UNITS AND MEASUREMENTS

DIMENSIONAL ANALYSIS AND ITS APPLICATIONS

Limitations of Dimensional Analysis

The value of the dimensionless constants cannot be calculated.

The equation containing trigonometric, exponential, and logarithmic terms cannot be analyses.

If a physical quantity depends on more than three factors, then the relation among them cannot be established because we can only get three equations by equating the powers of M, L, and T.

Dimensional Analysis

The dimensional formula can be used to

1. To check the correctness of the equation.
2. Convert the unit of the physical quantity from one system to another.
3. Deduce the relation connecting the physical quantities.

Principle of Homogeneity

According to the principle of homogeneity of dimensions, all the terms in a given physical equation must be the same.

Ex.

$s = ut + (½)\, at^2$

Dimensionally

$[L] = [LT^{-1}.T] + [LT^{-2}.\, T^2]$ $[L] = [L] + [L]$

Defects of Dimensional Analysis

1. While deriving the formula the proportionality constant cannot be found.
2. The equation of a physical quantity that depends on more than three independent physical quantities cannot be deduced.

3. This method cannot be used if the physical quantity depends on more parameters than the number of fundamental quantities.
4. The equations containing trigonometric functions and exponential functions cannot be derived

Points to Remember

Those quantities which can describe the laws of physics are called the physical quantity.

Example: -

length, mass and time

Physical quantities can be classified as fundamental quantities and derived quantities.

The reference standard used to measure the physical quantities is called the unit. Units are classified as fundamental units and derived units.

SI system is the most commonly used system of units

The SI is based on seven basic units and two supplementary units.

The dimensional formula of any physical quantity is the formula that tells which of the fundamental units have been used for the measurement of that physical quantity.The dimensional formula follows the principle of homogeneity

Ex. Consider density (D), area (A), and velocity (V) as fundamental quantities, and write the dimensional formula for force (F).

Sol. We know that the dimensions of the given quantities are as follows

$[D] = [ML^{-3}]$

$[V] = [LT^{-1}]$

$[A] = [L^2]$

Let, Force, $F = k\, D^a\, A^b\, V^c$

Then,

$[F] = [k]\,[D]^a\,[A]^b\,[V]^c$

$[MLT^{-2}] = [ML^{-3}]^a\,[L2]^b\,[LT^{-1}]^c$

$[MLT^{-2}] = [Ma\, L^{-3a + 2b + c}\, T^{-c}]$

On comparing, we get

$a = 1, c = 2$ and $-3a + 2b + c = 1 \rightarrow b = 1$

So,

$F = k\, D\, A\, V^2$