FREE EDITION · NOTES + 3 SAMPLE MCQS

CUET · PHYSICS · CLASS XI · CODE 322

Units and Measurements

CUET unit: Units and Measurements

By **UniDrill** · NCERT-grounded study material

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📌 Snapshot

- Establishes the SI system with **seven base units** and the framework of derived units that the rest of physics rests on (NCERT §1.2, p. 2).
- Lays out **significant figures**, rounding-off conventions, and arithmetic rules for measured quantities — pure recall + calculation territory for CUET (NCERT §1.3, pp. 3–7).
- Develops **dimensions, dimensional formulae and dimensional analysis** as a tool to check equations, convert units, and deduce relations such as the time period of a simple pendulum (NCERT §1.4–§1.6, pp. 7–9).
- Introduces **uncertainty/error propagation** rules for sum, difference, product, quotient and powers — CUET routinely tests these as direct numericals (NCERT §1.3.3, p. 6).
- Treats supplementary geometric units **radian** (plane angle) and **steradian** (solid angle), both of which are dimensionless (NCERT §1.2, Fig. 1.1, p. 2).
- Almost every concept here has a direct numerical or statement-based MCQ analogue in NTA papers — careful memorisation pays off more than physical intuition.

📖 Detailed Notes

2.1 Core concepts

Physics rests on measurement, and measurement rests on a chosen reference standard. NCERT opens by defining **measurement** as the comparison of a physical quantity with a basic, internationally accepted reference standard called a **unit**; the result of any measurement is therefore a number accompanied by a unit (NCERT §1.1, p. 1). Two classes of quantities are distinguished. A small set of **fundamental or base quantities** is chosen, and their units are called **base units**; units of all other physical quantities are obtained as combinations of these base units and are called **derived units**, the set of base and derived units together forming a system of units (NCERT §1.1, p. 1).

Earlier systems — CGS (cm, g, s), FPS or British (foot, pound, second) and MKS (m, kg, s) — were superseded by the **Système International d'Unités (SI)**, the internationally accepted system whose latest revision came into effect in November 2018 (NCERT §1.2, p. 1). SI is decimal-based, which makes inter-unit conversions straightforward. The

seven SI base units are: metre (m, length), kilogram (kg, mass), second (s, time), ampere (A, electric current), kelvin (K, thermodynamic temperature), mole (mol, amount of substance) and candela (cd, luminous intensity) (NCERT §1.2, Table 1.1, p. 2). NCERT additionally describes the two **supplementary geometric units** — the **radian (rad)** for plane angle, defined as $d\theta = ds/r$, and the **steradian (sr)** for solid angle, defined as $d\Omega = dA/r^2$ — both of which are dimensionless because they are ratios of like quantities (NCERT §1.2, Fig. 1.1, p. 2). When the mole is used, the elementary entities — atoms, molecules, ions, electrons, etc. — must always be specified (NCERT §1.2, p. 3).

The next major theme is **precision and significant figures**. A measured value has reliable digits plus the first uncertain digit, all of which are termed **significant figures**. For example, the period of oscillation reported as 1.62 s has three significant figures; a length of 287.5 cm has four. The number of significant figures indicates the precision of the measurement and is fixed by the least count of the instrument (NCERT §1.3, p. 3). A key point that CUET routinely tests: the **choice of unit does not change the count of significant figures** — 2.308 cm = 0.02308 m = 23.08 mm = 23080 μm all carry four significant figures (the digits 2, 3, 0, 8) (NCERT §1.3, p. 3).

NCERT codifies five **rules** for counting significant figures: (i) all non-zero digits are significant; (ii) zeros between two non-zero digits are significant irrespective of decimal position; (iii) for numbers less than 1, zeros to the right of the decimal point but to the left of the first non-zero digit are not significant; (iv) trailing zeros in a number without a decimal point are not significant; (v) trailing zeros in a number with a decimal point are significant — so 3.500 and 0.06900 each have four significant figures (NCERT §1.3, p. 4). **Scientific notation** $a \times 10^b$ with $1 \leqslant a < 10$ removes ambiguity about trailing zeros, since every zero in the base number a is then significant and the power of ten is irrelevant to the count (NCERT §1.3, p. 4). **Exact numbers** — pure counts or definitions, e.g. the 2 in $s = 2\pi r$ or n in $T = t/n$ — have infinite significant figures (NCERT §1.3, p. 5).

Two arithmetic rules govern measured quantities. In **multiplication or division**, the result retains as many significant figures as the input with the fewest significant figures — e.g. 4.237 g / 2.51 cm^3 = 1.69 g cm^{-3} (3 sig figs) (NCERT §1.3.1, p. 5). In **addition or subtraction**, the result retains as many decimal places as the input with the fewest decimal places — so 436.32 g + 227.2 g + 0.301 g = 663.821 g, which must be reported as 663.8 g (NCERT §1.3.1, pp. 5–6). The **rounding rule** for a discarded digit 5 is the even/odd convention: raise the preceding digit by 1 if it is odd, leave unchanged if it is even — so 2.745 → 2.74 and 2.735 → 2.74 (NCERT §1.3.2, p. 6). In intermediate steps of multi-step calculations one keeps one extra digit beyond the least significant input and rounds only at the very end; π is taken as 3.14 or 3.142 as appropriate (NCERT §1.3.2, pp. 6–7).

Error/uncertainty propagation is laid out in §1.3.3. For products and quotients, percentage (relative) errors add: if l = 16.2 ± 0.1 cm (±0.6 %) and b = 10.1 ± 0.1 cm (±1 %), then lb = 163.62 cm^2 ± 1.6 % = 164 ± 3 cm^2 (NCERT §1.3.3, p. 6). For subtraction, significant figures may be lost: 12.9 g − 7.06 g = 5.8 g, not 5.84 g (NCERT §1.3.3, p. 6).

The relative error of an n-sig-fig number depends on the number itself — 1.02 g (±0.01) gives ±1 %, while 9.89 g (±0.01) gives ±0.1 % (NCERT §1.3.3, p. 6).

Dimensions. The seven base dimensions [L], [M], [T], [A], [K], [cd], [mol] are the powers to which fundamental quantities are raised to represent any physical quantity (NCERT §1.4, p. 7). Volume → $[L^3]$; force → $[M\ L\ T^{-2}]$; density → $[M\ L^{-3}\ T^0]$; velocity (initial, average, final, or change) shares dimensions $[L\ T^{-1}]$ because magnitude is irrelevant to dimension (NCERT §1.5, p. 7). The **principle of homogeneity** states that only quantities with the same dimensions can be added or subtracted, and both sides of any physically valid equation must have the same dimensions (NCERT §1.6, p. 8). Dimensional analysis lets us check equations such as $x = x_0 + v_0t + ½at^2$ (each term reduces to [L]) and deduce relations such as $T = k\sqrt{(l/g)}$ for a simple pendulum (NCERT §1.6.1–§1.6.2, pp. 8–9). Its **limits** are well known: arguments of sin, cos, log and exp must be dimensionless; a dimensionally correct equation need not be physically correct; and dimensional analysis cannot determine dimensionless constants like the 2π in $T = 2\pi\sqrt{(l/g)}$ (NCERT §1.6.2, p. 9).

2.2 Definitions to memorise

Term	Definition	Page
Unit	Basic, arbitrarily chosen, internationally accepted reference standard with which a physical quantity is compared	1
Base / fundamental unit	Unit chosen for a fundamental (base) physical quantity	1
Derived unit	Unit of a derived physical quantity expressed as a combination of base units	1
SI	Système International d'Unités — the internationally accepted decimal system of units, revised in 2018	1
Metre (m)	SI base unit of length, defined via the fixed numerical value of $c = 299\ 792\ 458\ m\ s^{-1}$	2
Kilogram (kg)	SI base unit of mass, defined via the fixed numerical value of Planck constant h	2
Second (s)	SI base unit of time, defined via the caesium hyperfine frequency $\Delta\nu\_Cs$	2
Ampere (A)	SI base unit of electric current, defined via the elementary charge e	2
Kelvin (K)	SI base unit of thermodynamic temperature, defined via the Boltzmann constant k	2
Mole (mol)	SI base unit of amount of substance, defined via the Avogadro constant N_A	2
Candela (cd)	SI base unit of luminous intensity, defined via the luminous efficacy K_cd	2

Term	Definition	Page
Radian (rad)	SI unit of plane angle, $d\theta = ds/r$; dimensionless	2
Steradian (sr)	SI unit of solid angle, $d\Omega = dA/r^2$; dimensionless	2
Significant figures	All reliable digits plus the first uncertain digit in a measurement	3
Scientific notation	Expression $a \times 10^b$ with $1 \leqslant a < 10$ used to make significant figures unambiguous	4
Order of magnitude	Exponent b of 10 when a quantity is approximated as 10^b (a rounded to 1 if $a \leqslant 5$, to 10 if $5 < a \leqslant 10$)	4
Exact number	Pure count or defined factor (e.g. 2, π) carrying infinite significant figures	5
Rounding-off rule	If discarded digit >5 raise preceding; <5 leave; =5 raise if preceding is odd, leave if even	6
Absolute error	Magnitude of the difference between the true (or mean) value and an individual measurement	6
Relative / percentage error	Ratio of absolute error to the mean value, expressed as fraction or %	6
Dimensions of a physical quantity	Powers to which the base quantities are raised to represent that quantity	7
Dimensional formula	Expression showing how base quantities represent the dimensions of a physical quantity, e.g. $[M\ L\ T^{-2}]$ for force	7
Dimensional equation	Equation obtained by equating a physical quantity to its dimensional formula, e.g. $[F] = [M\ L\ T^{-2}]$	7
Principle of homogeneity of dimensions	Dimensions of every term on both sides of a physical equation must be the same	8
Dimensional analysis	Use of dimensions to check, convert or deduce physical relations	8

2.3 Diagrams / processes to remember

A small but high-yield set of figures and worked examples supports these ideas. **Fig. 1.1(a) and (b) on p. 2** give the geometric definitions of plane and solid angles about an apex O: a plane angle $d\theta$ subtended by an arc of length ds at radius r is $d\theta = ds/r$ (radians), and a solid angle $d\Omega$ subtended by an area dA at radius r is $d\Omega = dA/r^2$ (steradians). Both definitions reduce angles to ratios of two like quantities, which is why both units are dimensionless — a recurring CUET MCQ. **Table 1.1, p. 2** is the canonical seven-row table of SI base units with their post-2018 redefinitions: the metre is now fixed by the speed of light c = 299 792 458 m s^{-1}; the kilogram by Planck's constant h; the second by the caesium hyperfine frequency $\Delta\nu_{Cs}$; the ampere by the elementary charge e; the kelvin by the Boltzmann constant k; the mole by the Avogadro constant N_A; and the candela by the luminous efficacy K_{cd} of monochromatic radiation at 540

THz. CUET has tested simple recall of which constant defines which unit. **Table 1.2 on p. 3** lists units retained for general use though outside SI (e.g. litre, hour, electron-volt, atomic mass unit, ångström) — these are referenced quantities, not memorisation candidates.

Worked Example 1.1 (p. 6) illustrates the multiplication-rule cascade: a cube of side 7.203 m has surface area 311.3 m^2 and volume 373.7 m^3, both retaining the same four significant figures as the input. **Worked Example 1.5 (pp. 8–9)** is the classic dimensional derivation of the simple-pendulum period: assuming T = k l^x g^y m^z, equating dimensions gives x = ½, y = –½, z = 0, hence $T = k\sqrt{(l/g)}$ — and the constant k = 2π must come from experiment or first-principles dynamics, not from dimensions. The **process to internalise** for any dimensional-analysis question is therefore: (1) write the assumed power-law product, (2) put dimensions of both sides in [L], [M], [T] form, (3) match exponents to get a small linear system, (4) solve for the exponents, and (5) remember that the dimensionless prefactor must be supplied separately. Equally important is the **error-propagation flow**: identify whether the operation is sum/difference (use decimal places, add absolute errors) or product/quotient/power (use sig figs, add percentage errors with power multipliers), then round only at the end.

2.4 Common confusions / NTA trap points

- **Trailing zeros without a decimal point** are NOT significant — 12300 cm has 3 sig figs — but **trailing zeros with a decimal point** ARE significant: 12.300 has 5 (NCERT §1.3, p. 4). Students systematically mis-count this.
- **Addition/subtraction uses decimal places, not significant figures.** Writing 663.821 g as 664 g (the multiplication rule) is wrong; the correct answer is 663.8 g because 227.2 g has only one decimal place (NCERT §1.3.1, p. 5).
- **The rounding rule for a discarded digit 5** is governed by the even/odd convention — 2.745 → 2.74 (preceding 4 is even, leave), 2.735 → 2.74 (preceding 3 is odd, raise). Many students wrongly always round 5 up (NCERT §1.3.2, p. 6).
- **Dimensional correctness ≠ physical correctness.** An equation can pass the dimension test and still be wrong (e.g. an incorrect numerical factor); arguments of sin, cos, log and exp must be dimensionless (NCERT §1.6.1, p. 8).
- **Equal-dimension distractors.** Work, energy, torque, moment of a couple all carry $[M L^2 T^{-2}]$; dimensional analysis cannot tell them apart — a classic NTA trap.
- **Mole specification.** When using mole, the elementary entity (atom, molecule, ion, electron) must always be specified — frequently asked in "which of the following statements is correct" items (NCERT §1.2, p. 3).
- **Leading zeros are never significant** — 0.0025 has 2 sig figs, not 4. The leading zero before the decimal is never counted (NCERT §1.3, p. 4).
- **Subtraction can reduce significant figures**, even if both inputs have many — 12.9 – 7.06 = 5.84 must be reported as 5.8 because 12.9 has only one decimal place (NCERT §1.3.3, p. 6).

- **Radian and steradian are not "base" units** — both are dimensionless supplementary units; counting them among the seven base quantities is a frequent error.
- **Powers in error propagation get multiplied.** If $Z = A^2 / B$ then $\Delta Z/Z = 2(\Delta A/A) + (\Delta B/B)$; forgetting the factor of 2 is a recurring CUET slip (NCERT §1.3.3, p. 6).
- **Dimensional analysis cannot find dimensionless constants** like 2π in $T = 2\pi\sqrt{(l/g)}$ or ½ in KE = ½ mv^2 — only experiment or derivation can (NCERT §1.6.2, p. 9).
- **All velocities share dimensions $[L\,T^{-1}]$**, whether initial, final, average or change — do not assume "different" velocities have different dimensions (NCERT §1.4, p. 7).

2.5 Key formulas

Symbol	Formula	Meaning	NCERT page
$d\theta$	$d\theta = ds/r$	Plane angle in radians	2
$d\Omega$	$d\Omega = dA/r^2$	Solid angle in steradians	2
[V]	$[M^0 L^3 T^0]$	Dimensional formula of volume	7
[v]	$[M^0 L T^{-1}]$	Dimensional formula of velocity	7
[F]	$[M L T^{-2}]$	Dimensional formula of force	7
$[\rho]$	$[M L^{-3} T^0]$	Dimensional formula of mass density	7
[W] / [E] / $[\tau]$	$[M L^2 T^{-2}]$	Same dimensions for work, energy, torque	7
[P]	$[M L^{-1} T^{-2}]$	Dimensional formula of pressure / stress	7
$[\eta]$	$[M L^{-1} T^{-1}]$	Dimensional formula of dynamic viscosity	7
[G]	$[M^{-1} L^3 T^{-2}]$	Universal gravitational constant	8
T (pendulum)	$T = 2\pi\sqrt{(l/g)}$	Time period of simple pendulum	9
$\Delta(a \pm b)$	$\Delta(a \pm b) = \Delta a + \Delta b$	Absolute errors add in sum/difference	6
$\Delta(ab)/(ab)$	$\Delta Z/Z = \Delta A/A + \Delta B/B$	Relative errors add in product/quotient	6
$\Delta Z/Z$ (power)	$\Delta Z/Z = p(\Delta a/a) + q(\Delta b/b) + r(\Delta c/c)$ for Z = a^p b^q / c^r	Power rule for error propagation	6

Symbol	Formula	Meaning	NCERT page
Sig-fig (×/÷)	result sig figs = min(input sig figs)	Rounding rule for products/ quotients	5
Sig-fig (+/−)	result decimals = min(input decimals)	Rounding rule for sums/ differences	5
Mean value	$\bar{a} = (a_1+a_2+\cdots+a_n)/n$	Best estimate from n measurements	6
Relative error	$\delta a = \Delta a\_mean / a\_mean$	Fractional uncertainty	6
Percentage error	$\%\delta a = (\Delta a\_mean / a\_mean) \times 100\ \%$	Percentage uncertainty	6
Scientific notation	$N = a \times 10^b,\ 1 \leqslant a < 10$	Standard form removing trailing-zero ambiguity	4

🎯 Practice MCQs

📊 PYQ Alignment

Units and Measurements is among the most heavily tested chapters in CUET-UG Physics, with roughly 6–9 MCQs across CUET 2023–25 papers. Frequent question types are: counting significant figures, applying multiplication/division vs addition/subtraction rules in numericals, percentage-error propagation for area/volume/density problems, identifying dimensional formulae (often with same-dimension distractors like work–torque or momentum–impulse), checking dimensional consistency of given equations, and deducing relations like the pendulum period via dimensional analysis. For year-wise solved PYQs see /pyq/physics.

CUET 2023–25 — Actual PYQs from this chapter

No PYQs from this chapter appeared in CUET 2023, 2024 or 2025.