PHYSICS

MEDICAL

UNITS & MEASUREMENT, VECTOR & MATHEMATICAL TOOLS

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CONTENT

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Units and Measurements

PHYSICAL QUANTITIES

All quantities that can be measured are called physical quantities. eg. time, length, mass, force, work done, etc. In physics we study about physical quantities and their inter relationship.

MEASUREMENT

Measurement is the comparison of a quantity with a standard of the same physical quantity.

Different countries followed different standards.

UNITS

All physical quantities are measured w.r.t. standard magnitude of the **same** physical quantity and these standards are called UNITS. eg. second, meter, kilogram, etc.

So the four basic properties of units are:—

1. They must be well defined.
2. They should be easily available and reproducible.
3. They should be invariable
4. They should be accepted to all.

SET OF FUNDAMENTAL QUANTITIES

A set of physical quanties which are completely independent of each other and all other physical quantities can be expressed in terms of these physical quantities is called Set of Fundamental Quantities.

DERIVED PHYSICAL QUANTITIES :

The physical quantities that can be expressed in terms of fundamental physical quantities are called derived physical quantities.eg. speed = distance/time.

System of Units :

1. **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.
2. **CGS or Gaussian system :** In this system the fundamental quantities are length, mass and time and their respective units are centimetre (cm), gram (g) and second (s).

3. **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.

Units of some physical quantities in different systems

Type of physical Quantity	Physical Quantity	System		
		CGS	MKS	FPS
Fundamental	Length	cm	m	ft
	Mass	g	kg	lb
	Time	s	s	s

4. **International system (SI) of units :** This system is modification over the MKS system. Besides the three base units of MKS system four fundamental and two 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	kg
5	Electric current	ampere	A
6	Luminous Intensity	candela	cd
7	Amount of substance	mole	mol

Physical Quantity (SI Unit)	**Definition**
Length (m)	The distance travelled by light in vacuum in $\frac{1}{299,792,458}$ second is called **1 metre.**
Mass (kg)	The mass of a cylinder made of platinum-iridium alloy kept at International Bureau of Weights and Measures is defined as ***1 kilogram***.
Time (s)	The second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.
Electric Current (A)	If equal currents are maintained in the two parallel infinitely long wires of negligible cross-section, so that the force between them is 2×10^{-7} newton per metre of the wires, the current in any of the wires is called ***1 Ampere***.
Thermodynamic Temperature (K)	The fraction $\frac{1}{273.16}$ of the thermodynamic temperature of triple point of water is called ***1 Kelvin***
Luminous Intensity (cd)	***1 candela*** is the luminous intensity of a blackbody of

	surface area $\frac{1}{600,000}\,m^2$ placed at the temperature of freezing platinum and at a pressure of 101,325 N/m^2, in the direction perpendicular to its surface.
Amount of substance (mole)	***The mole*** is the amount of a substance that contains as many elementary entities as there are number of atoms in 0.012 kg of carbon-12.
There are two supplementary units too:	
1. Plane angle (radian)	angle = arc / radius $\theta = l / r$
2. Solid Angle (steradian)	Ω = Area/ (Radius)^2

DIMENSIONS AND DIMENSIONAL FORMULA :

All the physical quantities of interest can be derived from the base quantities. "The power (exponent) of base quantity that enters into the expression of a physical quantity, is called the dimension of the quantity in that base. To make it clear, consider the physical quantity force.

Force = mass × acceleration

$$= \text{mass} \times \frac{\text{length / time}}{\text{time}}$$

$$= \text{mass} \times \text{length} \times (\text{time})^{-2}$$

So the dimensions of force are 1 in mass, 1 in length and –2 in time. Thus

$$[\text{Force}] = MLT^{-2}$$

Similarly energy has dimensional formula given by

$$[\text{Energy}] = ML^2T^{-2}$$

i.e. energy has dimensions, 1 in mass, 2 in length and -2 in time.

Such an expression for a physical quantity in terms of base quantities is called dimensional formula.

Physical quantity can be further of four types :

(1) dimension less constant i.e. 1,2,3,π etc.

(2) Dimension less variable i.e. angle θ etc.

(3) dimensional constant i.e. G, h etc.

(4) Dimensional variable i.e. F, v, etc.

DIMENSIONAL EQUATION :

Whenever the dimension of a physical quantity is equated with its dimensional formula, we get a dimensional equation.

PRINCIPLE OF HOMOGENEITY:

The magnitude of a physical quantity may be added or subtracted from each other only if they have the same dimension, also the dimension on both sides of an equation must be same. This is called as principle of homogencity.