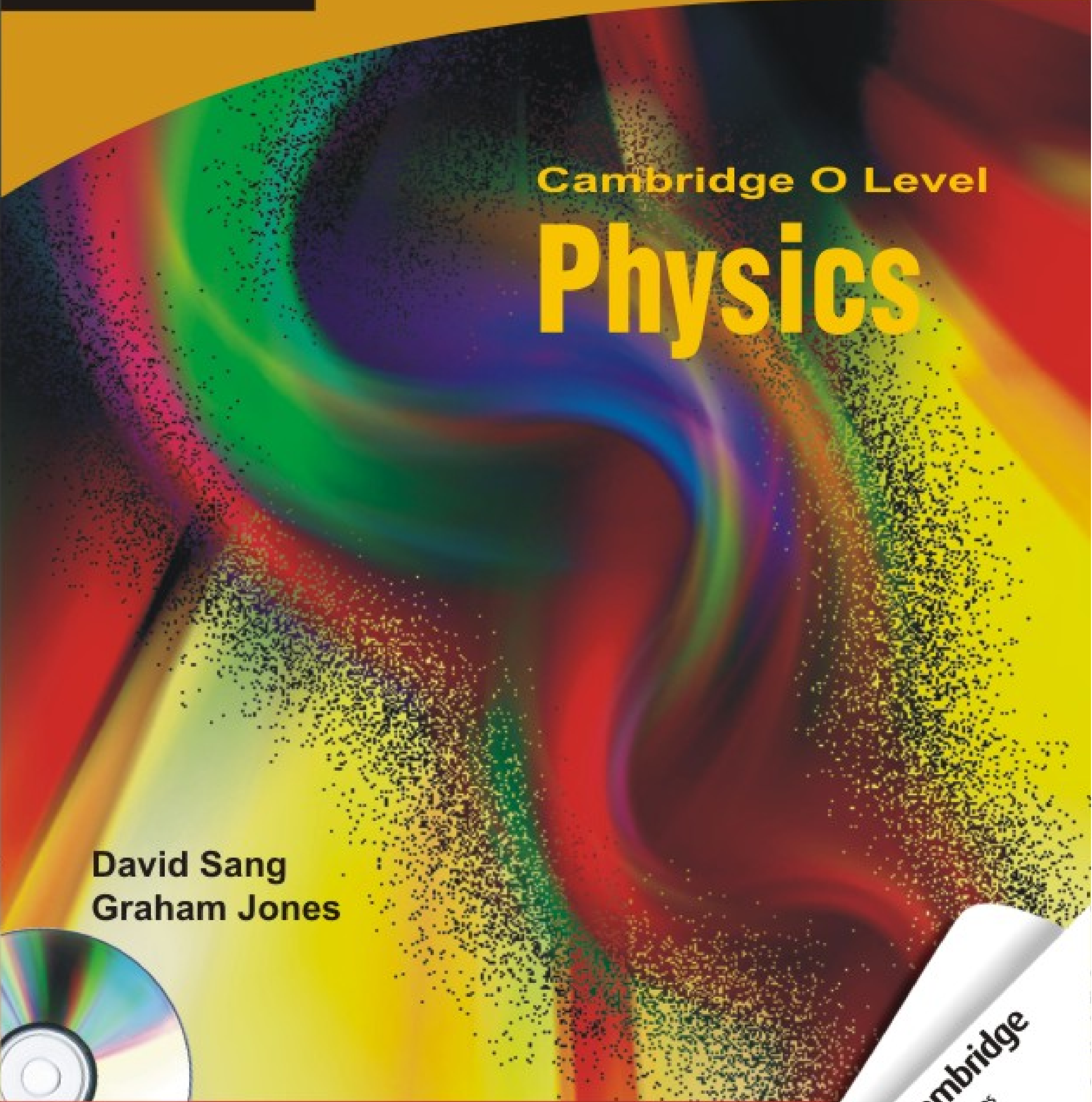
CAMBRIDGE



Cambridge O Level
Physics

David Sang
Graham Jones

Endorsed by
University of Cambridge
International Examinations

completely Cambridge
Cambridge resources for Cambridge qualifications

Cambridge O Level

Physics

David Sang

Graham Jones

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town,
Singapore, São Paulo, Delhi, Tokyo, Mexico City

Cambridge University Press
4381/4 Ansari Road, Daryaganj, Delhi 110002, India

www.cambridge.org
Information on this title: www.cambridge.org/9781107607835

© Cambridge University Press 2012

This publication is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without the written
permission of Cambridge University Press.

First published 2012

Printed in India at

A catalogue for this publication is available from the British Library

ISBN 978-1-107-60783-5 Paperback

Cambridge University Press has no responsibility for the persistence or
accuracy of URLs for external or third-party internet websites referred to in
this publication, and does not guarantee that any content on such websites is,
or will remain, accurate or appropriate. Information regarding prices, travel
timetables and other factual information given in this work is correct at
the time of first printing but Cambridge University Press does not guarantee
the accuracy of such information thereafter.

Contents

Acknowledgements

The publishers would like to thank the following for permission to reproduce photographs. While every effort has been made, it has not always been possible to identify the sources of all the material used, or to trace all copyright holders. If any omissions are brought to our notice we will be happy to include the appropriate acknowledgement on reprinting.

p. vii(*l*) AJ Photo/SPL; p. vii(*r*), 1.2 Andrew Brookes, National Physical Laboratory/SPL; p. viii(*l*) Mark Garlick/SPL; p. viii(*r*) Volker Steger/SPL; p. 1, 6.11, 15.6, p.173 NASA/SPL; 1.1, 5.8, 20.1, 21.4, 23.5 SPL; 1.12 GoGo Images Corporation/Alamy; 2.1 TRL Ltd/SPL; 2.3, 6.7, 13.22, 15.1 Nigel Luckhurst; 2.7 Brian F. Peterson/Corbis; 2.8 Alejandro Ernesto/EFE/Corbis; 3.1 Nelson Jeans/Corbis; 3.2 Scott Andrews/Science Faction/Corbis; 3.9 Birdlike Images Gregory Bajor/Alamy; 3.10 Eric Schremp/SPL; 3.13 Stockshot/Alamy; 4.1 Frans Lemmens/zefa/Corbis; 4.12 NCNA, Camera Press London; 5.2, 6.13 Gustoimages/SPL; 5.3 PhotoStock-Israel/Alamy; 5.9 Colin Cuthbert/SPL; 5.10 imagebroker/Alamy; 5.11 Alexis Rosenfeld/SPL; 6.1 Jeff Rotman/naturepl; 6.5 Visions of America LLC/Alamy; 6.6a European Space Agency/SPL; 6.10a, 9.11, 10.5a, 10.8, 10.9a, 10.9b, 13.2, 13.6a, 13.8, 13.9, 13.14, 13.18, 13.20, 14.4a, 14.4b, 14.10a, 18.3a, 18.4, 18.13, 19.4a, 19.5a, 19.6a, 19.17a, 19.29, 20.15, 23.10 Andrew Lambert/SPL; 7.1 Jim Wileman/Alamy; 7.3 Liba Taylor/Corbis; 7.4 Ryan Pyle/Corbis; 7.6 BNFL; 7.7 Worldwide Picture Library/Alamy; 8.7 Ace Stock Limited/Alamy; 9.1 Caro/Alamy; 9.8 81A Productions/Corbis; 10.1 Bubbles Photolibrary/Alamy; 10.2a CC Studio/SPL; 10.2b Paul Whitehall/SPL; 10.12 Matt Meadows/SPL; 11.1 Staffan Widstrand/naturepl; 11.2 Karl Ammann/naturepl; 11.7 Dr Gary Settler/SPL; 11.8, 12.8 sciencephotos/Alamy; 11.11 Edward Kinsman/SPL; 11.12 Justin Kaze zsixz/Alamy; p. 127 AFP/Getty Images; 12.1 Jill Douglas/Redferns/Getty Images; 12.2 John Eccles/Alamy; 12.3 Cardiff University; 12.4(*t*) Mode Images Limited/Alamy; 12.4(*b*) Niall McDiarmid/Alamy; 12.5 David Redfern/Redferns/Getty Images; 13.1 Royal Grenwich Observatory/SPL; 13.3 Hank Morgan/SPL; 13.4 Mark Bowler Scientific Images/www.markbowler.com; 13.16a, 23.18 TEK Image/SPL; 13.17 Dr Jeremy Burgess/SPL; 14.1 David Hosking/FLPA; 14.2 Rick Strange/Alamy; 14.11a Berenice Abbott/SPL; 15.2, p. 249 David Parker/SPL; 15.4 CCI Archives/SPL; 15.9 David R. Frazier/SPL; 16.1 The London Art Archive/Alamy; 16.7 Cordelia Molloy/SPL; 16.10 Jeremy Walker/SPL; 17.1 Photo Researchers/SPL; 18.1 Maximilian Stock Ltd/Alamy; 18.2 Martin Dorhn/SPL; 19.1 Rosenfeld Images Ltd/SPL; 19.3, 19.30a, 23.15a Leslie Garland Picture Library/Alamy; 19.31 Sheila Terry/SPL; 21.1a, 21.1b Adam Hart-Davis/SPL; 21.3 Alex Bartel/SPL; 21.8 Ed Michaels/SPL; 21.9 D Burke/Alamy; 22.1 David Simson; 22.2 IBM/SPL; 23.1 Radiation Protection Division/Health Protection Agency/SPL; 23.2 US Air Force/SPL; 23.3 Yoav Levy/Phototake Science/Photolibrary; 23.6 Pascal Goetgheluck/SPL; 23.16 National Radiation Protection Board; 23.19 P. Deliss/Godong/Corbis

b = bottom, *l* = left, *r* = right, *t* = top, SPL = Science Photo Library

Introduction

Studying physics

Why study physics? Some people study physics for the simple reason that they find it interesting. Physicists study matter, energy and their interactions. They might be interested in the tiniest sub-atomic particles, or the nature of the Universe itself. (Some even hope to discover whether there are more universes than just the one we live in!)

When they were first discovered, X-rays were sometimes treated as an entertaining novelty. Today, they can give detailed views of a patient's bones and organs.

On a more human scale, physicists study materials to try to predict and control their properties. They study the interactions of radiation with matter, including the biological materials we are made of.

Some people don't want to study physics simply for its own sake. They want to know how it can be used, perhaps in an engineering project, or for medical purposes. Depending on how our knowledge is applied, it can make the world a better place.

Some people study physics as part of their course because they want to become some other type of scientist – perhaps a chemist, biologist or geologist. These branches of science draw a great deal on ideas from physics, and physics may draw on them.

Thinking physics

How do physicists think? One of the characteristics of physicists is that they try to simplify problems – reduce them to their basics – and then solve them by applying

Physicists often work in extreme conditions. Here, physicists at the UK's National Physical Laboratory prepare a dilution refrigerator, capable of cooling materials down almost to absolute zero, the lowest possible temperature.

The Milky Way, our Galaxy. Although we can never hope to see it from this angle, careful measurements of the positions of millions of stars has allowed astronomers to produce this computer-generated view.

some very fundamental ideas. For example, you will be familiar with the idea that matter is made of tiny particles that attract and repel each other and move about. This is a very powerful idea, which has helped us to understand the behaviour of matter, how sound travels, how electricity flows, and so on.

Once a fundamental idea is established, physicists look around for other areas where it might help to solve problems. One of the surprises of 20th-century physics was that, once physicists had begun to understand the fundamental particles of which atoms are made, they realised that this helped to explain the earliest moments in the history of the Universe, at the time of the Big Bang.

The more you study physics, the more you will come to realise how the ideas join up. Also, physics is still expanding. Many physicists work in economics and finance, using ideas from physics to predict how markets will change. Others use their understanding of

The Internet, used by millions around the world. Originally invented by a physicist, Tim Berners-Lee, the Internet is used by physicists to link thousands of computers in different countries to form supercomputers capable of handling vast amounts of data.

particles in motion to predict how traffic will flow, or how people will move in crowded spaces.

Physics relies on mathematics. Physicists measure quantities and process their data. They invent mathematical models – equations and so on – to explain their findings. (In fact, a great deal of mathematics was invented by physicists, to help them to understand their experimental results.)

Computers have made a big difference in physics. Because a computer can 'crunch' vast quantities of data, whole new fields of physics have opened up. Computers can analyse data from telescopes, control distant spacecraft and predict the behaviour of billions of atoms in a solid material.

Joining in

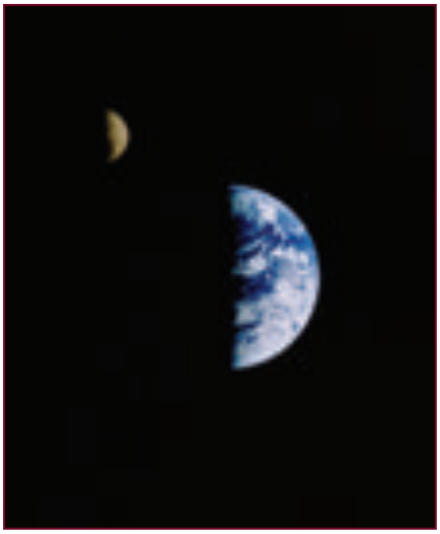
So, when you study physics, you are doing two things. You are joining in with a big human project – learning more about the world around us, and applying that knowledge. At the same time, you will be learning to think like a physicist – how to apply some basic ideas, how to look critically at data, and how to recognise underlying patterns. Whatever your aim, these ideas can stay with you throughout your life.

Block 1

General physics

In your studies of science, you will already have come across many of the fundamental ideas of physics. In this block, you will develop a better understanding of two powerful ideas: (i) the idea of force and (ii) the idea of energy.

Where do ideas in physics come from? Partly, they come from observation. When Galileo looked at the planets through his telescope, he observed the changing face of Venus. He also saw that Jupiter had moons. Galileo's observations formed the basis of a new, more scientific, astronomy.



In 1992, a spacecraft named Galileo was sent to photograph Jupiter and its moons. On its way, it looked back to take this photograph of the Earth and the Moon.

Ideas also come from thought. Newton (who was born in the year that Galileo died) is famous for his ideas about gravity. He realised that the force that pulls an apple to the ground is the same force that keeps the Moon in its orbit around the Earth. His ideas about forces are explored in this block.

You have probably studied some basic ideas about energy. However, Newton never knew about energy. This was an idea that was not developed until more than a century after his death, so you are already one step ahead of him!

1 Making measurements

Objectives

- Making measurements of length, volume and time
- Increasing the precision of measurements of length and time
- Determining the densities of solids and liquids

How measurement improves?

Galileo Galilei is often thought of as the father of modern science. He did a lot to revolutionise how we think of the world around us, and in particular how we make measurements. In 1582, Galileo was a medical student in Pisa. During a service in the cathedral there, he observed a lamp swinging (Figure **1.1**). Galileo noticed that the time it took for each swing was the same, whether the lamp was swinging through a large or a small angle. He realised that a swinging weight – a pendulum – could be used as a timing device. He went on to use it to measure a person's pulse rate, and he also designed a clock regulated by a swinging pendulum.

In Galileo's day, many measurements were based on the human body – for example, the foot and the yard (a pace). Weights were measured in units based on familiar objects such as cereal grains. These 'natural' units are inevitably variable – one person's foot is longer than another's – so efforts were made to standardise them. (It is said that the English 'yard' was defined as the distance from the tip of King Henry I's nose to the end of his outstretched arm.)

Today, we live in a globalised economy. We cannot rely on monarchs to be our standards of measurement. Instead, there are international agreements on the basic units of measurement. For example, the metre is defined as follows:

The metre is the distance travelled by light in $\frac{1}{299\,792\,458}$ second in a vacuum.

Laboratories around the world are set up to check that measuring devices match this standard.

Figure 1.1 An imaginative reconstruction of Galileo with the lamp that he saw swinging in Pisa Cathedral in 1582.

Figure 1.2 Professor Patrick Gill of the National Physical Laboratory is devising an atomic clock that will be one-thousand times more accurate than previous types.

Figure **1.2** shows a new atomic clock, undergoing development at the UK's National Physical Laboratory. Clocks like this are accurate to 1 part in 10^{14}, or one-billionth of a second in a day. You might think that this is far more precise than we could ever need. In fact, you may already rely on ultra-precise time measurements if you use a GPS (Global Positioning Satellite) system. These systems detect satellite signals, and they work out your position to within a fraction of a metre. Light travels one metre in about $\frac{1}{300\,000\,000}$ second, or 0.000 000 003 second. So, if you are one metre further away from the satellite, the signal will arrive this tiny fraction of a second later. Hence the electronic circuits of the GPS device must measure the time at which the signal arrives to this degree of accuracy.

1.1 Measuring length and volume

In physics, we make measurements of many different lengths – for example, the length of a piece of wire, the height of liquid in a tube, the distance moved by an object, the diameter of a planet or the radius of its orbit. In the laboratory, lengths are often measured using a rule (such as a metre rule).

Measuring lengths with a rule is a familiar task. But when you use a rule, it is worth thinking about the task and just how reliable your measurements may be. Consider measuring the length of a piece of wire (Figure **1.3**).

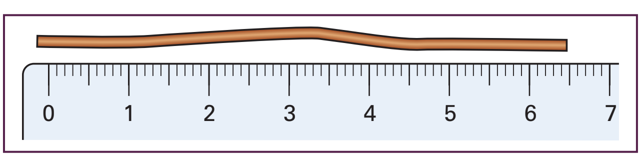


Figure 1.3 Simple measurements – for example, finding the length of a wire – still require careful technique.

- The wire must be straight, and laid closely alongside the rule. (This may be tricky with a bent piece of wire.)
- Look at the ends of the wire. Are they cut neatly, or are they ragged? Is it difficult to judge where the wire begins and ends?
- Look at the markings on the rule. They are probably 1 mm apart, but they may be quite wide. Line one end of the wire up against the zero of the scale. Because of the width of the mark, this may be awkward to judge.
- Look at the other end of the wire and read the scale. Again, this may be tricky to judge.

Now you have a measurement, with an idea of how precise it is. You can probably determine the length of the wire to within a millimetre. But there is something else to think about – the rule itself. How sure can you be that it is correctly calibrated? Are the marks at the ends of a metre rule separated by exactly one metre? Any error in this will lead to an inaccuracy (probably small) in your result.

The point here is to recognise that it is always important to think critically about the measurements you make, however straightforward they may seem. You have to consider the method you use, as well as the instrument (in this case, the rule).

More measurement techniques

If you have to measure a small length, such as the thickness of a wire, it may be better to measure several thicknesses and then calculate the average. You can use the same approach when measuring

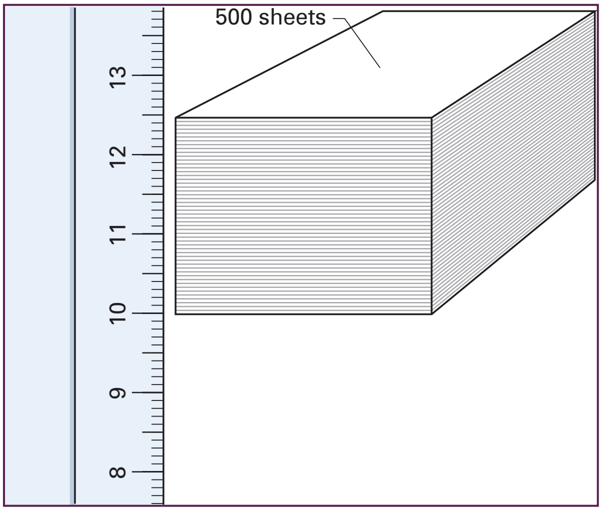


Figure 1.4 Making multiple measurements.

something very thin, such as a sheet of paper. Take a stack of 500 sheets and measure its thickness with a rule (Figure **1.4**). Then divide by 500 to find the thickness of one sheet.

For some measurements of length, such as curved lines, it can help to lay a thread along the line. Mark the thread at either end of the line and then lay it along a rule to find the length. This technique can also be used for measuring the circumference of a cylindrical object such as a wooden rod or a measuring cylinder.

Measuring volumes

There are two approaches to measuring volumes, depending on whether or not the shape is regular.

For a regularly shaped object, such as a rectangular block, measure the lengths of the three different sides and multiply them together. For objects of other regular shapes, such as spheres or cylinders, you may have to make one or two measurements and then look up the formula for the volume.

For liquids, measuring cylinders can be used. (Recall that these are designed so that you look at the scale **horizontally**, not at an oblique angle, and read the level of the **bottom** of the meniscus.) Think carefully about the choice of cylinder. A one-litre cylinder is unlikely to be suitable for measuring a small volume such as 5 cm^3. You will get a more accurate answer using a 10 cm^3 cylinder.

Units of length and volume

In physics, we generally use SI units (this is short for *Le Système International d'Unités* or The International System of Units). The SI unit of length is the metre (m). Table **1.1** shows some alternative units of length, together with some units of volume.

Quantity	Units
length	metre (m)
	1 centimetre (cm) = 0.01 m
	1 millimetre (mm) = 0.001 m
	1 micrometre (μm) = 0.000 001 m
	1 kilometre (km) = 1000 m
volume	cubic metre (m^3)
	1 cubic centimetre (cm^3) = 0.000 001 m^3
	1 cubic decimetre (dm^3) = 0.001 m^3
	1 litre (l) = 0.001 m^3
	1 litre (l) = 1 cubic decimetre (dm^3)
	1 millilitre (ml) = 1 cubic centimetre (cm^3)

Table 1.1 Some units of length and volume in the SI system.

QUESTIONS

1 A rectangular block of wood has dimensions 240 mm × 20.5 cm × 0.040 m. Calculate its volume in cm^3.

2 Ten identical lengths of wire are laid closely side-by-side. Their combined width is measured and found to be 14.2 mm. Calculate:

a the radius of a single wire

b the volume in mm^3 of a single wire if its length is 10.0 cm. (Volume of a cylinder = $\pi r^2 h$, where r = radius and h = height.)

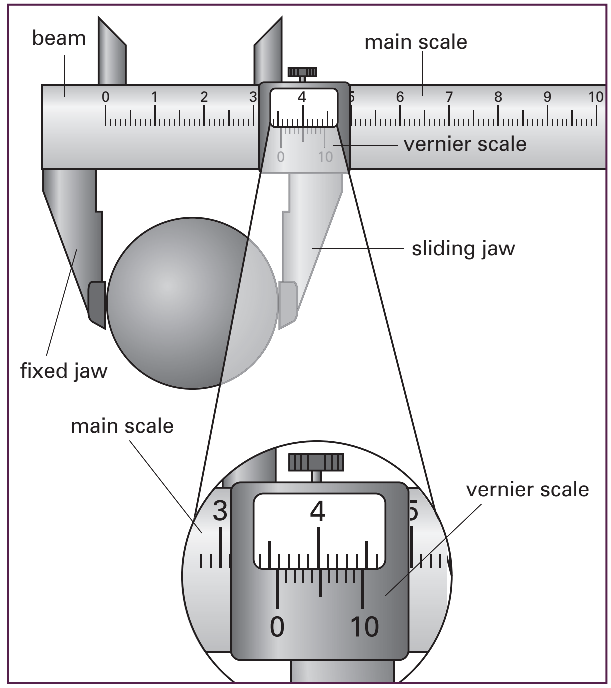


Figure 1.5 Using vernier callipers.

1.2 Improving precision in measurements

A rule is a simple measuring instrument, with many uses. However, there are instruments designed to give greater precision in measurements. Here we will look at how to use two of these.

Vernier callipers

The callipers have two scales, the main scale and the vernier scale. Together, these scales give a measurement of the distance between the two inner faces of the jaws (Figure **1.5**).

The method is as follows:

- Close the callipers so that the jaws touch lightly but firmly on the sides of the object being measured.
- Look at the zero on the vernier scale. Read the main scale, just to the left of the zero. This tells you the length in millimetres.
- Now look at the vernier scale. Find the point where one of its markings is **exactly** aligned with one of the markings on the main scale. Read the value on the vernier scale. This tells you the fraction of a millimetre that you must add to the main scale reading.

For the example in Figure **1.5**:

thickness of rod
= main scale reading + vernier reading
= 35 mm + 0.7 mm
= 35.7 mm

Micrometer screw gauge

Again, this has two scales. The main scale is on the shaft, and the fractional scale is on the rotating barrel. The fractional scale has 50 divisions, so that one complete turn represents 0.50 mm (Figure **1.6**).

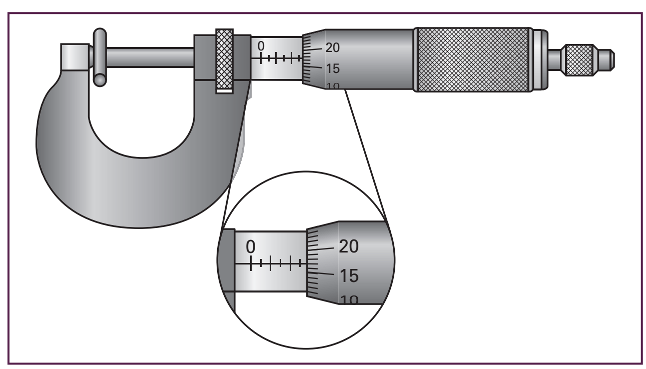


Figure 1.6 Using a micrometer screw gauge.

The method is as follows:

- Turn the barrel until the jaws just tighten on the object. Using the friction clutch ensures just the right pressure.

- Read the main scale to the nearest 0.5 mm.
- Read the additional fraction of a millimetre from the fractional scale.

For the example in Figure **1.6**:

thickness of rod
= main scale reading + fractional scale reading
= 2.5 mm + 0.17 mm
= 2.67 mm

Activity 1.1 Precise measurements

Practise reading the scales of vernier callipers and micrometer screw gauges.

Measuring volume by displacement

It is not just instruments that improve our measurements. Techniques also can be devised to help. Here is a simple example, to measure the volume of an irregularly shaped object:

- Select a measuring cylinder that is somewhat (three or four times) larger than the object. Partially fill it with water (Figure **1.7**), enough to cover the object. Note the volume of the water.
- Immerse the object in the water. The level of water in the cylinder will increase. The increase in its volume is equal to the volume of the object.

This technique is known as measuring volume by displacement.

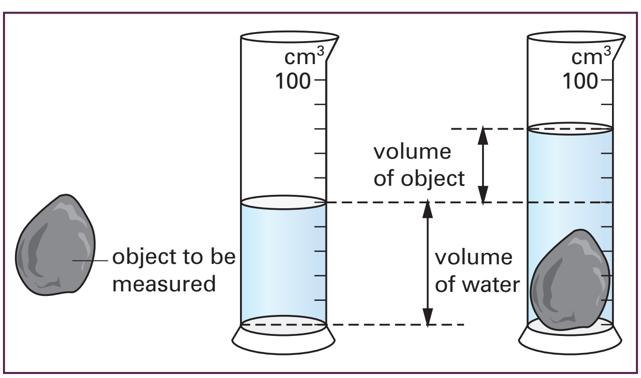


Figure 1.7 Measuring volume by displacement.

QUESTIONS

3 State the measurements shown in Figure **1.8** on the scale of

a the vernier callipers

b the micrometer screw gauge.

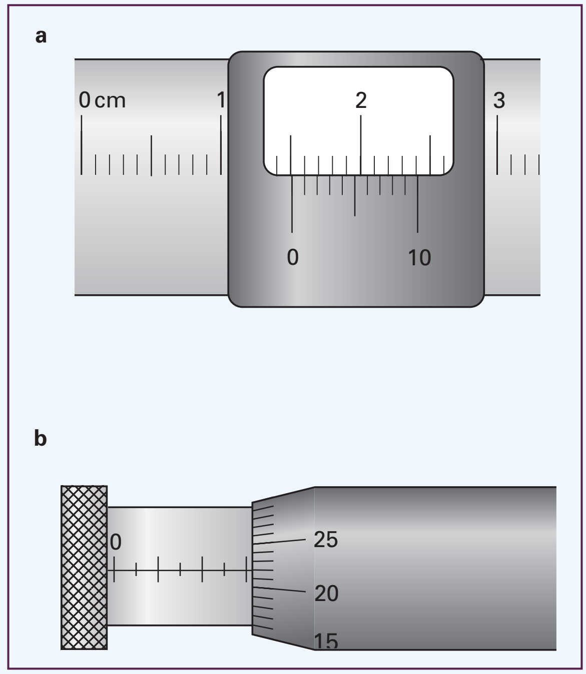


Figure 1.8 For Question **3**.

4 Figure **1.9** shows how the volume of a piece of wood (which floats in water) can be measured. Write a brief paragraph to describe the procedure. State the volume of the wood.

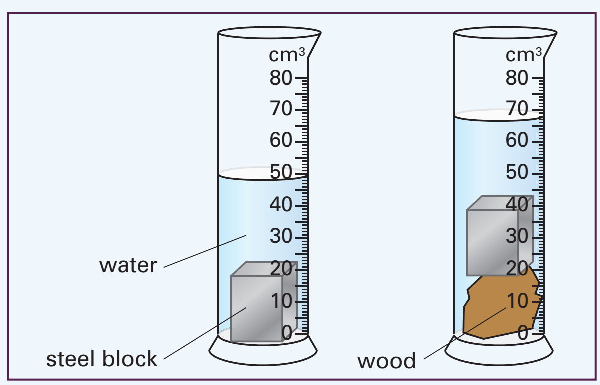


Figure 1.9 For Question **4**.

1.3 Density

Our eyes can deceive us. When we look at an object, we can judge its volume. However, we can only guess its mass. We may guess incorrectly, because we misjudge the density. You may offer to carry someone's bag, only to discover that it contains heavy books. A large box of chocolates may have a mass of only 200 g, a great disappointment!

The **mass** of an object is the amount of matter it is made of. Mass is measured in kilograms. But **density** is a property of a material. It tells us how concentrated its mass is. (There is more about the meaning of **mass** and how it differs from **weight** in Chapter **3**.)

In everyday speech, we might say that lead is heavier than wood. We mean that, given equal volumes of lead and wood, the lead is heavier. In scientific terms, the density of lead is greater than the density of wood. So we define density as follows:

$$\text{density} = \frac{\text{mass}}{\text{volume}} \qquad D = \frac{M}{V}$$

The SI unit of density is kg/m^3 (kilograms per cubic metre). You may come across other units, as shown in Table **1.2**. A useful value to remember is the density of water (Table **1.3**):

density of water = $1000\,kg/m^3$

Unit of mass	Unit of volume	Unit of density	Density of water
kilogram, kg	cubic metre, m^3	kilograms per cubic metre	$1000\,kg/m^3$
kilogram, kg	litre, l	kilograms per litre	1.0 kg/litre
kilogram, kg	cubic decimetre, dm^3	kilograms per cubic decimetre	$1.0\,kg/dm^3$
gram, g	cubic centimetre, cm^3	grams per cubic centimetre	$1.0\,g/cm^3$

Table 1.2 Units of density.

	Material	Density / kg/m^3
gases	air	1.29
	hydrogen	0.09
	helium	0.18
	carbon dioxide	1.98
liquids	water	1 000
	alcohol (ethanol)	790
	mercury	13 600

	Material	Density / kg/m^3
solids	ice	920
	wood	400–1 200
	polythene	910–970
	glass	2 500–4 200
	steel	7 500–8 100
	lead	11 340
	silver	10 500
	gold	19 300

Table 1.3 Densities of some substances. For gases, these are given at a temperature of 0 °C and a pressure of 1.0×10^5 Pa.

Values of density

Some values of density are shown in Table **1.3**. Here are some points to note:

- Gases have much lower densities than solids or liquids.
- Density is the key to floating. Ice is less dense than water. This explains why icebergs float in the sea, rather than sinking to the bottom.
- Many materials have a range of densities. Some types of wood, for example, are less dense than water and will float. Others (such as mahogany) are more dense and sink. The density depends on the composition.
- Gold is denser than silver. Pure gold is a soft metal, so jewellers add silver to make it harder. The amount of silver added can be judged by measuring the density.
- It is useful to remember that the density of water is 1000 kg/m^3, 1.0 g/cm^3 or 1 kg/litre.

Calculating density

To calculate the density of a material, we need to know the mass and volume of a sample of the material.

Worked example 1

A sample of ethanol has a volume of 240 cm^3. Its mass is found to be 190.0 g. What is the density of ethanol?

Step 1: Write down what you know and what you want to know.

mass M = 190.0 g
volume V = 240 cm^3
density D = ?

Step 2: Write down the equation for density, substitute values and calculate D.

$$D = \frac{M}{V} = \frac{190}{240} = 0.79\ \text{g/cm}^3$$

Measuring density

The easiest way to determine the density of a substance is to find the mass and volume of a sample of the substance.

For a solid with a regular shape, find its volume by measurement (see page **4**). Find its mass using a balance. Then calculate the density.

Figure **1.10** shows one way to find the density of a liquid. Place a measuring cylinder on a balance. Set the balance to zero. Now pour liquid into the cylinder. Read the volume from the scale on the cylinder. The balance shows the mass.

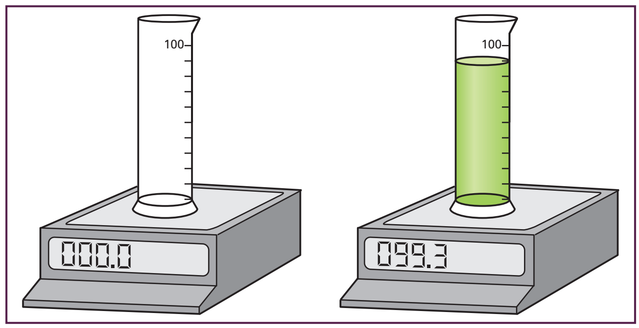


Figure 1.10 Measuring the density of a liquid.

Activity 1.2 Measuring density

Make measurements to find the densities of some blocks of different materials.

QUESTIONS

5 Calculate the density of mercury if 500 cm^3 has a mass of 6.60 kg. Give your answer in g/cm^3.

6 A steel block has mass 40 g. It is in the form of a cube. Each edge of the cube is 1.74 cm long. Calculate the density of the steel.

7 A student measures the density of a piece of steel. She uses the method of displacement to find its volume. Figure **1.11** shows her measurements. Calculate the volume of the steel and its density.

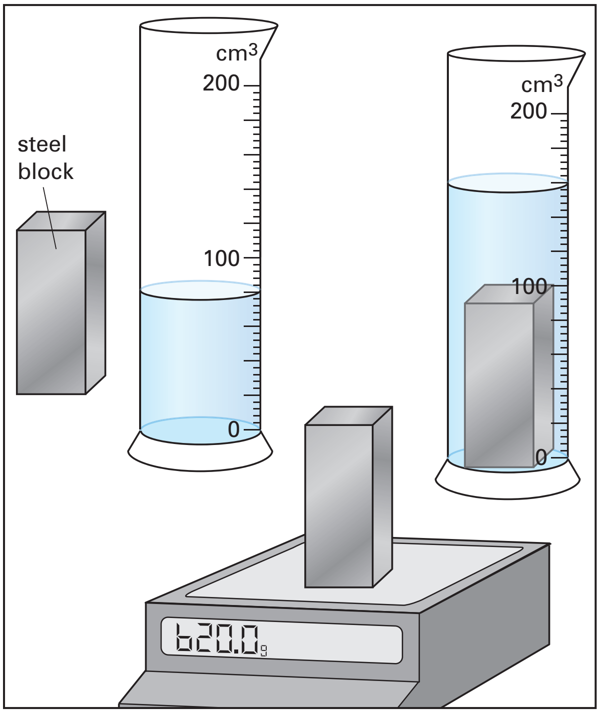


Figure 1.11 For Question **7**.

1.4 Measuring time

The athletics coach in Figure **1.12** is using her stopwatch to time a sprinter. For a sprinter, a fraction of a second (perhaps just 0.01 s) can make all the difference between winning and coming second or third. It is different in a marathon, where the race lasts for more than two hours and the runners are timed to the nearest second.

Figure 1.12 The female athletics coach uses a stopwatch to time a sprinter, who can then learn whether she has improved.

In the lab, you might need to record the temperature of a container of water every minute, or find the time for which an electric current is flowing. For measurements like these, stopclocks and stopwatches can be used.

When studying motion, you may need to measure the time taken for a rapidly moving object to move between two points. In this case, you might use a device called a light gate connected to an electronic timer. This is similar to the way in which runners are timed in major athletics events. An electronic timer starts when the marshal's gun is fired, and stops as the runner crosses the finishing line.

There is more about how to use electronic timing instruments in Chapter **2**.

Measuring short intervals of time

The time for one swing of a pendulum (from left to right and back again) is called its **period**. A single period is usually too short a time to measure accurately. However, because a pendulum swings at a steady rate, you can use a stopwatch to measure the time for a large number of swings (perhaps 20 or 50), and calculate the average time per swing. Any inaccuracy in the time at which the stopwatch is started and stopped will be much less significant if you measure the total time for a large number of swings.

Activity 1.3 The period of a pendulum

Figure **1.13** shows a typical lab pendulum. Devise a means of testing Galileo's idea that the period of a pendulum does not depend on the size of its swing.

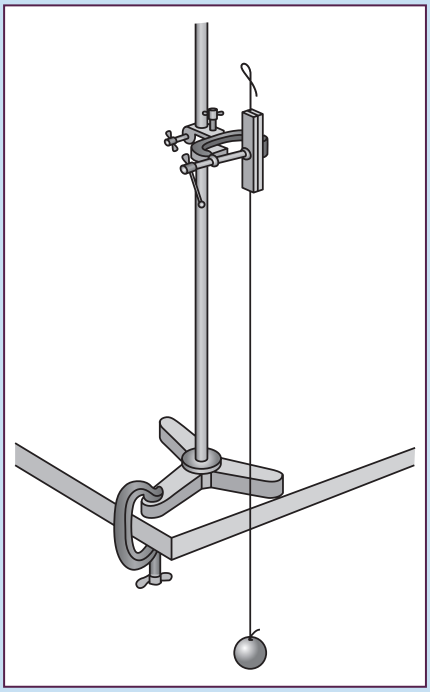


Figure 1.13 A simple pendulum.

QUESTIONS

8 Many television sets show 25 images, called 'frames', each second. What is the time interval between one frame and the next?

9 A pendulum is timed, first for 20 swings and then for 50 swings:

time for 20 swings = 17.4 s
time for 50 swings = 43.2 s

Calculate the average time per swing in each case. The answers are slightly different. Can you suggest any experimental reasons for this?

Summary

Rules and measuring cylinders are used to measure length and volume.

Clocks and electronic timers are used to measure intervals of time.

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Measurements of small quantities can be improved using special instruments (for example, vernier callipers and micrometer screw gauge) or by making multiple measurements.

End-of-chapter questions

1.1 An ice cube has the dimensions shown in Figure **1.14**. Its mass is 340 g. Calculate:

a its volume [3]

b its density. [3]

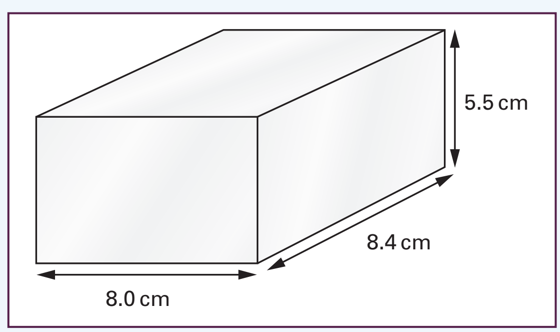


Figure 1.14 A block of ice – for Question **1.1**.

1.2 A student is collecting water as it runs into a measuring cylinder. She uses a clock to measure the time interval between measurements. Figure **1.15** shows the level of water in the cylinder at two times, together with the clock at these times. Calculate:

a the volume of water collected between these two times [2]

b the time interval. [2]

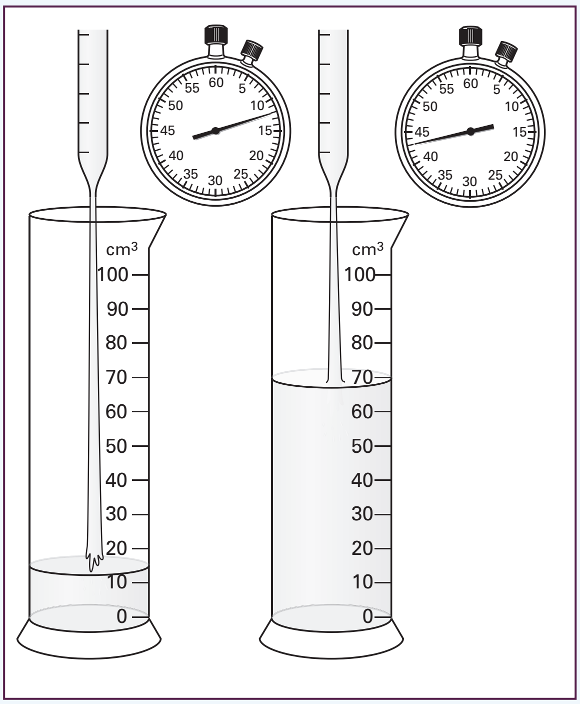


Figure 1.15 For Question **1.2**.

1.3 A student is measuring the density of a liquid. He places a measuring cylinder on a balance and records its mass. He then pours liquid into the cylinder and records the new reading on the balance. He also records the volume of the liquid.

Mass of empty cylinder = 147 g

Mass of cylinder + liquid = 203 g

Volume of liquid = 59 cm^3

Using the results shown above, calculate the density of the liquid. [5]

1.4 The inside of a sports hall measures 80 m long by 40 m wide by 15 m high. The air in it has a density of 1.3 kg/m^3 when it is cool.

a Calculate the volume of the air in the sports hall, in m^3. [3]

b Calculate the mass of the air. State the equation you are using. [3]

1.5 A geologist needs to measure the density of an irregularly shaped pebble.

a Describe how she can find its volume by the method of displacement. [4]

b What other measurement must she make if she is to find its density? [1]

1.6 An O-level student thinks it may be possible to identify different rocks (A, B and C) by measuring their densities. She uses an electronic balance to measure the mass of each sample and uses the 'displacement method' to determine the volume of each sample. Figure **1.16** shows her displacement results for sample A.

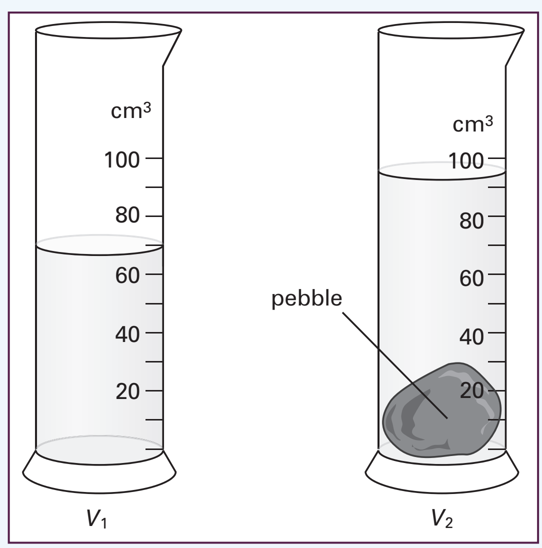


Figure 1.16 For Question **1.6**.

Sample	m / g	…… /……	…… /……	V /……	Density /……
B	144	80	44	……	……
C	166	124	71	……	……

Table 1.4 For Question **1.6**.

a State the volume shown in each measuring cylinder. [2]

b Calculate the volume V of the rock sample A. [2]

c Sample A has a mass of 102 g. Calculate its density. [3]

Table **1.4** shows the student's readings for samples B and C.

d Copy and complete the table by inserting the appropriate column headings and units, and calculating the densities. [12]