

CHAPTER-1: UNITS AND MEASUREMENTS

1. Measurement

Definition

Measurement is the comparison of an unknown physical quantity with a standard unit of the same kind.

$$\boxed{\text{Physical Quantity} = \text{Magnitude} + \text{Unit}}$$

2. SI Base Quantities and Units

Physical Quantity	SI Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Thermodynamic Temperature	kelvin	K
Amount of Substance	mole	mol
Luminous Intensity	candela	cd

3. Common SI Prefixes

Prefix	Symbol	Factor
tera	T	10^{12}
giga	G	10^9
mega	M	10^6
kilo	k	10^3
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

4. Scientific Notation

General form:

Scientific notation expresses numbers in the form

$$\boxed{a \times 10^n}$$

where:

- $1 \leq a < 10$
- n is an integer.

5. Dimensional Formulae (Most Important)

Quantity	Formula	Dimensions
Length	—	[L]
Mass	—	[M]
Time	—	[T]
Area	$l \times b$	$[L^2]$
Volume	$l \times b \times h$	$[L^3]$
Velocity	s/t	$[LT^{-1}]$
Acceleration	v/t	$[LT^{-2}]$
Momentum	mv	$[MLT^{-1}]$
Force	ma	$[MLT^{-2}]$
Work/Energy	Fs	$[ML^2T^{-2}]$
Power	W/t	$[ML^2T^{-3}]$
Pressure	F/A	$[ML^{-1}T^{-2}]$
Density	m/V	$[ML^{-3}]$
Frequency	$1/T$	$[T^{-1}]$

6. Principle of Dimensional Homogeneity

For every correct physical equation,

In any correct physical equation, the dimensions of all terms must be the same. Any equation may be separated by +, >, <, + or - , will have same dimensions both sides.

$$\text{Dimensions of LHS} = \text{Dimensions of RHS}$$

7. Error Formulae

Mean Value

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \dots + x_n}{n}$$

Absolute Error

$$\Delta x = |x_i - \bar{x}|$$

Mean Absolute Error

$$\Delta x_{\text{mean}} = \frac{\Delta x_1 + \Delta x_2 + \Delta x_3 + \dots + \Delta x_n}{n}$$

Relative Error

$$\text{Relative Error} = \frac{\Delta x_{\text{mean}}}{\bar{x}}$$

Percentage Error

$$\% \text{Error} = \text{Relative Error} \times 100$$

8. Propagation of Errors

Addition / Subtraction

If $Z = A \pm B$, then

$$\Delta Z = \Delta A \pm \Delta B$$

Multiplication / Division

If $Z = AB / C$, then

$$\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B} + \frac{\Delta C}{C}$$

Relative errors are added.

Power Rule

If $Z = A^n$, then

$$\frac{\Delta Z}{Z} = n \frac{\Delta A}{A}$$

General Formula

If

$$Z = \frac{A^m B^n}{C^p}$$

Then

$$\frac{\Delta Z}{Z} = m \frac{\Delta A}{A} + n \frac{\Delta B}{B} + p \frac{\Delta C}{C}$$

9. Unit Conversion Formula

For dimensions

If the dimensional formula of a quantity is

$$[M^a L^b T^c]$$

then, during unit conversion,

$$n_2 = n_1 \left(\frac{M_1}{M_2}\right)^a \left(\frac{L_1}{L_2}\right)^b \left(\frac{T_1}{T_2}\right)^c$$

This formula is especially useful for **JEE Advanced** problems.

10. Standard Unit Conversions

Quantity	Standard Form
1 km	$10^3 m$
1 mm	$10^{-3} m$
1 μm	$10^{-6} m$
1 nm	$10^{-9} m$
1 pm	10^{-12}

Speed Conversion

$$1 ms^{-1} = 3.6 kmh^{-1}$$

$$1 kmh^{-1} = \frac{5}{18} ms^{-1}$$

11. Significant Figures – Quick Rules

1. All non-zero digits are significant.
 2. Zeros between non-zero digits are significant.
 3. Leading zeros are **not** significant.
 4. Trailing zeros after the decimal point are significant.
 5. Trailing zeros in whole numbers without a decimal point are generally **not** significant.
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12. Rounding-Off Rules

- Digit < 5 → Leave unchanged.
 - Digit > 5 → Increase previous digit by 1.
 - Digit = 5 followed by non-zero digits → Round up.
 - Digit = 5 only:
 - Previous digit even → Leave unchanged.
 - Previous digit odd → Increase by 1.
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13. Important Dimensionless Quantities

- Plane angle
 - Solid angle
 - Strain
 - Relative density
 - Refractive index
 - Coefficient of friction
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14. Frequently Asked Values

Quantity	Value
Speed of light (c)	$3.0 \times 10^8 m/s$
Planck constant (h)	$6.626 \times 10^{-34} Js$
Avogadro constant (N_A)	$6.022 \times 10^{23} mol^{-1}$
Elementary charge (e)	$1.602 \times 10^{-19} C$