IGCSE PHYSICS 0625 · CHAPTER 1 NOTES · ~10 MIN READ

Measurement & motion

How to measure properly, then the whole story of speed, acceleration and motion graphs — the topic that decorates every Paper 2 and Paper 4.

Measuring instruments | Scalars & vectors | Speed & velocity | Acceleration | Distance–time & speed–time graphs | Free fall & terminal velocity

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No tag = **Core** (everyone) EXTENDED Extended only highlight = comes up again and again

Test yourself at the end

IN 30 SECONDS

- Every measurement needs a **number AND a unit**. Read instruments at eye level and measure many to reduce error.
- **Speed** = distance ÷ time. **Acceleration** = change in speed ÷ time.
- **Distance–time graph**: gradient = speed. **Speed–time graph**: gradient = acceleration, area = distance.
- EXT A falling object speeds up until **air resistance = weight**, then moves at terminal velocity.

BY THE END YOU CAN

- Read a ruler, measuring cylinder and stopwatch correctly, and spread the error by measuring many.
- Tell scalars from vectors and add two perpendicular vectors. EXT
- Use v = s ÷ t and a = Δv ÷ Δt, including unit conversions.
- Sketch and read distance–time and speed–time graphs, and find distance from an area.
- Explain terminal velocity step by step, with forces. EXT

1 Measuring things

Quantities and SI units

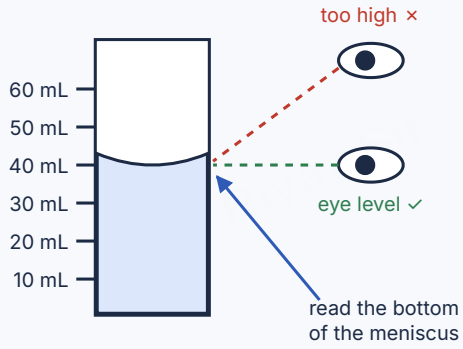
Quantity	SI unit	Measured with
length	metre (m)	ruler, tape measure
mass	kilogram (kg)	balance
time	second (s)	stopwatch, digital timer
volume	m^3 (also cm^3, litre)	measuring cylinder; displacement for solids

Prefixes and conversions

Prefix	Meaning	Example
kilo (k)	× 1000	1 km = 1000 m
centi (c)	÷ 100	1 m = 100 cm
milli (m)	÷ 1000	1 m = 1000 mm
micro (μ)	÷ 1 000 000	1 m = 1 000 000 μm
mega (M)	× 1 000 000	1 MHz = 10^6 Hz

- 1 cm^3 = 1 mL and 1 litre = 1000 cm^3. Time: 1 h = 3600 s.

Read the measuring cylinder properly



Eye level with the liquid, and read the BOTTOM of the meniscus (the curved surface). Reading from above gives a false value (parallax error).

COMMON MISTAKE

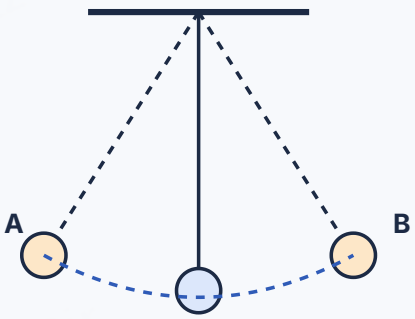
Reading the top of the meniscus, or the scale from above or below.

Measure many, then divide

PICTURE IT

One sheet of paper is far too thin to measure, but 200 sheets make a stack you can measure easily. The tiny error in your ruler is shared out over 200 sheets — so it matters 200 times less.

- **Thickness of one sheet** = thickness of a stack ÷ number of sheets.
- **Period of a pendulum** = time for many swings ÷ number of swings. This also shrinks the effect of your slow reaction time (about 0.2 s).



one swing: A → B → A (T = time for ONE swing)

One swing = A to B and back to A. Time 20 swings and divide by 20.

WORKED EXAMPLE

A stack of 200 sheets of paper is 2.0 cm thick. What is the thickness of one sheet?

1. 2.0 cm = 20 mm
2. 20 mm ÷ 200
3. **= 0.10 mm**

WORKED EXAMPLE

20 swings of a pendulum take 32 s. What is the period T?

1. T = total time ÷ number of swings
2. T = 32 ÷ 20
3. **= 1.6 s**

2 Scalars and vectors

Scalars and vectors

EXTENDED

Scalar — has size (magnitude) only. Examples: distance, speed, time, mass, energy, temperature.

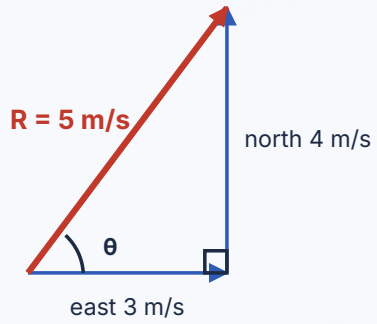
Vector — has size AND direction. Examples: displacement, velocity, acceleration, force, weight, momentum, field strength.

PICTURE IT

"5 km" is a scalar — it only tells you how far you walked. "5 km north" is a vector — it also tells you where you ended up.

- Forces on the same line: **add** if they point the same way, **subtract** if they point opposite ways.
- Two vectors at a right angle: draw them **head-to-tail**; the resultant is the diagonal, so use **Pythagoras** (and tan θ for the direction).

$R^2 = 3^2 + 4^2 \rightarrow R = 5$



A boat pointing east at 3 m/s in a river flowing north at 4 m/s actually moves at 5 m/s, in a direction 53° north of east.

WORKED EXAMPLE

A boat heads east at 3 m/s. The river flows north at 4 m/s. Find the resultant speed and direction.

1. Draw the vectors head-to-tail at a right angle
2. $R^2 = 3^2 + 4^2 = 25$
3. R = **5 m/s**
4. **tan θ = 4 ÷ 3, so θ = 53° north of east**

3 Speed, velocity and acceleration

Speed and velocity

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

speed (m/s) = distance (m) ÷ time (s)

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

includes stops — use ALL the time

Velocity — speed in a stated direction (a vector). Going round a bend at constant speed still changes your velocity, because the direction changes.

- To convert: **km/h → m/s: ÷ 3.6**. m/s → km/h: × 3.6. (72 km/h = 20 m/s.)

WORKED EXAMPLE

A cyclist rides 3.0 km in 10 minutes. Find the average speed in m/s and km/h.

1. Convert first: 3.0 km = 3000 m, 10 min = 600 s
2. v = 3000 ÷ 600 = **5.0 m/s**
3. **× 3.6 = 18 km/h**

COMMON MISTAKE

Mixing units (km with seconds). Convert before you divide.

Acceleration

EXTENDED

$$a = \frac{\Delta v}{\Delta t} = \frac{\text{final speed} - \text{initial speed}}{\text{time taken}}$$

unit m/s² (metres per second, every second)

- **Deceleration** is a **negative** acceleration (slowing down).
- Constant acceleration → a straight sloping line on a speed–time graph. A curve means the acceleration is changing.

PICTURE IT

A car with a = 2 m/s² gains 2 m/s of speed every second: 0, 2, 4, 6, 8 m/s ...

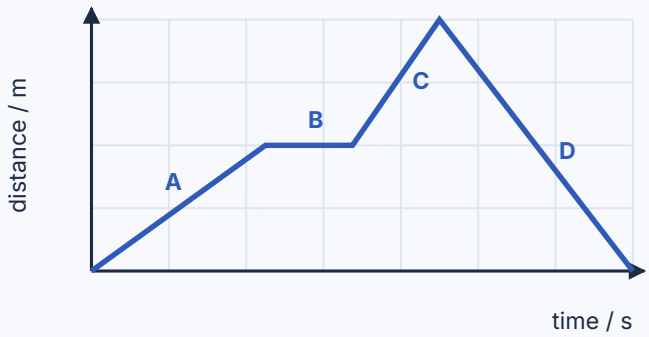
WORKED EXAMPLE

A car speeds up from 4 m/s to 20 m/s in 8 s. Find its acceleration.

1. Change in speed: Δv = 20 − 4 = 16 m/s
2. a = Δv ÷ Δt = 16 ÷ 8
3. **= 2 m/s²**

4 Motion graphs

Distance–time graph



A steady speed · B at rest · C faster · D returning

gradient = speed, so a flat line = not moving

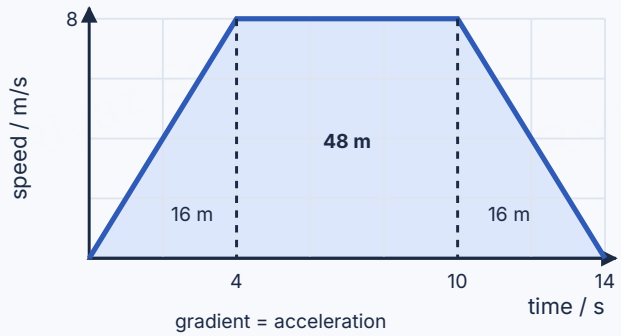
Steeper line = faster. A flat line = at rest. A line coming back down means the object is returning.

- **Gradient = speed.** Straight line = constant speed. A curve that steepens = speeding up.
- Horizontal line = **stationary** (distance not changing).

COMMON MISTAKE

Reading a flat line on a distance–time graph as "constant speed". It means the object has stopped.

Speed–time graph



gradient = acceleration
area under graph = distance (16 + 48 + 16 = 80 m)

Gradient = acceleration. Area under the graph = distance travelled.

- Horizontal line = constant speed (NOT at rest — rest is the line along the x-axis).
- Sloping up = accelerating; sloping down = decelerating. **Area under the line = distance.**
- Split the area into triangles (½ × base × height) and rectangles (base × height).

EXAM TIP

In "find the distance" questions, quote the units and show the shapes you added: 16 + 48 + 16 = 80 m.

WORKED EXAMPLE

Use the graph above: find (a) the acceleration during the first 4 s and (b) the distance travelled in total.

1. (a) a = gradient = 8 ÷ 4 = **2 m/s²**
2. (b) Triangle 1: ½ × 4 × 8 = 16 m
3. Rectangle: 6 × 8 = 48 m
4. Triangle 2: ½ × 4 × 8 = 16 m
5. **Total distance = 80 m**

5 Falling objects

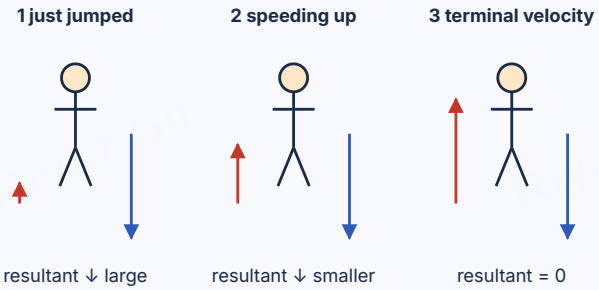
Free fall

- Near the Earth's surface, a falling object with no air resistance accelerates at **g = 9.8 m/s²** (the same for heavy and light objects).
- That means its speed rises by about 9.8 m/s every second: 0 → 9.8 → 19.6 → 29.4 m/s …
- With air resistance the acceleration is smaller — a feather falls slower than a stone in air, but they fall together in a vacuum.

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Terminal velocity

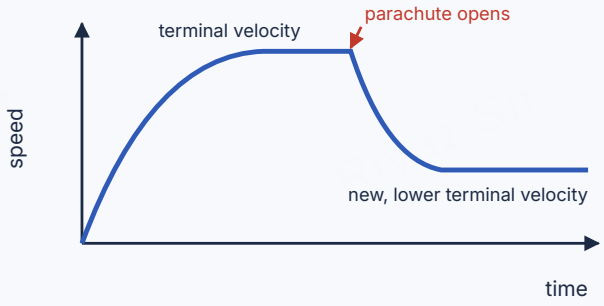
EXTENDED



red = air resistance (grows with speed) blue = weight (stays 600 N)

Weight stays the same. Air resistance grows as speed grows, until the two forces are equal.

- **1.** At the start air resistance is tiny, so weight is bigger: big resultant force down, big acceleration.
- **2.** As speed rises, air resistance rises, so the resultant force (and acceleration) gets smaller.
- **3.** When air resistance = weight, the resultant force is zero, so the speed stays constant: **terminal velocity**.



speed rises → drag rises → forces balance → constant speed

A parachute opens: air resistance jumps above weight, so the skydiver slows down to a new, lower terminal velocity.

EXAM TIP

Never say "gravity stops". Gravity (weight) is still there — the forces are BALANCED, so there is no acceleration.

COMMON MISTAKE

Saying the speed is zero at terminal velocity. The speed is constant and not zero.

6 Test yourself

Test yourself — cover the answers first

QUICK CHECK

1. Convert 90 km/h into m/s.
2. 20 swings of a pendulum take 30 s. Find the period.
3. What does a horizontal line mean on (a) a distance–time graph and (b) a speed–time graph?
4. What does the area under a speed–time graph represent?
5. Is velocity a scalar or a vector? Why?
6. Name the instrument and the correct way to read the volume of a liquid.

EXAM-STYLE

7. A cyclist accelerates uniformly from rest to 12 m/s in 6.0 s, then rides at constant speed for 20 s. Calculate (a) the acceleration, (b) the total distance.
8. Two forces act on an object: 6.0 N east and 8.0 N north. Find the size of the resultant force.
9. A skydiver reaches terminal velocity. Explain this in terms of forces. [3]
10. A car travels 120 km in 1.5 h, stops for 30 min, then travels 60 km in 1.0 h. Calculate its average speed for the whole journey.

Show answers

1. 90 ÷ 3.6 = 25 m/s
2. 30 ÷ 20 = 1.5 s
3. (a) stationary (b) constant speed
4. the distance travelled
5. A vector — it has direction as well as size.
6. A measuring cylinder; eye level with the liquid, reading the bottom of the meniscus.
7. (a) $a = \Delta v \div \Delta t = 12 \div 6.0 = 2.0\ m/s^2$
   (b) first 6 s: ½ × 6.0 × 12 = 36 m
   next 20 s: 12 × 20 = 240 m
   total = 276 m
8. $R^2 = 6.0^2 + 8.0^2 = 100$
   R = 10 N
9. Air resistance increases as the speed increases
   until air resistance equals the weight
   the resultant force is then zero, so the acceleration is zero and the speed is constant
10. total distance = 120 + 60 = 180 km
    total time = 1.5 + 0.5 + 1.0 = 3.0 h
    average speed = 180 ÷ 3.0 = 60 km/h

Stuck on a question?

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