Units And Dimension

Any physical quantity requires a numerical value and a standard or scale for its quantitative representation. The standard or the scale by which the physical quantity is represented is known as the UNIT.

All physical quantities do not have unit, quantities which are represented as the ration of the two same physical quantities do not have any unit.

Example: Refractive Index (μ) =velocity of light in vacuum/velocity of light in medium

Specific Gravity = Density of the substance/density of water

Generally we have three fundamental physical quantities

1. Mass

2. Length

3. Time

They are called fundamental because they do not require the help of other physical quantity for their representation.

Most of the other physical quantities can be represented in terms of these physical quantities. When a physical quantity is represented in terms of fundamental quantities it is known as dimension of that physical quantity.

Units: Generally we have two types of units

1. Fundamental Unit

2. Derived Unit

Fundamental Unit: The units of fundamental quantities are known as fundamental units.

Derived Unit: The units of all other physical quantities which can be derived from the fundamental units are known as derived units.

System of Units: We have the following system of fundamental units

Sr No.	System	Length	Mass	Time	Current
1	F.P.S	Foot	Pound	Second	
2	C.G.S	Centimetre	Gram	Second	
3	M.K.S	Meter	Kilogram	Second	
4	M.K.S.A	Meter	Kilogram	Second	Ampere
5	SI	Meter	Kilogram	Second	Ampere

Angle: Radian, Solid Angle : Ste-Radian, Temperature : Kelvin, Luminous Intensity: Candela

The MKSA was un-rational system later MKSA was rationalised by introducing special constant and is known as International System of Unit (SI unit).

Derived Unit: To find derived unit of a physical quantity we must write the dimension of that physical quantity.

1. $Speed = \frac{Distance}{Time} = \frac{L}{T} = [LT^{-1}]$

   Unit: CGS = cm sec^{-1}

   SI=m sec^{-1}

2. $\text{Acceleration} = \frac{\text{Velocity}}{\text{Time}} = \frac{\text{LT}^{-1}}{\text{T}} = [\text{LT}^{-2}]$

   Unit: CGS = cm sec^{-2}

   SI=m sec^{-2}

3. $Force = \text{mass} \times \text{acceleration} = [\text{MLT}^{-2}]$

   Unit: CGS = gm.cm. sec^{-2} = 1 dyne

   SI=kg.m. sec^{-2} = 1 Newton

4. $Work = Force \times Displacement = [\text{MLT}^{-2}][\text{L}] = [\text{ML}^2\text{T}^{-2}]$

   Unit: CGS = gm.cm^2. sec^{-2} = 1 erg

   SI=kg.m^2. sec^{-2} = 1 Joule

5. $Coefficient\ Of\ Viscosity(\eta)$

   $Given\ F = \eta A \frac{\Delta u}{\Delta z}$

$F = force, A = area, \Delta u = change\ in\ velocity, \Delta z = change\ in\ distance$

$$[\eta] = \frac{F}{A}\frac{\Delta z}{\Delta u} = \frac{[MLT^{-2}]}{[L^2]}\frac{[L]}{[LT^{-1}]} = [ML^{-1}T^{-1}]$$

Unit: CGS=gmcm^{-1}Sec^{-1} = (1 Poise)

SI: Kg m^{-1}S^{-1}

6.$Universal\ Gravitational\ Constant(G)$: $F = G\frac{m_1 m_2}{r^2}$

$F = force, m_1\ and\ m_2 = mass, r = distance$

$$G = \frac{Fr^2}{m_1 m_2} = \frac{[MLT^{-2}][L^2]}{[M][M]}$$
$$= [M^{-1}L^3T^{-2}]$$

Use of Dimension

A. From the dimension of physical quantity we can convert from one system of unit to other.

1. Example: Dyne and Newton both are units of force one in C.G.S and other is in SI respectively find 1 Dyne = ? Newton

   We know $Force = \text{mass} \times \text{acceleration} = [\text{MLT}^{-2}]$

   In C.G.S 1 Dyne = 1 gm.1cm.1sec^{-2}

   1 Dyne = 10^{-3} Kg.10^{-2}m.1 sec^{-2}
   1 Dyne = 10^{-5} Newton
   Or
   1 Newton = 10^5 Dyne

2. Both Erg and Joule are units of Work find 1 Erg = ? Joule

   We know $Work = [\text{ML}^2\text{T}^{-2}]$

   In CGS = gm.cm^2. sec^{-2} = 1 erg

   SI=kg.m^2. sec^{-2} = 1 Joule

   1 Erg = 1gm.cm^2. sec^{-2}

   1 Erg = 10^{-3}Kg.$(10^{-2})^2$m^2. sec^{-2}

   1 Erg = 10^{-7} Joule

   1 Joule = 10^{-7} Erg

3. Vlaue of G = 6.667 X 10^{-8} CGS Unit. Find the value in S.I Unit

We Know that [G] $= [M^{-1}L^{3}T^{-2}]$

In C.G.S G = 6.667 X 10^{-8} gm^{-1} cm^{3} sec^{-2}

G = 6.667 X $10^{-8}(10^{-3})^{-1}$ Kg^{-1} $(10^{-2})^{3}m^{3}$ sec^{-2}

G = 6.667 X 10^{-11} S.I unit

B. By writing dimension we can check whether the given equation is correct or not?

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Dimension of L.H.S = [T]

Dimension of R.H.S = $\sqrt{\frac{L}{LT^{-2}}}$ = [T]

We found that the dimension of both sides of this equation is same hence above equation is dimensionally correct.