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David Sang , Darrell Hamilton
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Chapter 1

Making measurements

Measurements and units

Exercise 1.1

IN THIS EXERCISE YOU WILL:

recall and use the SI units used in physics.

Focus

1 a State the SI units (name and symbol) of the following quantities:

length

....

volume

....

b State the name in words and the symbol for the following:

one thousand metres

....

one-thousandth of a metre

....

c How many?

State the number of centimetres there are in a metre. ....

State the number of litres there are in a cubic metre. ....

Practice

2 a State how many cm^2 there are in 1 m^2.

....

b State how many m^2 there are in 1 km^2.

....

Challenge

3 A cube has sides 3.50 m long. Calculate:

a the surface area of the cube in cm^2.

....

....

....

....

....

b the volume of the cube in mm^3.

....

....

....

....

....

Practical applications

KEY WORD

density: the ratio of mass to volume for a substance

KEY EQUATION

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

$$\rho = \frac{m}{V}$$

Exercise 1.2

IN THIS EXERCISE YOU WILL:

- practise converting between units
- practise applying the density formula
- apply your understanding of how density affects the behaviour of materials.

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TIP

Don't assume that you know the answer. Always work it out. For example, 1 m³ in mm³ is 1000 × 1000 × 1000 mm³, since there are 1000 mm in 1 m.

Focus

1 a Some data about the density of various solids and liquids are shown in Table 1.1. Complete the fourth column in Table 1.1 by converting each density in kg/m³ to the equivalent value in g/cm³. The first two have been done for you.

Material	State / type	Density / kg/m³	Density / g/cm³
water	liquid / non-metal	1000	1.000
ethanol	liquid / non-metal	800	0.800
olive oil	liquid / non-metal	920	
mercury	liquid / metal	13500	
ice	solid / non-metal	920	
diamond	solid / non-metal	3500	
cork	solid / non-metal	250	
chalk	solid / non-metal	2700	
iron	solid / metal	7900	
tungsten	solid / metal	19300	
aluminium	solid / metal	2700	
gold	solid / metal	19300	

Table 1.1 Densities of various solids and liquids

Two units are used for the densities, kg/m³ and g/cm³.

b Use the data to explain why ice floats on water.

....

....

2 A cook mixes equal volumes of water and olive oil in a jar. Predict whether one liquid will float on another liquid based on the data given in Table 1.1. Assume that the liquids do not mix.

....

....

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Practice

3 A learner wrote: 'These data show that metals are denser than non-metals.' Do you agree? Explain your answer, using the data in Table 1.1.

....

....

....

....

....

4 Using the data in Table 1.1, calculate the mass of a block of gold that measures 20 cm × 15 cm × 10 cm. State your answer in kg.

....

....

....

....

....

5 A metalworker finds a block of silvery metal, weighs it and measures its volume. Here are their results:

mass of block = 0.270 kg

volume of block = 14.0 cm^3

Calculate the density of the block.

Suggest what metal this might be. ....

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Challenge

6 Describe how you could find the density of the metal object in Figure 1.1.

Include:

- the equipment you would use
- how you would use the equipment
- what you would do with the data you collect.

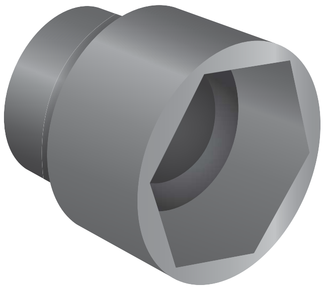

Figure 1.1

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Exercise 1.3

IN THIS EXERCISE YOU WILL:

find out how good your pulse would be as a means of measuring time intervals.

Galileo used the regular pulse of his heart as a means of measuring intervals of time, until he noticed that a swinging pendulum was more reliable.

In this exercise, you need to be able to measure the pulse in your wrist. Place two fingers of one hand gently on the inside of the opposite wrist (see Figure 1.2). Press gently at different points until you find the pulse. Alternatively, press two fingers gently under your jawbone on either side of your neck.

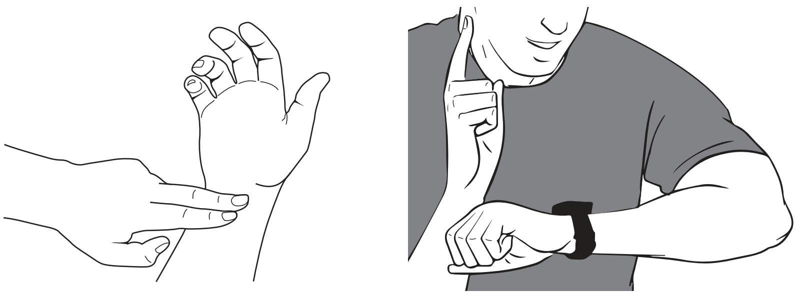

Figure 1.2: Taking a pulse.

You will also need a clock or watch that will allow you to measure intervals of time in seconds.

Focus

1 **a** Start by timing 10 pulses. (Remember to start counting from zero: 0, 1, 2, 3, …, 9, 10.) Repeat this several times and record your results in the table.

b Comment on your results.

i How much do your results vary?

....

....

ii Give a possible reason for this: is it difficult to time the pulses or is your heart rate varying?

....

....

c Calculate the average time for one pulse using your results.

....

....

....

Practice

2 Time how long it takes for 50 pulses. Record your results in the table.

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3 Calculate the average time for one pulse.

....

....

....

Challenge

4 Investigate how your pulse changes if you take some gentle exercise, for example, by walking briskly, or by walking up and down stairs.

Write up your investigation in the lined space. Use the following as a guide.

- Briefly describe your gentle exercise.
- State the measurements of pulse rate that you have made.
- Comment on whether you agree with Galileo that a pendulum is a better time-measuring instrument than your pulse.

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SELF-ASSESSMENT

Compare your answers to those of your peers. Do you agree with their points? Are you able to justify yours?

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Chapter 2

Describing motion

Understanding speed

KEY WORDS

speed: the distance travelled by an object in unit time

velocity: speed in a given direction

KEY EQUATIONS

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$v = \frac{s}{t}$$

$$\text{average speed} = \frac{\text{total distance travelled}}{\text{total time taken}}$$

TIP

There are three mistakes that you can make in calculations:

- rearranging the equation incorrectly
- incorrect or missing unit conversion
- missing or incorrect units.

Practise rearranging equations until you are really happy with it. To test that you are doing it right, pick a calculation where you know all the quantities. For example, in this chapter, we might say 7 m/s would mean 35 metres travelled in 5 seconds. Now rearrange the equation for speed, to make distance, then time, the subject. In each case, having rearranged the equation, substitute the numbers into the equation. If you've done the rearrangement correctly, both sides of the equation should still be equal!

Exercise 2.1

IN THIS EXERCISE YOU WILL:

recall how to measure and calculate the speed of a moving object.

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Focus

1 One way to find the speed of an object is to measure the time it takes to travel a measured distance. The table shows the three quantities involved.

Complete the table as follows:

- In the second column, give the SI unit for each quantity (name and symbol).
- In the third column, give some other, non-SI, units for these quantities.
- In the fourth column, name suitable measuring instruments for distance and time.

Quantity	SI unit (name and symbol)	Non-SI units	Measuring instrument
distance			
time			
speed			

TIP

Make sure you are very clear on how to calculate the number of:

- metres in a km
- seconds in an hour (or a day, year)
- cm^3 in a m^3.

Take care with units. Always make 'what units should I have here?' the last thing you ask yourself when you've completed a calculation.

2 In the laboratory, the speed of a moving trolley can be found using two light gates. A timer measures the time taken for a trolley to travel from one light gate to the other.

a State what other quantity must be measured to determine the trolley's speed.

....

b Write down the equation used to calculate the speed of the trolley.

....

....

c A trolley takes 0.80 s to travel between two light gates, which are separated by 2.24 m. Calculate its average speed.

....

....

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Practice

3 The speed of moving vehicles is sometimes measured using detectors buried in the road. The two detectors are about 1 m apart. As a vehicle passes over the first detector, an electronic timer starts. As it passes over the second detector, the timer stops.

a Explain how the vehicle's speed can then be calculated.

....

....

....

b On one stretch of road, any vehicle travelling faster than 25 m/s is breaking the speed limit. The detectors are placed 1.2 m apart. Calculate the speed of a car that takes 0.050 s to travel this distance. Is it breaking the speed limit?

....

....

....

c Calculate the shortest time that a car can take to cross the detectors if it is not to break the speed limit.

....

....

Challenge

4 Describe briefly how a speed-detection system such as that in Question **3** could be used to light up a warning light whenever a speeding car goes past.

....

....

....

....

....

PEER ASSESSMENT

Now compare your answers with others. What are the best aspects of their solutions? How could they improve their solutions?