Chapter 1

Motion

Measuring length and volume

Exercise 1.1

IN THIS EXERCISE YOU WILL:

- recall and use the SI units used in physics.

Focus

1 a State the SI unit (name and symbol) for each of these quantities:

length .....

volume. .....

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

one thousand metres .....

one-thousandth of a metre. .....

c State the number of centimetres in a metre. .....

d State the number of litres in a cubic metre. .....

Practice

2 a State the number of cm^2 in 1 m^2.

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b State the number of m^2 in 1 km^2.

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Challenge

3 A cube has sides 3.50 m long. Calculate:

a the surface area of the cube in cm^2

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b the volume of the cube in mm^3.

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Density

Exercise 1.2

IN THIS EXERCISE YOU WILL:

- practise converting between units
- practise applying the density formula.

KEY WORD

density: the ratio of mass to volume for a substance.

KEY EQUATION

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

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

Focus

1 a Table 1.1 shows data about the density of various solids and liquids. Complete the fourth column of the table by converting each density in kg/m^3 to the equivalent value in g/cm^3. The first two have been done for you.

Material	State / type	Density / kg/m^3	Density / g/cm^3
water	liquid / non-metal	1000	1.000
ethanol	liquid / non-metal	800	0.800
olive oil	liquid / non-metal	920	
mercury	liquid / metal	13 500	
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	19 300	
aluminium	solid / metal	2700	
gold	solid / metal	19 300	

Table 1.1

TIP

Do not assume you know the answer. Always work it out. For example, 1 m^3 in mm^3 is 1000 × 1000 × 1000 mm^3, because there are 1000 mm in 1 m.

b Use the data in Table 1.1 to explain why ice floats on water.

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c Name *two* materials from the table (other than ice) which will float in water.

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d Name *two* materials from the table which will sink in water.

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Practice

2 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.

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3 Use the data in Table 1.1 to calculate:

a the mass of a block of iron which has a volume of 4.5 m³.
Show your working out. Give your answer in kg.

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b the mass of a block of gold that measures 20 cm × 15 cm × 10 cm.
Show your working out. Give your answer in kg.

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c the volume of an aluminium block which has a mass of 81 kg.
Show your working out. Give your answer in m³.

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4 A metalworker finds a block of silvery metal. They weigh it and measure its volume. Here are their results:

mass of block = 0.270 kg

volume of block = 14.0 cm³

a Calculate the density of the block.

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b Suggest what metal it might be.

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Challenge

5 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.

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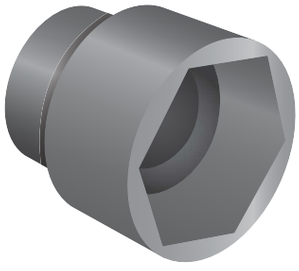

Figure 1.1: A metal object.

› Measuring time

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 to measure 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 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. Safety – throughout this activity you should consider your level of fitness and not push yourself too hard.

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

Figure 1.2: Two methods for taking a pulse.

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?

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ii Give a possible reason for this. Is it difficult to time the pulses or does your heart rate vary?

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c Use your results to calculate the average time for one pulse.

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Practice

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

3 Calculate the average time for one pulse.

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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.

- 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 instrument for measuring time 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?

Understanding speed

Exercise 1.4

IN THIS EXERCISE YOU WILL:

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

KEY WORDS

speed: the distance travelled by an object in unit time.

velocity: speed in a given direction.

KEY EQUATIONS

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

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

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

$$\text{speed} = \text{gradient of distance–time graph}$$

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 confident. To check that you are doing it right, choose a calculation where you know all the quantities. For example, in this chapter, you might say 7 m/s would mean 35 metres travelled in 5 seconds. Rearrange the equation for speed to make distance the subject. Then rearrange again to make time the subject. Substitute the numbers into each rearranged equation. If you have rearranged correctly, both sides of the equation should still be equal.

Focus

1 To find the speed of an object, you can measure the time it takes to travel a known distance. Table 1.2 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 one or more non-SI units for each quantity.
- In the fourth column, name suitable instruments to measure distance and time.

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

Table 1.2

2 There are lots of different units for speed and it is important to use an appropriate unit. Connect each measurement with the most suitable unit.

Measurement	Unit
speed of a moving car	centimetres per year
speed of movement of a tectonic plate	metres per second
speed of sound	centimetres per minute
speed at which a snail crawls	kilometres per hour

TIP

Make sure you know how to calculate the number of:

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

Take care with units. Whenever you complete a calculation, remember to ask: 'What units should I have here?'.

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

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

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

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

Calculate the average speed of the trolley.

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Practice

4 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.

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b On one stretch of road, any vehicle travelling faster than 25 m/s is breaking the speed limit.

Two 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?

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