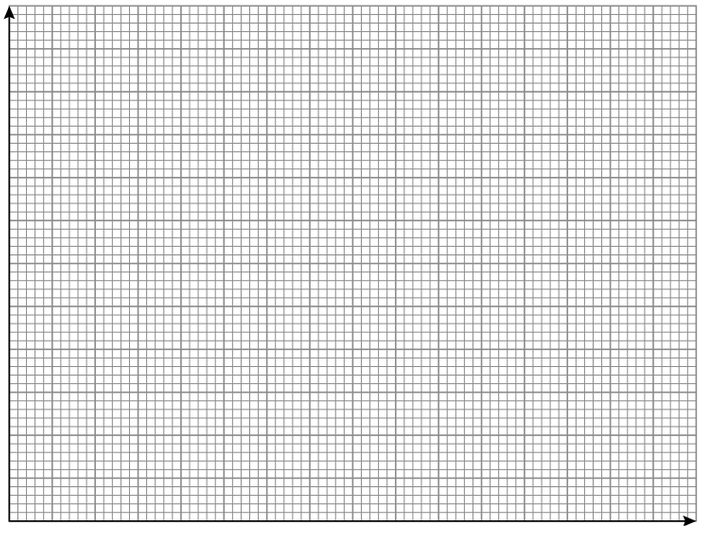
Handling data

2 Use your results to plot a graph of volume against mass for each of the liquids you have measured. Plot all three graphs on the grid provided.

TIP

When you draw the graph, label each axis and include the appropriate unit. For this graph, plot the volume along the horizontal axis and the mass up the vertical axis.

Remember to choose an appropriate scale for each axis.



Analysis

3 Draw a line of best fit for each of the liquids you have tested. Label them clearly.

4 The gradient of the line of best fit in each graph is equal to the density of the liquid. By looking at your graph, predict which liquid has the highest density. In the space below, explain how you can make this assumption by sight alone.

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5 Calculate the gradient of each of the lines of best fit. Do your values support your answer to question **4**?

Water ……

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Oil ……

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Saltwater solution ……

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6 Liquids that are less dense float on top of more dense substances. The liquids do not mix. In the measuring beaker shown, draw in the order in which the liquids would settle, labelling each one clearly.