Cambridge IGCSE · Physics 0625 · Notes

Physical quantities and measurement techniques

Read online at **pastopic.com/cambridge/physics-0625/notes/measurement**

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What you need to know

By the end of this topic you should be able to:

1. **Use rulers and measuring cylinders** to find a length or a volume, and describe how you did it: where to line up the ruler, where to put your eye, which part of the water surface to read.
2. **Measure time intervals** with clocks, stop-watches and digital timers, including working out the time between two readings.
3. **Measure something small by measuring many of it** and dividing: the thickness of one sheet from a stack, the diameter of one ball from a row, the period of a pendulum from many swings. Take an average value this way.
4. **Extended only:** understand that a **scalar** has size (magnitude) only, and a **vector** has size **and** direction.
5. **Extended only:** know that distance, speed, time, mass, energy and temperature are scalars.
6. **Extended only:** know that force, weight, velocity, acceleration, momentum, electric field strength and gravitational field strength are vectors.
7. **Extended only:** find the resultant of two forces or two velocities at right angles, either by calculation or with a scale drawing.

Finding the volume of an irregular solid by displacement belongs to the Density topic (1.4) in the syllabus, but it is asked so often with measuring cylinders that it is covered here too. Measuring mass with a balance belongs to Mass and weight (1.3); it is here only as one of the instruments you choose between.

Understand it

Measuring length

A **ruler** (30 cm or half-metre) or a **metre rule** has its smallest divisions 1 mm apart. For long distances, such as the length of a sports field or a swimming pool, use a **tape measure**.

- **Read from zero, or subtract.** If the end of the ruler is worn or damaged, line the object up with a clear mark instead (say 1.0 cm) and subtract: an object from the 1.0 cm mark to the 7.3 cm mark is $7.3 - 1.0 = 6.3$ cm, or 63 mm, long.

- **Look straight at the scale.** If your eye is to one side, the mark seems to move against the scale behind it. This is called a **parallax** error. Put your eye directly above (at right angles to) the mark you are reading.
- **Record to the ruler's precision.** A mm scale lets you write 12.0 cm, not 12 cm: the final 0 says you checked the millimetres. In metres, the same reading to the nearest millimetre is 0.120 m.
- **Round objects.** You can't hold a ruler across a ball exactly on its widest part. Put the ball between two flat blocks (or set squares) with faces parallel, and measure the gap between the blocks.

Units of length from smallest to largest: $1\ \mathrm{mm} < 1\ \mathrm{cm} < 1\ \mathrm{m}$, with $10\ \mathrm{mm} = 1\ \mathrm{cm}$ and $100\ \mathrm{cm} = 1\ \mathrm{m}$.

Measuring volume

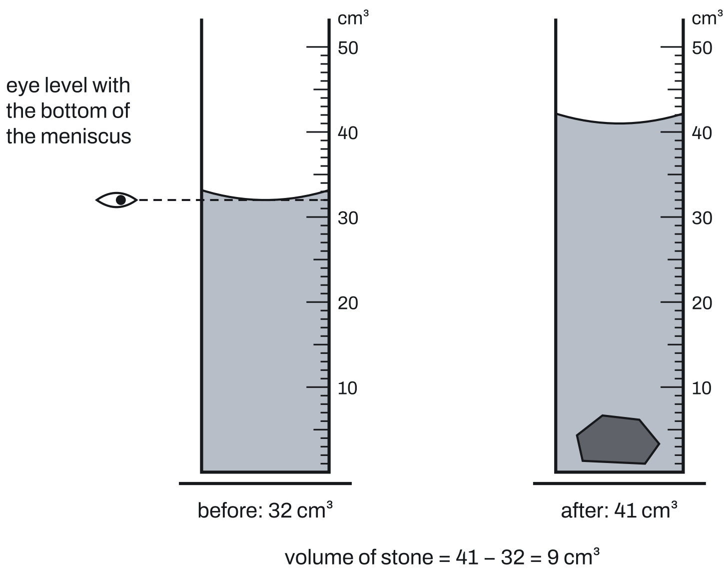
A **liquid**: pour it into a **measuring cylinder**. Stand the cylinder on a flat, level bench. Water curves at the edges, making a dip called the **meniscus**. Read the **bottom of the meniscus**, with your eye level with it. Read to the nearest half of the smallest division.

Choose the right cylinder. For about $40\ \mathrm{cm}^3$, a $50\ \mathrm{cm}^3$ cylinder is better than a $250\ \mathrm{cm}^3$ one: the smaller cylinder is narrower, so its divisions are smaller and more precise. $1\ \mathrm{cm}^3$ is the same as 1 ml.

A **regular solid** (a cube or a box shape): measure its length, width and height with a ruler and multiply, $V = l \times w \times h$.

An **irregular solid that sinks** (a stone, a key, a lump of metal): use **displacement**.

1. Pour enough water into a measuring cylinder to cover the object, and read the volume V_1.
2. Lower the object in gently (tilt the cylinder or use a thread so no water splashes out) until it is completely under water.
3. Read the new volume V_2.
4. Volume of the object $= V_2 - V_1$.



If the object is too big for a measuring cylinder, use a **displacement (eureka) can**: fill it until water just runs out of the spout, then lower the object in and catch the water that overflows in a measuring cylinder. The volume of that water is the object's volume.

Moving an object from one cylinder to a wider one changes how far the level moves, but not the volume it displaces: a stone that pushes the reading up by $15\ \mathrm{cm}^3$ in one cylinder pushes it up by $15\ \mathrm{cm}^3$ in any other.

Measuring time

Instrument	Use it for	Reads to
Clock or watch	minutes and hours	1 s
Stop-watch	a few seconds to several minutes	0.01 s (or 0.1 s)
Digital timer	short intervals, especially when it is started and stopped automatically	0.01 s or better

A stop-watch display such as `02:37.25` means 2 minutes 37.25 seconds, which is $2 \times 60 + 37.25 = 157.25$ s. A display of `0:00  64` with a small "100" label means 0.64 s: the last digits are hundredths of a second.

Reaction time. A person takes about 0.2 s to react when starting or stopping a stop-watch. For a long interval this hardly matters, but it is a big part of a time of 1 s.

Time between two readings. Subtract the earlier reading from the later one, working in seconds. If a runner's stop-watch shows 1 min 05 s after lap 1 and 2 min 14 s after lap 2, lap 2 took $134 - 65 = 69$ s, or 1 min 09 s.

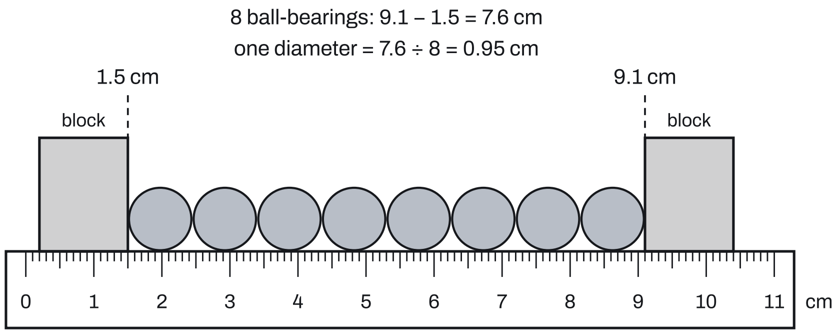
Measuring many to find one

A single sheet of paper is about 0.1 mm thick, less than one division of a ruler, so you can't measure it directly. A stack of 250 identical sheets might be 27 mm thick, which a ruler measures easily. Then

$$\text{thickness of one sheet} = \frac{\text{total thickness}}{\text{number of sheets}} = \frac{27\ \text{mm}}{250} = 0.108\ \text{mm}.$$

The reading error of the ruler (about half a millimetre) is now shared out between 250 sheets, so the answer is far more precise. The same idea works for:

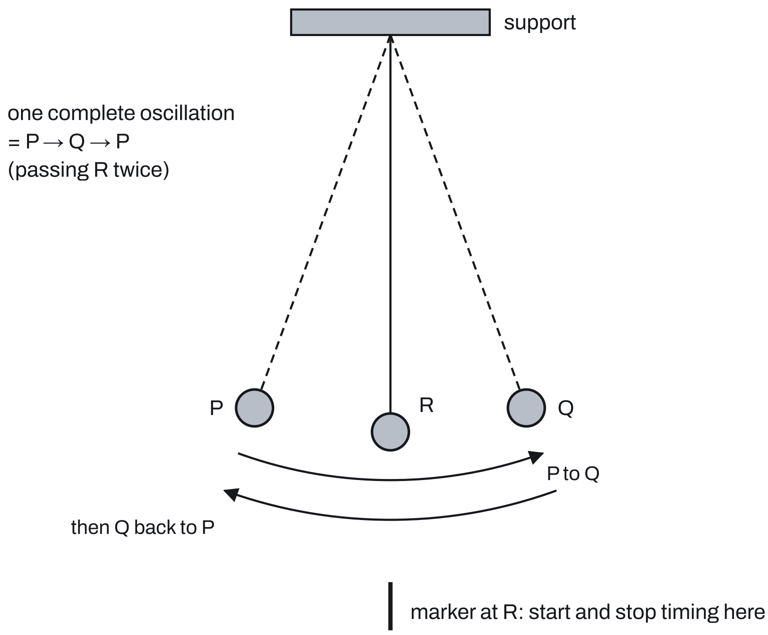
- the **diameter of a thin wire**: wind it tightly round a pencil in touching turns, measure the length of, say, 20 turns and divide by 20;
- the **diameter of a small ball**: line up several identical balls in a touching row between two blocks, measure the row and divide by the number of balls;
- the **thickness of a coin, tile or book page**: stack as many as you can (10 or more) and divide;
- the **volume of one drop** of water: let many drops fall into a measuring cylinder, read the volume collected and divide by the number of drops.



Always divide the **total** by the **number**. Dividing the other way round (number ÷ total) is a very common slip.

The period of a pendulum

The **period** of a pendulum is the time for **one complete oscillation**: from one end of the swing (P) across to the other end (Q) and **back** to P. Swinging from P to Q is only half an oscillation.



One period is often only about 1 s, so timing a single swing gives a large error from your reaction time. The standard method:

1. Place a **marker** (a fiducial mark) at the centre of the swing, R, where the bob moves fastest, so the moment it passes is easy to judge.
2. Start the stop-watch as the bob passes the marker, and count "0".
3. Count each time the bob passes the marker **moving in the same direction**, and stop the stop-watch at, say, 20.
4. Period $= \dfrac{\text{time for 20 oscillations}}{20}$.
5. Repeat the whole measurement and take the **average** of the times before dividing.

The reaction-time error (about 0.2 s at each end) is now shared between 20 oscillations, so the period is much more accurate. Timing more oscillations helps more than asking someone with faster reactions or using a timer with more digits.

Averages from repeated readings

Repeating a reading and taking the **mean** (add them up, divide by how many) makes the result more reliable. Give the answer to a sensible number of significant figures, no more than the readings themselves have. Four readings $23.6, 23.5, 23.5, 23.4$ cm have a mean of $\frac{94.0}{4} = 23.5$ cm, to 3 significant figures.

Scalars and vectors

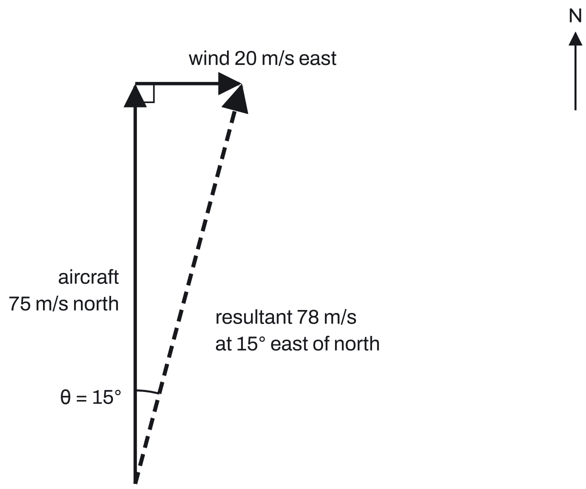
Extended only: a **scalar** quantity has only a size (magnitude), such as "30 kg" or "20 °C". A **vector** quantity has a size **and a direction**, such as "12 N downwards" or "25 m/s due north".

Scalars (size only)	Vectors (size and direction)
distance	force (and weight, which is a force)
speed	velocity
time	acceleration
mass	momentum
energy	electric field strength
temperature	gravitational field strength

Pairs are worth remembering: **speed** is a scalar but **velocity** (speed in a given direction) is a vector; **mass** is a scalar but **weight** is a vector. Density, pressure, power and volume have no direction, so they are scalars too.

Adding two vectors at right angles

Extended only: when two forces (or two velocities) act at right angles, the single vector that has the same effect is the **resultant**. Draw the first vector as an arrow, then draw the second one starting from the **tip** of the first ("tip to tail"). The resultant joins the **start of the first** to the **tip of the second**.



scale 1 cm : 10 m/s: 7.5 cm and 2.0 cm give a 7.8 cm resultant

The triangle has a right angle, so:

- **Size** by Pythagoras: $R = \sqrt{a^2 + b^2}$. For 75 m/s and 20 m/s, $R = \sqrt{75^2 + 20^2} = \sqrt{6025} = 77.6 \approx 78$ m/s.
- **Direction** by trigonometry: $\tan\theta = \dfrac{\text{opposite}}{\text{adjacent}}$. Here $\tan\theta = \dfrac{20}{75}$, so $\theta = 15^\circ$ east of north. Always say which line the angle is measured from.

By scale drawing: choose a scale that makes the diagram big (1 cm to 10 m/s here), draw the two arrows at right angles with a ruler and a protractor, draw the resultant, measure its length (7.8 cm) and convert back with the scale (7.8 × 10 = 78 m/s). Measure the angle with a protractor.

Two forces in a straight line are much simpler (add them if they point the same way, subtract if they are opposite), but two forces at right angles always give a resultant **bigger than either** and **smaller than their sum**: 5 N and 12 N at right angles give 13 N, not 17 N or 7 N.

Key facts and formulas

The 0625 exams have no formula sheet, so learn everything here.

Formula	Status
Length measured from a mark other than zero $=$ end reading $-$ start reading	Learn it
Time interval $=$ later reading $-$ earlier reading, with $1\ \text{min} = 60\ \text{s}$	Learn it
Volume of a box shape: $V = l \times w \times h$	Learn it
Volume by displacement: $V = V_2 - V_1$	Learn it
One of many: $\text{size of one} = \dfrac{\text{total measured}}{\text{number of items}}$	Learn it

Formula	Status
Period of a pendulum: $T = \dfrac{\text{time for } n \text{ oscillations}}{n}$	Learn it
Mean $= \dfrac{\text{sum of the readings}}{\text{number of readings}}$	Learn it
Extended only: resultant of a and b at right angles: $R = \sqrt{a^2 + b^2}$	Learn it
Extended only: direction: $\tan\theta = \dfrac{b}{a}$, angle measured from the direction of a	Learn it

Units: $10\ \text{mm} = 1\ \text{cm}$, $100\ \text{cm} = 1\ \text{m}$, $1\ \text{cm}^3 = 1\ \text{ml}$, $1000\ \text{cm}^3 = 1$ litre.

Quantity	Instrument
Length (up to about 1 m)	ruler or metre rule
Long distance	tape measure
Volume of a liquid, or of an irregular solid	measuring cylinder (with water, for a solid)
Time	stop-watch, clock or digital timer
Mass	balance
Angle	protractor
Temperature	thermometer

How to do it

In the Paper 1 to 4 questions we have tagged for this topic (100 different questions, 2021–2025; 10 more appear on two papers), the types came up this often. 15 of the 100 questions mix two or three types, so the counts add up to more than 100.

Question type	Questions
Choosing an instrument or method	34
Measuring many to find one, and averages	26
Reading scales and recording readings	19
Scalars and vectors (Extended)	18
Resultant of two vectors at right angles (Extended)	11
Volume by displacement	9

1. Choosing an instrument or method (34 questions)

1. **Name the quantity** being measured: length, volume, time, mass, and how big it is.

2. **Pick the instrument** from the table in "Key facts": ruler for short lengths, tape measure for long ones, measuring cylinder for volume, stop-watch for time, balance for mass.
3. **For a volume, check the shape.** A liquid needs only a measuring cylinder. A regular solid needs only a ruler ($l \times w \times h$). An irregular solid needs a measuring cylinder **with water** (displacement), and nothing else; a balance measures mass, not volume.

Variations you will meet:

- **"Which is not useful?"** For a volume, a balance is the odd one out.
- **What else must be measured?** The volume of water in a box-shaped tank needs its length, its width and the **depth of the water** (not the height of the tank).
- **Which two measurements for speed?** Distance (with a ruler, metre rule or tape measure) and time (with a stop-watch).
- **The diameter of a ball**: a ruler with two blocks (or set squares) either side.
- **Older papers (2021–2022)** also ask about a **micrometer screw gauge**, which measures very small distances such as the diameter of a thin wire or the thickness of foil. It is not in the 2026–2028 syllabus: now you measure many and divide instead.

2. Measuring many to find one, and averages (26 questions)

1. **Measure the total** for many identical items: the thickness of a stack, the length of a row, the time for many oscillations, the volume of many drops.
2. **Divide by the number of items**: total ÷ number. Check the size is sensible (one sheet of paper is a fraction of a millimetre; one period of a lab pendulum is around 1–2 s).
3. **Give the unit** and a sensible number of significant figures.

For example, 50 staples side by side are 60 mm wide, so one is $60 \div 50 = 1.2$ mm wide.

Variations you will meet:

- **"Describe how to find the thickness (or diameter) accurately."** Say three things: stack (or coil, or line up) **10 or more**; **measure the total** with the ruler; **divide by the number**. Mention the blocks for balls, or tight touching turns for wire.
- **Several repeats.** Average the totals first, then divide by the number of oscillations. For 20 oscillations timed at 21.4, 20.6, 21.0 and 21.0 s, the mean is 21.0 s, so the period is $21.0 \div 20 = 1.05$ s (stopping at the mean gives the wrong answer, 21.0 s).
- **Counting passes.** If a timer reads 2 min 05 s when the bob passes a marker and 2 min 50 s after it has passed **15 more times in the same direction**, that is 15 oscillations in 45 s, so the period is $45 \div 15 = 3.0$ s.
- **Put the steps in order**: start the stop-watch as the bob passes the marker, count the oscillations, stop the stop-watch, then divide.
- **Which method is most accurate?** Timing many oscillations and dividing beats timing one swing, even with a faster person or a digital timer.

- **"Describe the motion in one complete oscillation"**: from P to Q and back to P (passing through the centre twice).

3. Reading scales and recording readings (19 questions)

1. **Find what one small division is worth**: the difference between two labelled marks ÷ the number of spaces between them.
2. **Read the start and the end** of the object on the scale, and subtract if the start is not zero.
3. For a measuring cylinder, read the **bottom of the meniscus**. For a stop-watch, turn minutes into seconds ($\times 60$) before subtracting.
4. **Record the reading** to the precision of the scale, with its unit.

Variations you will meet:

- **Two readings from a measuring cylinder** ("before" and "after" pouring): the amount poured out is the difference.
- **Lap times**: each lap is the difference between two stop-watch readings, not the reading itself.
- **Area from two rulers**: read the length and the width, then multiply.
- **"Which reading is to the nearest millimetre?"** On a metre rule in metres, that is **3 decimal places**, for example 0.475 m.
- **Which recorded volumes are right?** A reading should match the scale's precision: on a cylinder marked every 0.1 cm^3, write 0.7 cm^3, not 0.70 or 1.
- **Order units of length**: mm, cm, m (smallest first).
- **Time between two stop-clock readings.** A stop-clock showing minutes and whole seconds, from 01:40 to 03:05, gives $185 - 100 = 85$ s $=$ 1 min 25 s.

4. Scalars and vectors (18 questions, Extended)

1. **Learn the two lists** in "Understand it". If a quantity isn't on either list, ask "does it have a direction?"
2. **Answer the exact question**: "which list has only vectors", "how many are scalars", "one scalar and one vector".
3. **"State the difference"**: a vector has direction as well as size; a scalar has size only. Mention both.

Variations you will meet:

- **Circle or underline the vectors (or scalars) in a list.** Extra wrong choices lose the mark, so don't circle "just in case".
- **"Name one other scalar and one other vector"**: don't repeat the examples in the question.

5. Resultant of two vectors at right angles (11 questions, Extended)

1. **Sketch the vector triangle**: first arrow, then the second from its tip at 90°, then the resultant from start to finish.

2. **Size**: $R = \sqrt{a^2 + b^2}$, with a unit.
3. **Direction**: $\theta = \tan^{-1}\left(\frac{\text{opposite}}{\text{adjacent}}\right)$, and state what the angle is measured from ("to the river bank", "east of north", "to the vertical").
4. If a **scale diagram** is asked for, draw it (a calculation alone gets no credit): state the scale with units (1 cm : 10 N), make the diagram fill the space, measure the resultant and convert with the scale.

Variations you will meet:

- **A boat or swimmer crossing a river**: the boat's own velocity and the current are at right angles. The angle to the bank uses $\tan\theta = \dfrac{\text{boat speed}}{\text{current speed}}$. Then distance $=$ resultant speed $\times$ time for the next part.
- **Aircraft in a crosswind**: the plane's velocity and the wind at right angles, as in the diagram.
- **Multiple choice with numbers**: 5 N and 12 N at right angles give 13 N; 8 N and 15 N give 17 N.
- **Multiple choice with diagrams**: pick the triangle where the two vectors run tip to tail and the resultant runs from the start of one to the end of the other.
- **Vectors not at right angles** (for example two ropes at 60°) appear on some papers. Draw a scale diagram: the tip-to-tail method still works, so draw the parallelogram or triangle with a protractor and measure the resultant.

6. Volume by displacement (9 questions)

1. Read the water's volume before, V_1.
2. Read it after the object is fully under water, V_2.
3. Volume $= V_2 - V_1$.

Variations you will meet:

- **"Describe how to find the volume"**: give the four steps: part-fill the cylinder with water; read the volume; lower the object in so it is **completely covered**; read the new volume and **subtract**.
- **Volume then density**: the Density topic continues with $\rho = \dfrac{m}{V}$.
- **A wider cylinder**: the volume displaced is the same in any cylinder; only the change in level differs.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **M1** method mark: for a correct method, even if the numbers slip.
- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

Example 1

A student places 8 identical ball-bearings in a row between two wooden blocks on a ruler, as in the second diagram. The inner faces of the blocks are at 1.5 cm and 9.1 cm.

(a) Find the diameter of one ball-bearing. **[2]**

(b) She then times 25 complete oscillations of a pendulum three times. Her times are 38.2 s, 37.9 s and 38.2 s. Calculate the period of the pendulum. **[3]**

(c) Explain why she times 25 oscillations rather than one. **[1]**

(a) Length of the row $= 9.1 - 1.5 = 7.6$ cm. **M1** for subtracting the readings.

Diameter $= 7.6 \div 8 = 0.95$ cm. **A1**

(b) Mean time for 25 oscillations $= \dfrac{38.2 + 37.9 + 38.2}{3} = \dfrac{114.3}{3} = 38.1$ s. **M1**

Period $= \dfrac{38.1}{25}$ **M1** $= 1.524 \approx 1.52$ s. **A1**

(c) Her reaction time at the start and stop (about 0.2 s) is spread over 25 oscillations, so its effect on one period is 25 times smaller. **B1**

Example 2

A student adds 40 drops of water from a dropper to a measuring cylinder. The reading goes from $18.0\ \mathrm{cm}^3$ to $20.0\ \mathrm{cm}^3$.

(a) Calculate the average volume of one drop. **[3]**

(b) Another measuring cylinder contains $55\ \mathrm{cm}^3$ of water. A small stone is lowered into it and the reading becomes $72\ \mathrm{cm}^3$. Calculate the volume of the stone. **[1]**

(c) Describe how the student should read the level of the water to get an accurate reading. **[2]**

(a) Volume of 40 drops $= 20.0 - 18.0 = 2.0\ \mathrm{cm}^3$. **M1**

Volume of one drop $= \dfrac{\text{total volume}}{\text{number of drops}}$ **M1** $= \dfrac{2.0}{40} = 0.050\ \mathrm{cm}^3$. **A1**

(b) $72 - 55 = 17\ \mathrm{cm}^3$. **B1**

(c) Read the **bottom of the meniscus B1**, with the eye **level with the water surface** (looking at right angles to the scale) and the cylinder on a level bench. **B1**

Example 3

This question is **Extended only**.

(a) From the list below, name the vectors. **[1]**

speed, velocity, mass, weight, temperature, momentum

(b) An aircraft flies due north at 75 m/s relative to the air. A wind blows due east at 20 m/s. Calculate the size and direction of the aircraft's resultant velocity. **[4]**

(a) velocity, weight and momentum (all three, and nothing else). **B1**

(b) The two velocities are at right angles. **M1** for using Pythagoras:

$$R = \sqrt{75^2 + 20^2} = \sqrt{6025} = 77.6 \approx 78 \text{ m/s}.$$

A1

$\tan\theta = \dfrac{20}{75}$ **M1**, so $\theta = 14.9^\circ \approx 15^\circ$ east of north. **A1**

(A scale drawing at 1 cm to 10 m/s gives arrows of 7.5 cm and 2.0 cm and a resultant of about 7.8 cm, which is 78 m/s, as in the fourth diagram. Either method earns the marks unless the question asks for a drawing.)

Common mistakes

- **Dividing the wrong way round.** Examiners report this every year, for staples, drops, sheets and periods alike: number $\div$ total instead of total $\div$ number. Write "one $=$ total $\div$ number" in words first, then substitute.
- **Forgetting to divide by the number of oscillations.** Averaging several times for 20 oscillations gives the time for 20, not the period. Divide the average by 20 as well.
- **Copying the stop-watch digits.** `0:00  64` is 0.64 s, not 64 s or "0:00:64 s". `02:37.25` is 157.25 s; converting minutes with 100 instead of 60 is wrong.
- **Taking half an oscillation for a whole one.** P to Q is half; P to Q and back to P is one.
- **Reading the wrong part of the scale.** Read the bottom of the meniscus, not the top edge, and don't read the level at the top of the stone. On a damaged ruler, subtract the starting mark.
- **Vague measuring methods.** "Measure the coins with a ruler" earns little. Say how many (10 or more), what you measure (the total thickness) and what you do with it (divide by the number).
- **Displacement without the "before" reading or without full submersion.** Both volumes must be read, and the object must be completely under the water.
- **Naming the example quantities.** When the question says "speed is a scalar and velocity is a vector; name one other of each", speed and velocity earn nothing.
- **A resultant with no direction, or a direction with no reference.** "53°" on its own, or "south-east", is not enough: say "53° to the river bank". Give the unit with the size.
- **Scale drawings that are too small, or that just join the ends of the two arrows.** Choose a scale with a unit that makes the diagram large, and draw the vectors tip to tail.
- **Using trigonometry when the question asks for a drawing.** If it says "draw a scale diagram", a calculation gets no credit.

How to get the marks

- **Show the working for every calculation.** Most calculations have a mark for the method (the equation in words or the numbers substituted, such as $38.1 \div 25$), then a mark for the answer. A correct method with a slip still earns something.
- **"Describe how to..."** questions are marked point by point. Give each step in order as a separate short sentence: what you measure, with what, how many, and what you do with the numbers.
- **"Determine" or "State" the reading**: give just the value, with its unit, to the precision of the scale.
- **Units.** Always write the unit (cm, cm^3, s, m/s, N), unless the answer line already prints it.
- **Significant figures.** Two or three significant figures is usual. Don't round the steps: keep the full value until the final answer.
- **Multiple-choice data questions.** Work the answer out before looking at the options; wrong options are the results of common slips (not dividing, dividing the wrong way, using 100 s in a minute).
- **Vectors (Extended).** For "determine by calculation or graphically", either method gets full marks. The size needs a unit and the direction needs a stated reference line. For a scale diagram, write the scale down, use a sharp pencil, a ruler and a protractor.

Quick check

1. A stop-watch reads `01:12.46` after a pendulum has made 40 complete oscillations. Calculate the period.
2. The end of a ruler is broken, so a pencil is placed with one end at the 2.0 cm mark. Its other end is at 15.5 cm. How long is the pencil in millimetres?
3. A stack of 200 identical sheets of paper is 2.4 cm thick. Calculate the thickness of one sheet in mm.
4. **Extended only.** Sort these into scalars and vectors: acceleration, energy, gravitational field strength, time, weight, distance.
5. **Extended only.** A force of 9.0 N acts due east and a force of 12.0 N acts due north on the same object. Calculate the size of the resultant force and its angle from the east direction.

Answers

1. $01{:}12.46 = 60 + 12.46 = 72.46$ s. Period $= 72.46 \div 40 = 1.8115 \approx 1.81$ s.
2. $15.5 - 2.0 = 13.5$ cm $= 135$ mm.
3. $2.4 \text{ cm} = 24$ mm, and $24 \div 200 = 0.12$ mm.
4. Scalars: energy, time, distance. Vectors: acceleration, gravitational field strength, weight.
5. $R = \sqrt{9.0^2 + 12.0^2} = \sqrt{225} = 15.0$ N. $\tan\theta = \dfrac{12.0}{9.0}$, so $\theta = 53.1^\circ$ north of east.

Past questions to try

- **0625/31/O/N/25 Q2**: reading a measuring cylinder and the volume of one drop.
- **0625/32/O/N/24 Q2**: the diameter of a wire from a coil, then volume by displacement.
- **0625/12/O/N/25 Q1**: lap times from stop-watch readings.
- **0625/41/M/J/23 Q1**: a swimmer crossing a river, resultant velocity by calculation (Extended).