ANSWER KEY & MARKING SCHEME · CBSE CLASS 11

Units and Measurements

Physics · Chapter 1 · Use this with the Board Paper · Companion to Quick Drill

HOW TO USE

Attempt the Board Paper first (closed-book, full time). Then come here. For 2-mark+ questions, compare your answer to the model. For 3-4 mark questions, also consult the **Topper Templates** below — these show the exact step-by-step structure that scores full marks per CBSE marking-scheme conventions.

MODEL ANSWERS · BOARD PAPER

Section A — Very Short Answer (1 mark each, 4 Qs)

Q1. Name the SI base unit of luminous intensity. [1 mark]

Ans: The candela (cd).

Q2. State the number of significant figures in 0.00520. [1 mark]

Ans: Three significant figures (5, 2 and the trailing 0; the leading zeros are not significant).

Q3. Write the dimensional formula of pressure. [1 mark]

Ans: Pressure = force/area = $[M L T^{-2}]/[L^2] = [M L^{-1} T^{-2}]$.

Q4. Why must the argument of sin θ be dimensionless? [1 mark]

Ans: Trigonometric functions are defined only for pure numbers; their value is a ratio with no dimensions, so the angle fed into them must itself be dimensionless (radian = arc/radius).

Section B — Short Answer I (2 marks each, 3 Qs)

Q5. Distinguish between accuracy and precision with one example. [2 marks]

Ans: Accuracy is the closeness of a measured value to the true value; precision is the closeness of repeated measurements to one another (set by the least count). Example: a clock running 5 minutes fast is precise (same reading each time) but not accurate. The two are independent.

Q6. Differentiate between systematic and random errors, stating how each is reduced. [2 marks]

Ans: Systematic errors shift every reading by the same amount in the same direction (e.g. a zero error or wrong calibration) and are reduced by CORRECTING the readings, not by averaging. Random errors fluctuate unpredictably in size and sign and are reduced by taking many readings and using their mean.

Q7. If Z = A/B with A = 100 ± 2 and B = 50 ± 1, find the maximum percentage error in Z. [2 marks]

Ans: For a quotient the relative errors add: $\Delta Z/Z = \Delta A/A + \Delta B/B = 2/100 + 1/50 = 0.02 + 0.02 = 0.04$. Maximum percentage error = $0.04 \times 100 = 4\%$.

Section C — Short Answer II (3 marks each, 3 Qs)

Q8. Check the dimensional correctness of the equation $v^2 = u^2 + 2as$. [3 marks]

Ans: $[v^2] = (L T^{-1})^2 = L^2 T^{-2}$; $[u^2] = (L T^{-1})^2 = L^2 T^{-2}$; $[2as] = [a][s] = (L T^{-2})(L) = L^2 T^{-2}$ (the constant 2 is dimensionless). All three terms have dimensions $M^0L^2T^{-2}$, so by the principle of homogeneity the equation is dimensionally correct. Caveat: a dimensional check cannot confirm the value of dimensionless constants, so it cannot by itself prove the equation complete.

Q9. A physical quantity is given by $Z = A^2 B / C^3$. The percentage errors in A, B and C are 1%, 2% and 3% respectively. Find the maximum percentage error in Z. [3 marks]

Ans: For a power relation, $\Delta Z/Z = |2|(\Delta A/A) + |1|(\Delta B/B) + |3|(\Delta C/C)$. Substituting the percentage errors: %error in Z = 2(1%) + 1(2%) + 3(3%) = 2% + 2% + 9% = 13%. Maximum percentage error in Z = 13% (C, raised to the third power, contributes most and should be measured most carefully).

Q10. **Derive the dimensional formula of the gravitational constant G and hence write its SI unit.** **[3 marks]**

> **Ans:** From Newton's law $F = G M m / r^2$, $G = F r^2 / (M m)$. Substituting dimensions: $[G] = [M L T^{-2}][L^2] / ([M][M]) = [M L^3 T^{-2}] / [M^2] = [M^{-1} L^3 T^{-2}]$. The corresponding SI unit is therefore $kg^{-1}\, m^3\, s^{-2}$, usually written $N\, m^2\, kg^{-2}$.

Section D — Case Study / Long Answer (5 + 6 marks, 2 Qs)

Q11. **Significant figures and rounding govern how a computed result is reported. (a) State the number of significant figures in (i) 4.500, (ii) 0.00208, (iii) 6.320×10^3. (b) State the rule for significant figures in multiplication/division and the rule for addition/subtraction. (c) Evaluate 4.327×2.1 and report to the correct number of significant figures. (d) Evaluate 12.52 + 1.3 and report to the correct precision.** **[5 marks]**

> **Ans:** (a) (i) 4.500 → 4 s.f. (trailing zeros after a decimal count); (ii) 0.00208 → 3 s.f. (leading zeros don't count); (iii) 6.320×10^3 → 4 s.f. (mantissa only). (b) For multiplication/division the result keeps as many SIGNIFICANT FIGURES as the input with the fewest; for addition/subtraction it keeps as many DECIMAL PLACES as the input with the fewest. (c) $4.327 \times 2.1 = 9.0867$; since 2.1 has 2 s.f., report 9.1 (2 s.f.). (d) 12.52 + 1.3 = 13.82; since 1.3 has one decimal place, report 13.8.

Q12. **Dimensional analysis is a powerful but limited tool. (a) State the principle of homogeneity. (b) A student claims the period of a simple pendulum is $T = 2\pi\sqrt{(l/g)}$. Use dimensional analysis to verify the dependence $T \propto \sqrt{(l/g)}$, assuming T may depend on length l, acceleration due to gravity g and mass m. (c) State why the factor 2π cannot be obtained from dimensional analysis. (d) State two other situations in which dimensional analysis fails.** **[6 marks]**

> **Ans:** (a) Principle of homogeneity: every term that is added, subtracted or equated in a physically valid equation must have the same dimensions. (b) Assume $T \propto l^a g^b m^c$, i.e. $[M^0L^0T^1] = [L]^a[L\, T^{-2}]^b[M]^c = M^c L^{a+b} T^{-2b}$. Equating powers: M: c = 0; T: −2b = 1 ⇒ b = −½; L: a + b = 0 ⇒ a = ½. Hence $T \propto l^{1/2} g^{-1/2} m^0 = \sqrt{(l/g)}$; the period is independent of mass. (c) The factor 2π is a dimensionless pure number, and dimensional analysis tracks only the powers of M, L and T, so it cannot generate or detect any dimensionless constant — 2π must be found from experiment or detailed theory. (d) Any two of: it cannot handle equations containing trigonometric, exponential or logarithmic functions (their arguments are dimensionless); it cannot derive a relation that is a SUM of several terms (such as $s = ut + \frac{1}{2}at^2$); and it fails when a quantity depends on more than three unknowns, since there are only three equations (for M, L, T).

★ TOPPER ANSWER TEMPLATES

3 TEMPLATES · MEMORISE THE FORMAT

★ TOPPER TEMPLATE — 3-mark numerical: 'A physical quantity Z = A^a B^b / C^c. Given the percentage errors in A, B and C, find the maximum percentage error in Z.'

Almost every Class 11 Physics paper / SQP

Step 1 **[1 mark]**	**Write the propagation rule for powers**	State the rule explicitly: for Z = A^a B^b / C^c, the maximum relative error is $\Delta Z/Z = \lvert a\rvert(\Delta A/A) + \lvert b\rvert(\Delta B/B) + \lvert c\rvert(\Delta C/C)$. Writing the rule earns the first mark even before substitution.
Step 2 **[1 mark]**	**Substitute the given percentage errors with their exponents**	Multiply each percentage error by the MAGNITUDE of its exponent (always positive — errors add, never subtract). e.g. for Z = A^2 B / C^3 with errors 1%, 2%, 3%: %error in Z = 2(1) + 1(2) + 3(3) = 2 + 2 + 9 = 13%.
Step 3 **[1 mark]**	**Quote the final answer correctly**	State: 'Maximum percentage error in Z = 13%.' If the question gives a value of Z, also report Z ± its absolute error rounded to matching precision. Always say 'maximum' — error propagation gives the worst case.

COMMON LOSS OF MARKS:

- Subtracting errors because one quantity is in the denominator — errors ALWAYS add; the |c| handles the denominator (–1 mark).
- Forgetting to multiply by the exponent magnitude (treating A^3 like A) — the classic slip.
- Adding absolute errors instead of relative/percentage errors for a product (wrong rule entirely).

★ TOPPER TEMPLATE — 3-mark question: 'Check the dimensional correctness of the equation [e.g. v^2 = u^2 + 2as].'

Very common — SQP and school finals

Step 1 [1 mark]	**Write the dimensional formula of each term**	List dimensions term-by-term. For $v^2 = u^2 + 2as$: $[v^2] = (LT^{-1})^2 = L^2 T^{-2}$; $[u^2] = L^2 T^{-2}$; $[2as] = [a][s] = (LT^{-2})(L) = L^2 T^{-2}$ (the 2 is dimensionless).
Step 2 [1 mark]	**Compare every term — they must match**	Show that all three terms have identical dimensions $L^2 T^{-2}$. State the principle of homogeneity: only quantities with the SAME dimensions can be added or equated.
Step 3 [1 mark]	**Conclude with the correct caveat**	'Since every term has the dimensions $L^2 T^{-2}$, the equation is dimensionally correct (homogeneous).' Add the caveat for full marks: dimensional correctness does not guarantee the equation is physically complete, since dimensionless constants cannot be checked this way.

COMMON LOSS OF MARKS:

- Giving dimensions of a quantity (e.g. 'velocity') instead of the WHOLE term (e.g. 'v^2') — must square it.
- Treating the dimensionless '2' as if it had dimensions.
- Claiming a dimensionally correct equation is 'proved correct' — examiners want the homogeneity caveat.

★ TOPPER TEMPLATE — 2-mark question: 'State the number of significant figures in the given measurements and express the result of a calculation to the correct number of significant figures.'

Common — almost every paper

Step 1 [1 mark]	**Count significant figures using the rules**	Apply the rules: all non-zero digits count; zeros between non-zero digits count; leading zeros NEVER count; trailing zeros count only if a decimal point is present. e.g. 0.00520 → 3 s.f.; 4.500 → 4 s.f.; 6.320×10^3 → 4 s.f.
Step 2 [1 mark]	**Round the result to the least-precise input**	For multiplication/division, the result keeps as many significant figures as the input with the FEWEST. For addition/subtraction, keep as many DECIMAL PLACES as the input with the fewest. Round using the standard rule (≥ 5 rounds up; the 'round-to-even' convention is acceptable). State the final rounded value with its unit.

COMMON LOSS OF MARKS:

- Counting leading zeros as significant (0.0025 is 2 s.f., not 4) — very common slip.
- Using the multiplication rule (significant figures) when the operation is addition (which uses decimal places).
- Carrying too many digits into the final answer instead of rounding to the least-precise input.

MARKING SCHEME — GENERAL NOTES

- In error-propagation numericals, full marks require the correct rule (absolute errors add for ±; relative errors add, scaled by the exponent, for ×/÷/powers). Using the wrong rule caps the answer at 1 mark.
- Dimensional-check questions need every TERM's dimensions shown and the homogeneity conclusion; the limitation caveat earns the final half-mark.
- Significant-figure answers lose half a mark if leading zeros are counted or if the addition rule (decimal places) is confused with the multiplication rule (significant figures).
- Derivation-by-dimensions questions must show the power-equating step explicitly; quoting the result without solving for the exponents caps at half marks.
- Final numerical answers reported with the wrong number of significant figures lose 0.5 mark even when the working is correct.