BYJU'S Classes

P H Y S I C S

UNITS AND DIMENSIONS

INTRODUCTION TO UNITS AND DIMENSIONS

NOTES

What you will learn

- Physical quantities and their types
- Units and systems of writing units
- Rules of writing units

BOARDS

Physical Quantities

The **quantities** that can be measured by an instrument and by means of which we can describe the laws of physics are known as **physical quantities**.

- Physical quantities are used to define the material, space, time, and energy.

Process of measurement of physical quantities

Physical quantities are measured as the numerical value and supporting standard units for that numerical value. Units are necessary to define any physical quantity.

Example: Length is a physical quantity. We can measure the height of Burj Khalifa tower as 828 *metre*.

Types of physical quantities

- Fundamental
- Derived
- Supplementary

Fundamental physical quantities

Certain physical quantities are used to express all the physical quantities. Such quantities are known as fundamental, absolute, or base quantities.

- They are independent of each other and cannot be obtained from one another.
- All other quantities may be expressed in terms of fundamental quantities.

Following are the seven fundamental quantities with their general units.

Length	Thermodynamic temperature	Mass	Amount of substance
Unit: *metre (m)*	Unit: *kelvin (K)*	Unit: *kilogram (kg)*	Unit: *mole (mol)*

Time	Luminous intensity	Electric current
Unit: *second (s)*	Unit: *candela (cd)*	Unit: *ampere (A)*

The amount of substance is measured in terms of the number of moles.

One mole of a substance is equal to $6.02214076 \times 10^{23}$ number of particles of that substance. Here, particles can be atoms, molecules, ions, or electrons.

Derived physical quantities

Physical quantities that can be expressed as combinations of base quantities are known as derived quantities.

Example:

Speed can be written as distance per unit time. It can be expressed in unit ms^{-1}. Similarly, velocity, acceleration, force, momentum, pressure, energy etc. can be expressed as a combination of fundamental quantities. Thus, these are all derived quantities.

Supplementary physical quantity

There are two quantities that have units but no dimensions. These quantities can not be derived from fundamental quantities. These are known as supplementary quantities.

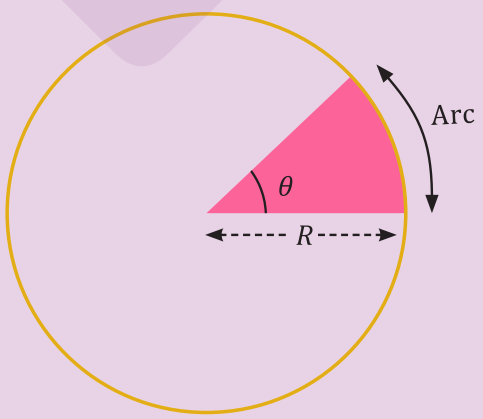
1. Plane angle

Angle (θ) is defined as

$$\theta = \frac{\text{Arc length}}{R},$$

where R is the radius of the arc.

Unit of angle is *radian*



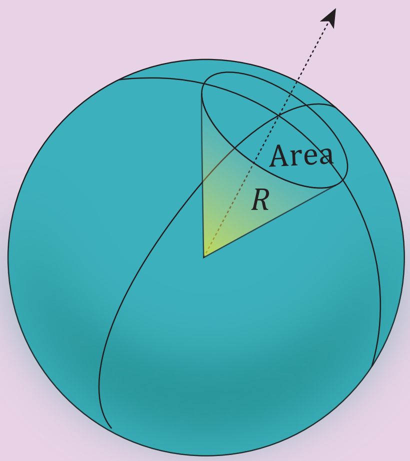
2. Solid angle

Solid angle (Ω) is defined as

$$\Omega = \frac{\text{Area}}{R^2},$$

where R is the radius of the arc.

Unit of solid angle is *steradian*



Rules for writing units of physical quantities

- Symbols for units of physical quantities are printed/written in Roman (upright type), and not in italics. For example, $1\ \mathrm{N}$ is correct but $1\ N$ is incorrect

  Note: This rule is followed strictly for scientific papers. In lower grades, this rule is sometimes not followed. However, for board exams, this rule should be followed.
- Unit is never written with a capital initial letter when it is written in full form, even if it is named after a scientist.

  For example, SI unit of force is *newton*.

- For a unit named after a scientist, the symbol or notation is a capital letter. However, for other units, the symbol is **not** a capital letter.

Magnitude of a quantity

- The magnitude of a physical quantity is equal to the numerical value.

  Example: Mass = 5 *kg*. Here, 5 is the numerical value and *kg* is the unit.
- The magnitude of a physical quantity is always constant, even though it can be expressed as different combinations of the numerical value and the unit.

Let a quantity have numerical value of n_1 for unit u_1 and n_2 for unit u_2.

Then, $n_1u_1 = n_2u_2$

Or it can be written as

Numerical value $\propto \dfrac{1}{\text{unit}}$

Example: $1000\ mm = 100\ cm = 1\ m$

We used some general units to define the physical quantities. In physics, there are a lot of quantities and their units can be written in different conventional systems. Hence, the definition of units and its system should be understood properly before proceeding to other chapters.

Units

- Measurement of any physical quantity is expressed in terms of an internationally accepted certain basic reference standard known as **unit**.

  Example: International standard unit for mass is *kilogram*
- The units for the fundamental or base quantities are known as fundamental or base units.
- Other physical quantities are expressed as combinations of these base units and hence, known as derived units.
- A complete set of units, both fundamental and derived, is known as a system of units.

Principle systems of unit

There are various systems of units used in the world. However, mostly used systems are CGS, FPS, and MKS. MKS system of writing units is an international standard, which is also known as SI (system international) system of units.

	Physical Quantity	CGS	MKS (SI)	FPS
Fundamental	Length	*centimetre*	*metre*	*foot*
	Mass	*gram*	*kilogram*	*pound*
	Time	*second*	*second*	*second*
Derived	Force	*dyne*	*newton*	*pound-force*
	Work or energy	*erg*	*joule*	*ft-pound*
	Power	*erg* sec^{-1}	*watt*	*ft-pound* sec^{-1}

Example

Find the SI units.

(a) Force (b) Work (c) Density (d) Pressure

Solution

(a) We know that

$$\text{Force} = \text{Mass} \times \text{Acceleration}$$

Unit of mass is kg and the unit of acceleration is ms^{-2}. Hence, the unit of force is $kg\ ms^{-2}$.

It is also known as *newton (N)*.

(b) We know that

$$\text{Work} = \text{Force} \times \text{Displacement}$$

Unit of force is N and the displacement is m. Hence, the unit of work is $N\ m$.

It is also known as *joule (J)*.

(c) We know that

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Unit of mass is kg and unit of volume is m^3. Hence, the unit of density is $kg\ m^{-3}$.

(d) We know that

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Unit of force is N and unit of area is m^2. Hence, the unit of pressure is $N\ m^{-2}$.

It is also known as *pascal (Pa)*.