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Block 1 General physics

1 Making measurements

A definition to learn

- **density** the ratio of mass to volume for a substance

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

Exercise 1.1 The SI system of units

To be part of the international community of scientists, you need to use the SI units (Le Système International d'Unités).

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

length

....

volume

....

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

one thousand metres

....

one-thousandth of a metre

....

c How many

centimetres are there in a metre? ....

litres are there in a cubic metre? ....

d List as many non-SI units of length as you can.

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e Give a reason why it is important for scientists to have a system of units that is agreed between all countries.

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f Name some more professions that make use of the SI system of units.

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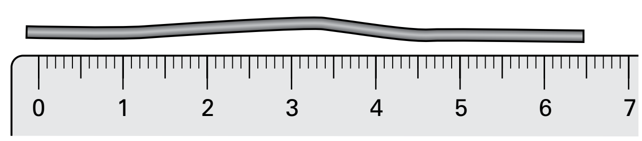
Exercise 1.2 Accurate measurements

To measure a length accurately, it is essential to have a careful technique. Special measuring instruments can also help.

a The diagram shows how a student attempted to measure the length of a piece of wire.



From the diagram, estimate the length of the wire. ....

State **three** ways in which the student could have improved his technique for measuring the wire.

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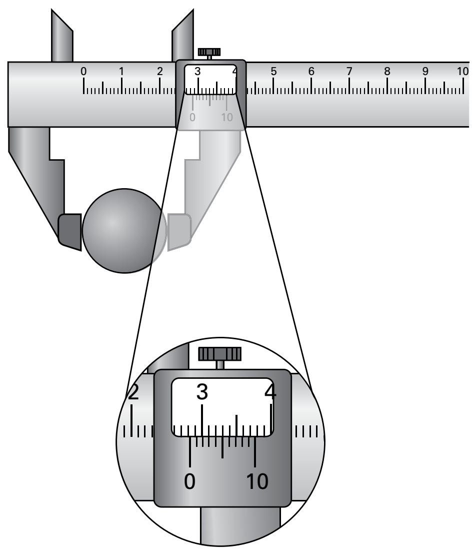
b The diagram shows a set of vernier callipers. Label the following parts of this measuring instrument:

vernier scale main scale jaws



c Determine the diameter of the ball, as measured by the vernier callipers shown in the diagram in **b**.

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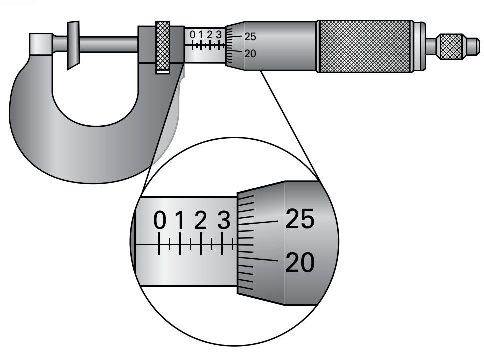
d A micrometer screw gauge can be used to measure the thickness of a sheet of plastic. What value is shown in the diagram? ....



e During an experiment, a student made the measurements shown in the table. In the second column, suggest the instrument that she used to make each measurement.

Measurement	**Measuring instrument**
length of wire = 20.4 cm	
thickness of wire = 4.24 mm	
thickness of wooden block = 17.5 mm	

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Exercise 1.3 Paper measurements

This exercise will test your ability to measure lengths.

Find a rectangular sheet of paper, at least as big as the pages of this book. A sheet of newspaper is ideal.

Your task is to use a ruler to measure three lengths: the short side, the long side and the diagonal.

For lengths that are longer than your ruler, you will need to devise a careful technique.

Describe the method you have used for measuring the length of the diagonal. It may help to include a diagram.

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Record your results (in centimetres) in the table.

Measurement	**Length / cm**	**Length^2 / cm^2**
short side		
long side		
diagonal		

Now you can use Pythagoras' theorem to test your results. In the third column of the table, calculate and write down the square of each length.

Then calculate:
(short side)^2 + (long side)^2 = ...

This should be equal to (diagonal)^2.

Round off your values to the nearest cm^2. How close are your two answers? Write a comment below.

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Exercise 1.4 Density data

This exercise presents some data for you to interpret and use.

Some data about the density of various solids and liquids are shown in the table.

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	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	

Two units are used for the densities, kg/m^3 and g/cm^3.

a Complete the second column by converting each density in kg/m^3 to the equivalent value in g/cm^3. The first two have been done for you.

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

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c A cook mixes equal volumes of water and olive oil in a jar. The two liquids separate. Complete the drawing of the jar to show how the liquids will appear. Label them.

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d A student wrote: "These data show that metals are denser than non-metals." Do you agree? Explain your answer.

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e Calculate the mass of a block of gold that measures 20 cm × 15 cm × 10 cm. Give your answer in kg.

f A metalworker finds a block of silvery metal. He weighs it and he measures its volume. Here are his 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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Exercise 1.5 Testing your body clock

How good would your pulse 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. Press gently at different points until you find the pulse. (Alternatively, press two fingers gently under your jawbone on either side of your neck.)

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

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 below.

b Comment on your results. How much do they vary? Is the problem that it is difficult to time them, or is your heart rate varying?

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

d Repeat the above, but now count 50 pulses. Record your results in the table below. Calculate the average time for one pulse.

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e Now 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.
- Give 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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2 Describing motion

Definitions to learn

- **speed** the distance travelled by an object in unit time
- **acceleration** the rate of change of an object's velocity

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

speed = gradient of distance–time graph

distance = area under speed–time graph

S

$$\text{acceleration} = \frac{\text{change in speed}}{\text{time taken}}$$

acceleration = gradient of speed–time graph

Exercise 2.1 Measuring speed

This exercise is about how we can measure the speed of a moving object.

a 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			

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b 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.

What other quantity must be measured to determine the trolley's speed?

....

Write down the equation used to calculate the speed of the trolley:

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

c 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.

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

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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?