

# A Level Physics 9702 — Paper 1 (AS) MCQ Survival Guide

Where Cambridge AS Physics candidates drop marks, and the technique to win them back.

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Built from every Paper 1 examiner report 2021–2025 (variants 9702/11, /12, /13 — and /14 from 2025).  
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## How to use this guide

This is not a content summary — you have the textbook for that. This is a forensic map of the **exact errors** Cambridge examiners flag in AS Paper 1 every single series. The list is shorter than you'd expect, but the same mistakes show up year after year because candidates either don't know them, don't slow down, or both.

If you can internalise the top 10 traps in this guide, you'll be operating at a level above most of the cohort.

Read it twice in your last fortnight. Look at the last-week checklist on exam morning.

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## The paper at a glance

- **40 multiple-choice questions, 1 hour 15 minutes** — about **1 min 50 s per question**.
- Four options (A, B, C, D). One correct. **No negative marking** — never leave a blank.
- Variants 11, 12, 13 (and 14 from 2025) per main series. Same misconception is usually flagged across variants in the same year.
- Topics covered: Physical quantities & units, Kinematics, Dynamics, Forces, Work-energy-power, Deformation of solids, Waves, Superposition, Electricity (current, resistance, circuits), Particle physics. Practical-skills questions (graph work, uncertainty) thread through.

What examiners want: rigorous physics from defined quantities, with clean unit work, vector awareness, and the ability to step back from a problem to sanity-check.

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## The Top 10 Mistakes That Cost AS Candidates Marks

Ranked by how often examiners flag them across 15 series. If you fix only these ten, you'll outscore most of the cohort.

## 1. Vector vs scalar — the single most flagged error

Flagged in 13 out of 15 series analysed.

The classic appearances:

- **Projectile components:** confusing  $\sin \theta$  with  $\cos \theta$ . The horizontal component of a velocity at angle  $\theta$  above horizontal is  $v \cos \theta$ ; the vertical is  $v \sin \theta$ . If the angle is given from the vertical, it's the other way round.
- **Resolving forces:** weight components on an incline —  $mg \cos \theta$  perpendicular to the slope;  $mg \sin \theta$  along it. Get the geometry on paper before substituting.
- **Momentum change:** when a ball rebounds, change in momentum =  $mv_{\text{after}} - mv_{\text{before}}$ . If one velocity is +25 m/s and the other is -20 m/s, the change in magnitude is 45, not 5.
- **Velocity vs speed:** "relative speed of approach = relative speed of separation" is an elastic collision rule. It uses **speed**, not velocity. Confusing the two costs the mark.

**The fix: Set a positive direction.** Every vector question — write a small arrow in the corner of your scratch space showing which way is +. Sign every quantity. Then add or subtract.

## 2. Definitions — know the **exact** syllabus wording

Flagged in 13 series.

Examiners are explicit: candidates lose marks because they "do not know the precise definitions of physical quantities" or "confuse the definition of a unit with the definition of a quantity".

Get these word-perfect:

- **Velocity:** rate of change of displacement (vector).
- **Acceleration:** rate of change of velocity. (Not "rate of change of velocity per unit time" — that would be jerk!)
- **Density:** mass per unit volume.
- **Pressure:** force per unit area.
- **Resistance:** ratio of potential difference across a component to current through it ( $V/I$ ).
- **EMF (e.m.f.):** the work done per unit charge by the source (e.g. cell) on the charge as it passes through the source. Units:  $J/C = V$ .
- **Potential difference:** work done per unit charge between two points in a circuit.
- **Power:** rate of doing work; rate of energy transfer.
- **Specific charge:** charge per unit mass.

**Definition trap:** options often differ by one word. Read every word.

### 3. Diffraction grating and double-slit equations

Flagged in 13 series.

$d \sin \theta = n\lambda$  (diffraction grating) or  $\lambda = ax/D$  (double slit, small angles).

The most common gotchas:

- **"Lines per mm"** needs converting. If a grating has 600 lines/mm, then  $d = 1 / (600 \times 10^3)$  m =  $1.67 \times 10^{-6}$  m. Not 600.
- **Order n is an integer.** Sometimes the question asks for the angle to the 3rd order maximum; weaker candidates calculate the 2nd order.
- **Two wavelengths overlapping:** the nth order of the longer  $\lambda$  overlaps with the (n+1)th order of the shorter one if  $n\lambda_{\text{long}} = (n+1)\lambda_{\text{short}}$ .
- **Stationary waves vs interference patterns:** know the difference — stationary waves have **nodes and antinodes**; interference patterns have **maxima and minima** with fringe spacings.

### 4. Momentum and impulse — including elastic collisions

Flagged in 13 series.

Key rules:

- **Conservation of momentum** applies in **isolated systems** (no external resultant force) — for both elastic and inelastic collisions. Examiners flag candidates who forget the "isolated system" requirement.
- **Conservation of KE** applies in **elastic collisions only**.
- **Elastic collision shortcut:** relative speed of approach = relative speed of separation. Equivalent to KE conservation, but often quicker.
- **Impulse =  $F \times t$  = change in momentum** (vector, signed).
- **Rate of change of momentum = resultant force** (Newton's 2nd law in its general form).
- **From a force–time graph, area = impulse.** From a momentum–time graph, **gradient = force**.

### 5. Reading questions carefully — NOT, EXCEPT, ONLY

Flagged in 11 series, and a permanent fixture in the general comments.

The exact phrase from 5 years of reports: "Candidates should always read each question through in its entirety before looking at the four possible answers, taking particular care when, for instance, a question asks 'which statement is **not** correct?'"

Other command-word traps:

- **"BEST" answer:** more than one option may be partly right — pick the most complete or precise.
- **"INITIAL" vs "AVERAGE" vs "FINAL":** especially in motion graphs.

- **"DIFFERENCE" vs "VALUE"**: is the question asking for absolute or relative?

## 6. Graph interpretation — gradient vs area, axis swaps

Flagged in 10 series.

The recurring traps:

- **Force–extension graph**: area under = work done. Only valid when the graph is plotted **F on y, x on x** (the conventional way). Examiners specifically flag the trap where the graph is plotted with **e on y-axis and F on x-axis** — the area under is now  $eF$  which isn't work done in the conventional sense.
- **Speed–time graph**: area = displacement. Gradient = acceleration.
- **Displacement–time graph**: gradient = velocity. (Area has no useful meaning here.)
- **I-V characteristic**: resistance =  $V/I$  at a given point, **not** the gradient (except for ohmic conductors).
- **Linearisation**: to test if a relationship is  $s = \frac{1}{2}at^2$ , plot  $s$  against  $t^2$  and the gradient is  $\frac{1}{2}a$ . Choose axes that linearise the relationship.

## 7. Potential dividers, potentiometers and internal resistance

Flagged in 10 series.

Key principles:

- **EMF ( $\epsilon$ ) = total work done per coulomb by the cell. Terminal PD ( $V$ ) = work done per coulomb on the external circuit only.** Difference = "lost volts"  $Ir$  across the internal resistance.
- $V = \epsilon - Ir$ . So larger current  $\rightarrow$  smaller terminal PD.
- **Doubling external resistance does NOT double the total resistance** — the internal resistance is still there. So the new current is **slightly more** than half the original current.
- **Potentiometer (balanced)**: galvanometer reads zero  $\rightarrow$  no current through cell X  $\rightarrow$  no "lost volts" across its internal resistance  $\rightarrow$  internal resistance value is **not needed** for the calculation.
- **Potential divider**: if  $R_1$  and  $R_2$  are in series, the PD across  $R_1$  is  $\frac{\epsilon \times R_1}{(R_1 + R_2)}$ . Watch for **thermistor or LDR** as one of the resistances — its resistance changes with conditions.

## 8. Nuclear physics — $\alpha$ , $\beta^+$ , $\beta^-$ , $\gamma$ distinctions

Flagged in 8 series, intensifying recently.

Recurring confusions:

- **$\beta^-$  decay:** a neutron decays into a proton + electron + antineutrino. The electron ( $\beta^-$  particle) is ejected. Proton number **+1**, nucleon number unchanged.
- **$\beta^+$  decay:** a proton decays into a neutron + positron + neutrino. The positron ( $\beta^+$  particle) is ejected. Proton number **-1**, nucleon number unchanged.
- **$\alpha$  decay:** nucleon number **-4**, proton number **-2**. Neutron number drops by **2**, not 4.
- **Energy from  $\alpha$  vs  $\beta$  decay:** different energies released;  $\beta^-$  particles are emitted with a **continuous range** of velocities (because the energy is shared with a neutrino).
- **Particle classification: leptons** (electron, positron, neutrino, muon), **hadrons** (proton, neutron, mesons). Quarks make up hadrons. Examiners flag candidates who can't classify a particle from a list.
- **Charge on quarks:** up =  $+\frac{2}{3}$ , down =  $-\frac{1}{3}$ . Proton (uud) = +1; neutron (udd) = 0.

## 9. Newton's third law — same type, different objects

Flagged in 5 series, regularly returning.

The third-law pair has two key features:

- **Two forces of the same type.** If one is gravitational, the other is gravitational. If one is electromagnetic, the other is electromagnetic.
- **They act on different objects.** Force on A from B; force on B from A.

**The common error:** picking the weight of an object and the upward normal force from the table as a "Newton's 3rd law pair". They are not! Both forces act on the **same object** (the book). They are equilibrium forces, not 3rd law pairs.

The actual 3rd law pair for a book on a table:

- Weight (gravitational pull of Earth on book)  $\leftrightarrow$  gravitational pull of book on Earth.
- Normal force (table pushing book up)  $\leftrightarrow$  book pushing table down.

## 10. Significant figures, SI prefixes, and powers of 10

Flagged in 5 series, and a fixture of every general-comments paragraph since 2022.

The recurring sentence from examiners: "candidates should be careful to consider SI prefixes and powers of ten, as well as possible unit conversions, and should be encouraged to check to their answers to ensure they are a sensible magnitude."

The signature errors:

- **Quadratic conversions:**  $1 \text{ cm}^2 = 10^{-4} \text{ m}^2$ , not  $10^{-2}$ . Squaring distance conversions.
- **Cubic conversions:**  $1 \text{ cm}^3 = 10^{-6} \text{ m}^3$ , not  $10^{-3}$ .
- **Diffraction grating lines/mm  $\rightarrow$  spacing in m.**
- **Significant figures:** if data is to 2 sig figs, the answer should be to 2 or 3 — not 5.

- **Magnitude check:** a calculated speed of  $3 \times 10^{10}$  m/s is impossible (above  $c$ ). Reasonable-sounding wrong magnitudes (e.g. 30 m/s for the speed of light in a fibre) need scrutiny.

## Topic-by-topic pitfalls (AS-specific)

### Physical Quantities and Units

- **SI base units:** kg, m, s, A, K, mol, cd. **Not** N, J, W, V — those are derived.
- **Homogeneity check:** every term in an equation must have the same units. If they don't, the equation is wrong.
- **Percentage uncertainty:** add for multiplication / division; multiply by power for exponentiated quantities. For  $s = \frac{1}{2}at^2$ , the percentage uncertainty in  $a$  is the percentage in  $s$  plus **2 × percentage** in  $t$ .
- **Density of a sphere:** uncertainty in diameter → uncertainty in volume is **3 × percentage** (since  $V \propto d^3$ ).
- **Estimating physical quantities:** know orders of magnitude. Mass of a person  $\sim 70$  kg. Mass of a car  $\sim 1000$  kg. Speed of sound in air  $\sim 340$  m/s. Mass of a proton  $\sim 10^{-27}$  kg.

### Kinematics and Dynamics

- **Constant acceleration equations** apply only when acceleration is **constant** — not in free fall with air resistance.
- **Projectile motion:** horizontal velocity is constant (no air resistance); vertical velocity changes due to  $g$ . Treat each direction independently.
- **"Maximum horizontal range":** for a given launch speed in a vacuum, max range is at  $45^\circ$  above horizontal. But examiners don't always ask the obvious version — read what's actually requested.
- **Terminal velocity:** drag = weight → zero resultant force → zero acceleration. Different from zero velocity.
- **Acceleration of a falling skydiver:** initially  $g$  (zero drag); decreases as drag builds; reaches terminal velocity when drag = weight.
- **Air resistance and free fall:** at higher speed, drag is larger → smaller resultant force. A ball thrown up reaches less height than expected from purely gravitational analysis.
- **Newton's 2nd law:**  $F = ma$  only when mass is constant. The more general form is  $F = dp/dt$  — useful for rocket-like problems.

### Forces, Work, Energy and Power

- **Work done = force × distance moved in the direction of the force.** Horizontal work on a horizontal surface; vertical work against gravity.

- **GPE = mgh** where h is the height **change** (final – initial). Not absolute height.
- **KE =  $\frac{1}{2}mv^2$** . Change in KE =  $\frac{1}{2}m(v^2 - u^2)$  — that's **the difference of squares**, not the square of the difference.  $\frac{1}{2}m(v - u)^2$  is wrong.
- **Power = work / time = force × velocity**. For an engine delivering constant force at velocity v,  $P = Fv$ .
- **Efficiency = useful output / total input** (× 100% if percentage).
- **Conservative forces** (gravity, spring): work done depends only on start and end points. Total mechanical energy conserved in their presence.
- **Non-conservative forces** (friction, drag): dissipate energy; total mechanical energy decreases.

### Deformation of Solids

- **Hooke's law:**  $F = ke$ , valid up to the **limit of proportionality**.
- **Elastic limit:** the point beyond which permanent deformation occurs. **Different** from the limit of proportionality, though often close.
- **Stress = force / cross-sectional area** (Pa).
- **Strain = extension / original length** (dimensionless).
- **Young modulus = stress / strain** (Pa). Only valid in the linear region.
- **Energy stored in a spring =  $\frac{1}{2} Fe = \frac{1}{2} ke^2$**  (area under F-e graph).

### Waves and Superposition

- **Wave speed:**  $v = f\lambda$ .
- **Phase difference:** measured in degrees or radians. Two waves at the same point with phase difference  $0^\circ$  or  $360^\circ$  interfere constructively;  $180^\circ$  gives destructive.
- **Path difference:** the difference in path lengths from two sources to a point.  $\lambda$  path difference =  $360^\circ$  phase.  $\lambda/2$  path difference =  $180^\circ$  phase = destructive interference (when sources are in phase).
- **Coherence:** sources are coherent if they have a **constant phase difference** (and usually the same frequency).
- **Stationary waves:** form from two waves of the same frequency travelling in opposite directions. **Nodes** = zero amplitude (always); **antinodes** = maximum amplitude.
- **Distance between adjacent nodes =  $\lambda/2$** .
- **Polarisation** is only possible for **transverse** waves — never longitudinal. So **sound cannot be polarised**, but light (and other EM waves) can.
- **Intensity  $\propto$  amplitude<sup>2</sup>**. So doubling intensity multiplies amplitude by  $\sqrt{2}$ , not 2. To halve amplitude, intensity must be quartered.

- **Doppler effect:** observed frequency changes when source and observer move relative to each other.  $f_{\text{observed}} = f_{\text{source}} \times v / (v - v_{\text{source}})$  (source approaching). Watch the sign of  $v_{\text{source}}$ .
- **Malus's law:** intensity through a second polariser =  $I_0 \cos^2 \theta$ , where  $\theta$  is the angle between the **transmission axes** (not from the vertical, not from the previous filter).

## Electricity and Circuits

- **Current = rate of flow of charge:**  $I = dQ/dt$ . Or  $Q = It$  for constant current.
- **Resistance** is **not** the gradient of an I-V graph (except for ohmic conductors at constant T). It's  $V/I$  at the operating point.
- **Filament lamp:** I-V curve flattens as  $V$  (and current) increases — because heating raises resistance.
- **Diode:** zero current below  $\sim 0.6$  V (silicon), then rapidly increasing.
- **Resistivity:**  $\rho = RA/L$ . Material property; doesn't depend on dimensions.
- **Drift velocity:**  $I = nAvq$ , where  $n$  is the charge carrier density,  $A$  is cross-sectional area,  $v$  is drift velocity,  $q$  is charge per carrier.
- **Kirchhoff's first law:** sum of currents into a junction = sum out. (Conservation of charge.)
- **Kirchhoff's second law:** sum of EMFs around a loop = sum of IR drops. (Conservation of energy.)
- **Internal resistance  $r$ :** terminal PD =  $\mathcal{E} - Ir$ . Larger  $I \rightarrow$  smaller  $V$  across terminals.

## Particle Physics (Quantum / Subatomic)

- **Quarks:** up ( $+\frac{2}{3} e$ ), down ( $-\frac{1}{3} e$ ), and "strange" / other types at A-level Year 2. AS focuses on  $u$  and  $d$ .
- **Proton (uud) = +1 e. Neutron (udd) = 0.**
- **Leptons:** electron, positron, neutrino, muon. Fundamental particles, not made of quarks.
- **$\beta^-$  decay** (quark-level): a down quark in a neutron becomes an up quark, emitting an electron and antineutrino.
- **$\beta^+$  decay** (quark-level): an up quark in a proton becomes a down quark, emitting a positron and neutrino.
- **Antimatter:** every particle has an antiparticle (electron / positron; proton / antiproton; neutrino / antineutrino).

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## Universal MCQ technique (AS edition)

### 1. Solve cleanly before looking at options.

Every general-comments paragraph from 2021 onwards: "calculate the answer before looking at the answer options". Plugging numbers in from A–D leads to back-fitting.

### 2. Cover-eliminate-choose.

If full calculation isn't yielding an obvious match, eliminate **the impossible**:

- Negative resistance? Impossible.
- Output frequency greater than input in refraction? Impossible.
- Velocity greater than  $c$  in any frame? Impossible at AS level.
- Magnitude wildly out of expected range? Probably impossible.

### 3. Sketch a diagram before resolving vectors.

For projectile, inclined plane, force balance, or Newton's 3rd law questions — a small sketch with all the forces / velocities and their directions saves you from sign errors.

### 4. Write the formula symbolically before substituting.

This catches inverted formulas ( $V/I$  vs  $I/V$ ,  $\sin i / \sin r$  vs  $\sin r / \sin i$ ,  $\frac{1}{2}mv^2$  vs  $\frac{1}{2}(mv)^2$ ).

### 5. Magnitude check.

Use rough orders of magnitude as a sanity check at the end:

- Speed of sound  $\sim 340$  m/s
- Speed of light =  $3 \times 10^8$  m/s
- $g = 9.81$  m/s<sup>2</sup> (often rounded to 9.8 or 10)
- 1 atm  $\approx 10^5$  Pa
- $e$  (electronic charge) =  $1.6 \times 10^{-19}$  C
- $m_e$  (electron mass) =  $9.1 \times 10^{-31}$  kg
- $m_p$  (proton mass) =  $1.67 \times 10^{-27}$  kg
- $\epsilon_0 \approx 8.85 \times 10^{-12}$  F/m (not on AS formula sheet in the same way, but useful)

### 6. SI prefix awareness.

Translate every prefix to a power of 10. Pico (p) =  $10^{-12}$ . Nano (n) =  $10^{-9}$ . Micro ( $\mu$ ) =  $10^{-6}$ . Milli (m) =  $10^{-3}$ . Kilo (k) =  $10^3$ . Mega (M) =  $10^6$ . Giga (G) =  $10^9$ .

## 7. Sig fig audit.

If the data is to 2 sig figs, your answer should be 2 or 3 sig figs. Options with 4+ sig figs from 2 sig fig data are usually wrong (or the examiner is making a point about precision).

## 8. Two-column options — check **both** columns.

Many AS MCQs have options with two columns (e.g. "frequency higher / lower" and "wavelength longer / shorter"). It's easy to get one right and miss the other.

## 9. Don't leave blanks.

No negative marking. After eliminating, pick.

## The trap-spotter — distractor patterns (AS)

PATTERN	HOW IT LOOKS	HOW TO BEAT IT
<b>Sin/cos swap</b>	Horizontal component option uses sin instead of cos (or vice versa)	Draw the angle and the components on a quick sketch
<b>Vector ignored</b>	Two velocities in opposite directions: option adds them instead of subtracting (or vice versa)	Set + direction, sign each, then combine
<b>Square of difference vs difference of squares</b>	KE change: option uses $\frac{1}{2}m(v-u)^2$ instead of $\frac{1}{2}m(v^2-u^2)$	Always: $\Delta KE = \frac{1}{2}m(v^2 - u^2)$ , then check sign
<b>Wrong rule applied</b>	Right-hand rule for motor instead of generator (or vice versa)	Motor = left hand; generator = right hand
<b>Sig fig too high</b>	Data to 2 sf, option to 4 sf	Match precision to data
<b>Failed prefix conversion</b>	mm or $\mu\text{m}$ not converted to m before substitution	Convert everything to SI at the start
<b>Quadratic / cubic prefix error</b>	Treated $\text{cm}^2$ as $10^2$ instead of $10^{-4} \text{m}^2$	Convert distance first, then square / cube
<b>Newton 3 pair wrong</b>	Picked weight + normal force as a 3rd law pair	Pairs act on different objects, same type
<b>Stopped one step early</b>	Background subtracted but not added back; $\Delta p$ calculated but not subtracted from atmospheric	List the steps; finish each
<b>Used wrong resistance formula</b>	Gradient of I-V for a filament lamp instead of $V/I$	Resistance = $V/I$ at the specific point
<b>Internal resistance ignored</b>	"Doubling R halves I" type — but the internal resistance is still there	Total R = external R + internal r; halving needs the <b>WHOLE</b> total to double

PATTERN	HOW IT LOOKS	HOW TO BEAT IT
<b>Phase / path difference muddled</b>	Used degrees where radians needed, or vice versa	Path difference / $\lambda \times 360^\circ =$ phase difference in degrees
<b>Order n confused with order n+1</b>	2nd order overlap claimed as 3rd order	Re-read the question; circle which order is asked

## Last-week checklist

Tick each one when you can do it cold.

### Quantities, units and uncertainties

- SI base units: kg, m, s, A, K, mol, cd
- Homogeneity check on equations
- Percentage uncertainty: add for  $\times/\div$ ; multiply by power for exponents
- Order-of-magnitude estimates for common quantities

### Kinematics and dynamics

- Equations of motion only with constant acceleration
- Projectile: horizontal  $v$  constant, vertical  $v$  changes by  $g$
- Free-fall acceleration =  $g$  (constant in absence of drag)
- Terminal velocity = zero resultant force
- $F = ma$  only when  $m$  is constant;  $F = dp/dt$  always

### Forces and energy

- Newton's 3rd law pair: same type, different objects
- Work done =  $F \times d$  in direction of  $F$
- $\Delta KE = \frac{1}{2}m(v^2 - u^2)$ , not  $\frac{1}{2}m(v-u)^2$
- Power =  $Fv$  when force is constant along motion
- Conservation of energy  $\rightarrow$  conservation of KE in elastic only

### Momentum

- Conservation of momentum in isolated systems (always)
- Sign every velocity before computing change
- Impulse =  $Ft = \Delta p$  (area under  $F-t$  graph)
- Elastic shortcut: relative speed of approach = relative speed of separation

### Deformation

- Hooke's law up to limit of proportionality
- Limit of proportionality  $\neq$  elastic limit (usually close)
- Stress =  $F/A$ , strain =  $e/L_0$ , Young modulus = stress/strain
- Energy stored =  $\frac{1}{2}Fe = \frac{1}{2}ke^2$

### Waves

- $v = f\lambda$
- All EM waves at speed  $c$  in vacuum
- Frequency unchanged in refraction
- Intensity  $\propto$  amplitude<sup>2</sup>
- Polarisation only for transverse waves (not sound)
- Malus's law uses angle between transmission axes

### Superposition

- Path difference /  $\lambda \times 360^\circ =$  phase difference (degrees)
- Diffraction grating:  $d \sin \theta = n\lambda$
- Double slit:  $\lambda = ax/D$  (small angles)
- Convert "lines per mm" to  $d$  (in metres)
- Stationary waves: nodes and antinodes; spacing =  $\lambda/2$

### Electricity and circuits

- $I = dQ/dt$  ;  $Q = It$  for constant  $I$
- $R = V/I$  (not gradient for non-ohmic)
- $I = nAvq$  for drift velocity
- Kirchhoff 1: junction currents balance
- Kirchhoff 2: EMFs = IR drops around a loop
- Terminal PD =  $\epsilon - Ir$
- Balanced potentiometer: galvanometer reads zero, ignore internal resistance of test cell

### Particle physics

- Quarks: up ( $+\frac{2}{3}$ ), down ( $-\frac{1}{3}$ ); proton (uud), neutron (udd)
- $\beta^-$ : neutron  $\rightarrow$  proton + electron + antineutrino; nucleon unchanged,  $Z+1$
- $\beta^+$ : proton  $\rightarrow$  neutron + positron + neutrino;  $Z-1$
- $\alpha$ :  $A-4$ ,  $Z-2$ ,  $N-2$  (not  $-4$ )
- Particle families: leptons (electron, positron, neutrino), hadrons (proton, neutron)

### Exam day habits

- Cover options, solve first
- Underline NOT / EXCEPT / ONLY
- Sketch vectors before resolving
- Convert all units to SI before substituting
- Two-column options: check both columns
- Sanity-check magnitudes
- Never leave a blank

## Worked example

**Question:** A ball of mass 0.50 kg travels horizontally at 8.0 m/s and strikes a wall. It rebounds horizontally at 6.0 m/s in the opposite direction. The contact time with the wall is 0.040 s.

What is the **average force** exerted by the wall on the ball?

A. 25 N B. 75 N C. 100 N D. 175 N

**Solving cleanly (cover the options first):**

Step 1 — what is asked? **Average force**. Use impulse =  $Ft = \Delta p$ .

Step 2 — set positive direction. Let **away from the wall** be positive. So:

- Initial velocity:  $-8.0$  m/s (toward the wall = negative).
- Final velocity:  $+6.0$  m/s (away from the wall = positive).

Step 3 — change in momentum:

- $\Delta p = m \times (v_{\text{final}} - v_{\text{initial}}) = 0.50 \times (+6.0 - (-8.0)) = 0.50 \times 14 = \mathbf{+7.0 \text{ kg}\cdot\text{m/s}}$ .

Step 4 — average force from impulse:

- $F = \Delta p / t = 7.0 / 0.040 = \mathbf{175 \text{ N}}$ .

Step 5 — match: **D. 175 N**.

**Why each wrong option exists:**

- **A (25 N)** = treated rebound speed as  $6.0 - 8.0 = -2.0$  (subtracted magnitudes, ignored direction reversal).  $F = 0.50 \times 2 / 0.040 = 25 \text{ N}$ .
- **B (75 N)** = used  $\Delta v = 6.0$  only (forgot the initial momentum entirely).  $F = 0.50 \times 6 / 0.040 = 75 \text{ N}$ .
- **C (100 N)** = used  $\Delta v = 8.0$  only (only the initial half).  $F = 0.50 \times 8 / 0.040 = 100 \text{ N}$ .

The trap is **direction**. Momentum is a vector. The change includes both the loss of incoming momentum and the gain of outgoing momentum in the opposite direction.

This pattern is flagged in **Jun 2021, Jun 2023, Jun 2024, Jun 2025, Mar 2021, Mar 2022, Mar 2023, Mar 2024, Mar 2025, Nov 2022, Nov 2023, Nov 2024, Nov 2025** — every series since 2021.

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## A final word

Most candidates who underperform on 9702 Paper 1 know more physics than they get credit for. They lose marks on **direction, units, and reading**. The fixes are all habits, not knowledge.

- Set a positive direction before every vector calculation.
- Write the formula symbolically before substituting.
- Convert every unit to SI at the very start.
- Underline every NOT and EXCEPT.
- Sanity-check the magnitude.
- Never leave a blank.

Slow down on questions where the diagram looks busy or the option set has two columns. Those are the trap-rich questions.

You've already put the work in. Now use the technique.

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