IB DP PHYSICS · EXAM SPECIAL · SL & HL · THE DATA-BASED QUESTIONS (SAME PAPER AT BOTH LEVELS) · ~8 MIN READ

IB Physics Paper 1B: Data, Uncertainties and Graph Skills

Everything Paper 1B tests in IB Physics: recording uncertainties, propagating them, max and min gradient lines, linearising graphs, units of gradients and evaluating experiments, with the errors examiners flagged.

Recording values & uncertainties | Propagating uncertainties | Gradients & intercepts | Max/min lines | Linearising | Units of gradients | Errors & improvements | Unfamiliar experiments

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No tag = **SL and HL** HL ONLY HL students only DATA BOOKLET given in the exam

M1 A1 how marks are awarded highlight = comes up again and again HANDY worth memorising

Test yourself at the end

IN 30 SECONDS

- **Paper 1B is the same paper at SL and HL:** 20 marks of data-based questions on experiments, sat straight after Paper 1A in one session.
- **It rewards lab skills, not memory.** Most marks come from uncertainties, graphs and judging an experiment, often one you have never seen.
- **Read the whole introduction first.** The 2025 reports note that students who skimmed the long description of an unfamiliar experiment lost easy marks later.

BY THE END YOU CAN

- Record measurements with correctly rounded uncertainties.
- Propagate uncertainties through products, quotients and powers.
- Find gradients and their uncertainties from max and min lines.
- Linearise relationships and state the units of a gradient.
- Evaluate experiments with specific, realistic improvements.

Riyaz Sir

1 Recording values and uncertainties

- **The uncertainty usually has 1 significant figure** (2 is acceptable when the first digit is 1).
- **The value is rounded to the same decimal place as the uncertainty.**

WORKED EXAMPLE

A student calculates a resistance of 1021 Ω with an uncertainty of 23 Ω. How should it be written?

1. Uncertainty to 1 s.f.: 23 → 20 Ω
2. value to the same place (tens): 1021 → 1020
3. **R = 1020 ± 20 Ω**

COMMON MISTAKE

Writing 1021 ± 20 Ω or 1020 ± 23.4 Ω. Both were penalised in 2025.

- **Absolute uncertainty** has units (± 0.5 cm). **Fractional** (Δx/x) and **percentage** (Δx/x × 100%) uncertainties have **no units**.
- **Analogue scales:** ± half the smallest division (or the full division, if the reading is hard). **Digital:** ± the last digit.
- **Repeated readings:** uncertainty ≈ ½ × (largest − smallest). If repeated readings don't vary, use the instrument's **least count**.
- **Convert the uncertainty with the value.** 2.5 ± 0.1 mm = (2.5 ± 0.1) × 10^{-3} m.

2 Propagating uncertainties

Result	Rule (from the data booklet)
y = a ± b	Add the **absolute** uncertainties: Δy = Δa + Δb
y = ab or a/b	Add the **fractional** (or %) uncertainties
$y = a^n$	Multiply the fractional uncertainty by **|n|**

WORKED EXAMPLE

Density: m = 50.0 ± 0.5 g and V = 20.0 ± 0.4 cm^3. Find ρ with its uncertainty.

1. ρ = 50.0/20.0 = 2.50 g cm^{-3}
2. %: 0.5/50.0 = 1%, 0.4/20.0 = 2%, total **3%**
3. Δρ = 0.03 × 2.50 = 0.075 ≈ 0.08
4. **ρ = 2.50 ± 0.08 g cm^{-3}**

WORKED EXAMPLE

A pendulum: $g = 4\pi^2L/T^2$. L has a 1% uncertainty and T has a 2% uncertainty. What is the % uncertainty in g?

1. % in L: 1%
2. % in T^2: 2 × 2% = 4%
3. **π is exact, so % in g = 1% + 4% = 5%**

- **Square roots halve it:** if $y = \sqrt{x}$, the fractional uncertainty in y is ½ that of x. Students often doubled it.
- **Radius from diameter:** r = d/2 has the **same fractional** uncertainty as d; the absolute uncertainty halves too.
- **A sum or difference can be large:** in $x_2 - x_1$ the absolute uncertainties **add**, so a small difference has a large % uncertainty.

3 Gradients and graphs

- **Gradient from the line, not the data.** Choose two points **on your best-fit line**, far apart (at least half the line's length), and show them.
- **Max and min lines** must pass through **all** the error bars, not just the first and last ones.
- **Uncertainty in the gradient** = (max gradient − min gradient) ÷ 2. The same method works for the intercept.

WORKED EXAMPLE

The steepest line through the error bars has gradient 2.46 and the shallowest 2.18. State the gradient with its uncertainty.

1. best ≈ (2.46 + 2.18)/2 = 2.32
2. Δ = (2.46 − 2.18)/2 = 0.14 → 0.1
3. **gradient = 2.3 ± 0.1 (with units from the axes)**

- **Check where the axes cross.** If the x-axis starts at 20 rather than 0, the intercept you see is **not** the y-intercept.
- **Error bars:** vertical bars show the uncertainty in the **y** variable, horizontal bars in **x**. Draw them to the scale of the graph.
- **Outliers:** circle a point that lies well off the line and give a reason before you ignore it.

4 Linearising

Common forms

Relationship	Plot y against x	Gradient	Intercept
$T = 2\pi\sqrt{(L/g)}$	T^2 against L	$4\pi^2/g$	0
pV = constant (Boyle)	p against 1/V	the constant (nRT)	0
$I = kV^n$	ln I against ln V	n	ln k
$N = N_0e^{-\lambda t}$	ln N against t	$-\lambda$	$\ln N_0$
$F = kq/r^2$	F against $1/r^2$	kq	0

- **Proportional** means a straight line **through the origin**. A straight line that misses the origin is linear, not proportional.
- **Testing proportionality from a table:** show that y/x is constant (within the uncertainties).

Units of a gradient

- **Gradient unit = y-axis unit ÷ x-axis unit.** Give it in SI base units if asked.

WORKED EXAMPLE

The gradient of a graph of p (Pa) against 1/V (m^{-3}). What are its units?

1. Pa ÷ m^{-3} = Pa m^3
2. **Pa = kg m^{-1} s^{-2}, so Pa m^3 = kg m^2 s^{-2} (the joule)**

5 Errors and improvements

Vocabulary examiners insist on

Term	Meaning	How to reduce it
Random error	Readings scatter both ways around the true value	Repeat and average; plot a graph
Systematic error	All readings shift the same way (e.g. a zero error)	Calibrate; check the zero; change the method
Accurate	Close to the true or accepted value	Remove systematic errors
Precise	Repeated readings agree closely (small spread)	Better instrument; reduce random error

COMMON MISTAKE

"Repeat the experiment" for a systematic error. Repeating reduces random error only. A zero error stays in every reading.

COMMON MISTAKE

"Make one measurement more accurate" answered with "repeat". Name a better instrument or technique: vernier calipers or a micrometer for a diameter, a ruler held perpendicular, a fiducial marker, timing 20 oscillations instead of 1.

- **Comparing with a theory:** "the accepted value **lies within** the uncertainty range (2.50 ± 0.08 includes 2.54), so the result is consistent". You need the uncertainty to make the comparison.
- **Variables:** independent (you change it), dependent (you measure it), control (kept constant, with **how** you keep it constant).

6 Unfamiliar experiments

- **Underline what is measured, what is varied and what is kept constant** in the introduction.
- **Later parts are often easier.** Every part can be attempted on its own; don't stop at the first hard one.
- **Units in tables:** headings carry units (t / s); values in a column have the same number of decimal places.

LINKING QUESTION

The physics of these experiments is in A.1 Kinematics, B.3 Gas laws and C.1 Simple harmonic motion. Pair this with Paper 1A strategies, and see the Physics IA guide for the same skills in your own investigation.

Test yourself — cover the answers first

QUICK CHECK

1. Write 9.8126 ± 0.0473 m s^{-2} correctly.
2. A length has a 4% uncertainty. What is the % uncertainty in its square root?
3. Which error does repeating readings reduce?
4. What is the uncertainty of a gradient?
5. How do you linearise $y = kx^3$ to find the power 3?

6. Does a straight line that misses the origin show proportionality?

Show answers

1. 9.81 ± 0.05 m s^{-2}
2. 2%
3. random error
4. (max gradient − min gradient)/2
5. plot ln y against ln x; the gradient is 3
6. no, only a linear relationship

Stuck on a question?

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