PHYSICS

CLASS NOTES FOR CBSE

Chapter 03. Units and Measurement

0.1 Physical Quantities

All the quantities which are used to describe the laws of physics are known as *physical quantities*.

Classification : Physical quantities can be classified on the following bases :

(A) Based on their directional properties

I. Scalars : The physical quantities which have only magnitude but no direction are called *scalar quantities*.

e.g. mass, density, volume, time, etc.

II. Vectors : The physical quantities which both magnitude and direction and obey laws of vector algebra are called *vector quantities*.

e.g. displacement, force, velocity, etc.

(B) Based on their dependency

I. Fundamental or base quantities : The quantities which do not depend upon other quantities for their complete definition are known as *fundamental or base quantities*.

e.g. length, mass, time, etc.

II. Derived quantities : The quantities which can be expressed in terms of the fundamental quantities are known as *derived quantities*.

e.g. Speed (=distance/time), volume, acceleration, force, pressure, etc.

Example Classify the quantities displacement, mass, force, time, speed, velocity, acceleration, pressure and work under the following categories:

(a) base and scalar
(b) base and vector
(c) derived and scalar
(d) derived and vector

Solution

(a) mass, time
(b) displacement
(c) speed, pressure, work
(d) force, velocity, acceleration

02. Units of Physical Quantities

The chosen reference standard of measurement in multiples of which, a physical quantity is expressed is called the *unit* of that quantity.

System of Units

(i) FPS or British Engineering system : In this system length, mass and time are taken as fundamental quantities and their base units are foot (ft), pound (lb) and second (s) respectively.

(ii) CGS or Gaussian system : In this system the fundamental quantities are length, mass and time and their respective units are centimeter (cm), gram (g) and second (s).

(iii) MKS system : In this system also the fundamental quantities are length, mass and time but their fundamental units are metre (m), kilogram (kg) and second (s) respectively.

(iv) International system (SI) of units : This system is modification over the MKS system and so it is also known as *Rationalised MKS* system. Besides the three base units of MKS system four fundamental and tow supplementary units are also included in this system.

SI BASE QUANTITIES AND THEIR UNITS

S. No.	Physical quantity	Unit	Symbol
1	Length	metre	m
2	Mass	kilogram	kg
3	Time	second	s
4	Temperature	kelvin	K
5	Electric current	ampere	A
6	Luminous intensity	candela	cd
7	Amount of substance	mole	mol

03. Classification of Units

The units of physical quantities can be classified as follows :

(i) Fundamental or base units

The units of fundamental quantities are called *base units*. In SI there are seven base units.

(ii) Derived units

The units of derived quantities or the units that can be expressed in terms of the base units are called *derived units*.

e.g. unit of speed = $\frac{\text{unit of distance}}{\text{unit of time}} = \frac{\text{metre}}{\text{second}} = \text{m/s}$

Some derived units are named in honour of great scientists.

e.g. unit of force – newton (N), unit of frequency – hertz (Hz), etc.

(iii) Supplementary units

In International System (SI) of units two *supplementary units* are also defined viz. radian (rad) for plane angle and steradian (sr) for solid angle.

- **radian :** 1 radian is the angle subtended at the centre of a circle by and arc equal in length to the radius of the circle.
- **steradian :** 1 steradian is the solid angle subtended at the centre of a sphere, by the surface of the sphere which is equal in area to the square of the radius of the sphere.

(iv) Practical units

Due to the fixed sizes of SI units, some *practical units* are also defined for both fundamental and derived quantities. e.g. light year (ly) is a practical unit of distance (a fundamental quantity) and horse power (hp) is a practical unit of power (a derived quantity).

Practical units may or may not belong to a particular system of units but can be expressed in any system of units.

e.g. 1 mile = 1.6 km = 1.6×10^3 m = 1.6×10^5 cm.

Conversion factors

To convert a physical quantity from one set of units to the other, the required multiplication factor is called *conversion factor*.

Magnitude of a physical quantity = numeric value (n) × unit (u)

While conversion from one set of units to the other the magnitude of the quantity must remain same. Therefore

$$n_1u_1 = n_2u_2 \quad \text{or} \quad nu = \text{constant} \quad \text{or} \quad n \propto \frac{1}{u}$$

This is the numeric value of a physical quantity is inversely proportional to the base unit.

e.g. 1m = 100 cm = 3.28 ft = 39.4 inch
(SI) (CGS) (FPS)

Example The acceleration due to gravity is 9.8 m s^{-2}. Given its value in ft s^{-2}

Solution As 1m = 3.2 ft

$\therefore$ 9.8 m/s^2 = 9.8 × 3.28 ft/s^2 = 32.14 ft/s^2 ≈ 32 ft/s^2

04. Dimensions

Dimensions of a physical quantity are the powers for exponents to which the base quantities are raised to represent that quantity.

Dimensional formula

The dimensional formula of any physical quantity is that expression which represents how and which of the base quantities are included in that quantity.

It is written by enclosing the symbols for base quantities with appropriate powers in square brackets i.e. [ ]

e. g. Dimensional formula of mass in $[M^1L^0\ T^0]$ is the dimensional formula of the force and the dimensions of force are 1 in mass, 1 in length and −2 in time