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CHAPTER NOTES

Units and Measurements Class 11 Notes | CBSE Physics Chapter 1

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CHAPTER SUMMARY

Units and Measurements lays the foundation of physics by defining how every physical quantity is measured against an agreed standard. It covers the seven SI base quantities and their derived units, dimensional formulae and the principle of homogeneity, and how to handle accuracy, errors and...

... see more

CHAPTER NOTES

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Key Concepts

1. Physical Quantities and Units

A **physical quantity** is any quantity that can be measured, such as length, mass, time, or temperature. Every measurement is written as a number followed by a **unit** — the chosen standard of that quantity (for example, 5 metres means 5 times the standard length called a metre).

Physical quantities are of two kinds. **Fundamental (base) quantities** are independent and cannot be expressed in terms of others — length, mass, and time are examples. **Derived quantities** are built from base quantities, such as speed (length/time) or force (mass × acceleration).

Key idea: The magnitude of a physical quantity = numerical value × unit. The bigger the unit, the smaller the numerical value ($n_1u_1 = n_2u_2$).

2. The SI System of Units

The **SI system** (Système Internationale d'Unités) is the internationally agreed set of units, built on **seven base units**. It is a coherent, rationalised, and metric system used worldwide in science.

The Seven Fundamental SI Units

Base Quantity	SI Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

There are also two **supplementary units**: the **radian (rad)** for plane angle and the **steradian (sr)** for solid angle.

Derived units are combinations of base units — for example the newton ($N = kg \cdot m/s^2$) for force and the joule ($J = kg \cdot m^2/s^2$) for energy.

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3. Dimensions and Dimensional Formulae

The **dimensions** of a physical quantity are the powers to which the base quantities must be raised to represent it. The base quantities are written as M (mass), L (length), T (time), A (current), K (temperature), mol, and cd.

The **dimensional formula** is the expression showing these powers. For example, the dimensional formula of force is $[M^1L^1T^{-2}]$, and the corresponding **dimensional equation** is $[F] = [MLT^{-2}]$.

Dimensional Formulae of Common Quantities

Quantity	Formula	Dimensional Formula
Area	length × breadth	$[L^2]$
Velocity	displacement/time	$[M^0L^1T^{-1}]$
Acceleration	velocity/time	$[M^0L^1T^{-2}]$
Force	mass × acceleration	$[M^1L^1T^{-2}]$
Work / Energy	force × displacement	$[M^1L^2T^{-2}]$
Power	work/time	$[M^1L^2T^{-3}]$
Pressure	force/area	$[M^1L^{-1}T^{-2}]$
Momentum / Impulse	mass × velocity	$[M^1L^1T^{-1}]$

Dimensionless quantities (like strain, angle, refractive index, and pure numbers) have all powers zero, i.e. $[M^0L^0T^0]$.

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4. Principle of Homogeneity of Dimensions

An equation is dimensionally correct only if **every term on both sides has the same dimensions**. You can only add or equate quantities of the same dimensions — you cannot add a length to a time.

This **principle of homogeneity** is the basis of dimensional analysis. For example, in $v = u + at$, every term has the dimension of velocity $[LT^{-1}]$, so the equation is dimensionally consistent.

Key idea: Dimensional correctness is necessary but not sufficient — an equation can be dimensionally correct yet still wrong by a numerical factor.

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5. Applications of Dimensional Analysis

Dimensional analysis is a powerful checking and deriving tool. It has three main uses.

- **Checking the correctness of an equation** using the principle of homogeneity.
- **Converting a unit from one system to another** using $n_1[M_1^aL_1^bT_1^c] = n_2[M_2^aL_2^bT_2^c]$.
- **Deriving a relation** between physical quantities when the dependence is known (for example, deriving $T = 2\pi\sqrt{(l/g)}$ for a pendulum, up to the constant).

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6. Limitations of Dimensional Analysis

Dimensional analysis cannot do everything. Knowing its limits is a favourite board question.

- It cannot find the value of **dimensionless constants** (like 2π or ½).
- It cannot be used if a quantity depends on **more than three other quantities**.
- It fails for equations involving **trigonometric, exponential, or logarithmic functions**.
- It cannot tell whether a quantity is a scalar or a vector.
- It cannot derive relations that contain a **sum of terms**, such as $s = ut + \frac{1}{2}at^2$.

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7. Significant Figures

Significant figures are the digits in a measurement that are known reliably plus the first uncertain digit. They tell you the precision of a measurement — 2.50 m is more precise than 2.5 m.

Rules for Counting Significant Figures

- All **non-zero digits** are significant (234 has 3).
- Zeros **between non-zero digits** are significant (2.004 has 4).
- Leading zeros are **not** significant (0.0025 has 2).
- Trailing zeros after a decimal point **are** significant (2.300 has 4).
- Trailing zeros in a number without a decimal are ambiguous (best written in scientific notation).

Rules for Rounding Off and Calculations

- **Addition/subtraction:** the result keeps as many decimal places as the term with the fewest decimal places.
- **Multiplication/division:** the result keeps as many significant figures as the term with the fewest significant figures.
- If the digit to be dropped is greater than 5, round up; if less than 5, round down; if exactly 5, round to the nearest even digit.

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8. Errors in Measurement

No measurement is perfectly exact — every measurement has an **error**, the difference between the measured value and the true value. Understanding errors lets you state results honestly.

Types of Errors

Type	Description
Systematic error	Consistent, one-directional error from faulty instruments, technique, or surroundings; can be minimised
Random error	Irregular error varying in size and sign; reduced by taking many readings and averaging
Gross error	Human mistake in reading or recording observations

Calculating Errors

If a quantity is measured n times giving readings $a_1, a_2, \ldots a_n$, the best value is the arithmetic mean.

- **Mean value:** $a_{mean} = (a_1 + a_2 + \ldots + a_n)/n$
- **Absolute error** of each reading: $\Delta a_i = |a_{mean} - a_i|$
- **Mean absolute error:** $\Delta a_{mean} = (|\Delta a_1| + |\Delta a_2| + \ldots + |\Delta a_n|)/n$
- **Relative (fractional) error:** $\Delta a_{mean}/a_{mean}$
- **Percentage error:** $(\Delta a_{mean}/a_{mean}) \times 100\%$

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9. Combination (Propagation) of Errors

When a result is calculated from several measured quantities, their errors combine. The rules below tell you the maximum possible error.

- **Sum or difference (Z = A ± B):** the absolute errors add — $\Delta Z = \Delta A + \Delta B$.
- **Product or quotient (Z = AB or A/B):** the relative errors add — $\Delta Z/Z = \Delta A/A + \Delta B/B$.
- **Power (Z = A^p·B^q/C^r):** $\Delta Z/Z = p(\Delta A/A) + q(\Delta B/B) + r(\Delta C/C)$.

Key idea: In a product/quotient, a quantity raised to a higher power contributes more to the total error, so it must be measured most carefully.

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10. Accuracy and Precision

These two words sound similar but mean different things, and the difference is a classic 1-mark question.

- **Accuracy** is how close a measured value is to the **true value**. High accuracy means small systematic error.

- **Precision** is how close repeated measurements are to **each other** — the resolution or fineness of the instrument. High precision means small random error.

A measurement can be precise but not accurate (consistently wrong) or accurate but not precise. The best measurements are both.

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11. Measurement of Large Distances — Parallax Method

Parallax is the apparent shift in the position of an object when viewed from two different points. Hold a pen at arm's length and look at it with each eye in turn — its position shifts against the background. That shift is parallax.

To measure the distance D of a far object (like a planet or star), it is observed from two points separated by a known **basis** b. If θ is the **parallax angle** subtended (in radians), then:

$D = b/\theta$

The same idea (angular diameter) gives the size of a planet: **$d = D\alpha$**, where α is the angle the planet subtends at the observer.

Read the rest of the chapter →

🃏 Flash Cards: Units and Measurements

Class 11 Physics · Chapter 2 – swipe through all 10 cards to understand the whole chapter.

📏 Start here 1/10

Why units exist

A measurement is meaningless until a number is paired with a unit.

measurement = number × unit

A bare number in a numerical answer loses marks.

- ✓ The unit is the agreed standard you compare against
- ✓ Same quantity, different units: 5 m/s = 18 km/h
- ✓ Always write the unit with the number

🧱 Core idea 2/10

The 7 SI Base Quantities

Seven independent base quantities are the building blocks of all physics.

m · kg · s · A · K · mol · cd

Mnemonic: Lovely Maths Teachers Are Truly Magical Companions.

- ✓ Length→metre, Mass→kilogram, Time→second
- ✓ Current→ampere, Temperature→kelvin
- ✓ Amount→mole, Luminous intensity→candela

🔧 Key idea

Derived Units

Anything that is not o built from them.

$1\ N = 1\ kg{\cdot}m{\cdot}s^{-2}$

Newton, joule, watt, pas

- ✓ Force = mass ×
- ✓ Energy = force ×
- ✓ 1 Pa = 1 N/m^2 =

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Q1 NEET 2021

If force [F], acceleration [a] and time [T] are chosen as the fundamental physical quantities, the dimensions of energy are

A [F][a][T]

B [F][a][T²]

C $[F][a][T^{-1}]$

D $[F][a^{-1}][T]$

Q2 NEET 2021

A screw gauge gives the following readings when used to measure the diameter of a wire. Main scale reading : 0 mm. Circular scale reading : 52 divisions. Given that 1 mm on main scale corresponds to 100 divisions on the circular scale. The diameter of the wire from the above data is

A 0.52 cm

B 0.026 cm

C 0.26 cm

D 0.052 cm

Q3 NEET 2021

If E and G respectively denote energy and gravitational constant, then E/G has the dimensions of

A $[M^2][L^{-1}][T^0]$

B $[M][L^{-1}][T^{-1}]$

C $[M][L^0][T^0]$

D $[M^2][L^{-2}][T^{-1}]$

Q4 NEET 2020

The angle of 1′ (minute of arc) in radian is nearly equal to

A 2.91×10^{-4} rad

B 4.85×10^{-4} rad

C 4.80×10^{-6} rad

D 1.75×10^{-2} rad

Q5 NEET 2020

Time intervals measured by a clock give the following readings: 1.25 s, 1.24 s, 1.27 s, 1.21 s and 1.28 s. What is the percentage relative error of the observations?

A 2%

B 4%

C 16%

D 1.6%

Q6 NEET 2020

Dimensions of stress are

A $[ML^2T^{-2}]$

B $[ML^0T^{-2}]$

C $[ML^{-1}T^{-2}]$

D $[MLT^{-2}]$

Q7 NEET 2020

A screw gauge has least count of 0.01 mm and there are 50 divisions in its circular scale. The pitch of the screw gauge is

A 0.25 mm

B 0.5 mm

C 1.0 mm

D 0.01 mm

Q8 NEET 2019

The unit of thermal conductivity is

A $J\ m^{-1}\ K^{-1}$

B $W\ m\ K^{-1}$

C $W\ m^{-1}\ K^{-1}$

D $J\ m\ K^{-1}$

Q9 NEET 2004

The unit of permittivity of free space, ε_0 is

A coulomb/newton-metre

B newton-metre^2/coulomb^2

C coulomb^2/newton-metre^2

D coulomb^2/(newton-metre)^2

Q10 NEET 2002

The value of Planck's constant in SI unit is

A 6.63×10^{-34} J-s

B 6.63×10^{-30} kg-m/s

C 6.63×10^{-32} kg-m²

D 6.63×10^{-31} J-s

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Frequently Asked Questions

What is the difference between a base unit and a derived unit?

A base unit measures one of the seven independent SI base quantities (metre, kilogram, second, ampere, kelvin, mole and candela). A derived unit is built by combining base units, for example the newton (kg and m per s squared) or the joule (kg and m squared per s squared).

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What is the principle of homogeneity in dimensional analysis?

It states that every term in a valid physical equation must have the same dimensions. It can be used to check whether an equation could be correct, convert between unit systems and guess the form of a relation, but it cannot prove an equation fully right because it misses dimensionless constants like on...

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How do you find the error in a quantity raised to a power?

For products and powers you add the relative (percentage) errors, and a power multiplies its term's percentage error. For example, if radius has a 2 percent error, the volume (which is proportional to radius cubed) has a 3 times 2 equal to 6 percent error.

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Is Units and Measurements important for NEET?

Yes. It is part of the Class 11 Physics NEET syllabus and usually contributes about one question. Dimensional analysis, error propagation and significant figures are favourite topics, and the concepts support numerical accuracy throughout the rest of physics.

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What is the difference between accuracy and precision?

Accuracy is how close a measurement is to the true value, while precision is how finely and consistently you can measure. A reading can be precise but inaccurate if it is consistently off by the same amount.

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