# DIMENSIONS

* **Dimensions :-** The dimension of a physical quantity are the power of the fundamental units present in the unit of that quantity.

* **Dimensional formula :-** The dimensional formula of a physical quantity shows that which of the fundamental units or quantities and with what powers are present in the unit of that quantity.

Ex :- The dimensional formula of velocity is $[LT^{-1}]$

* **Dimensional equation :-** The equation in which a physical quantity is equated to its dimensional formula is called dimesional equation.

Ex :- $[\text{velocity}] = [LT^{-1}]$

* Uses of dimensional equations :-

The main uses of dimensional equation are as follows —

1. To test the correctness of a physical equation.
2. To establish possible relation among various quantities.
3. To Convert from one system of unit to another.
4. To find the unknown unit of a constant.

* **Principle of homogeneity of dimensions :-**

The principle of homogeneity of dimensions state that the dimensions of term on both sides of a physical equation must be the same.

Ex:- Let us Consider a physical equation.

~~A + BC = DEF~~ $v = u + at$

~~It~~ Consist of one term

L.H.S = $V = \frac{\text{displacement}}{\text{Time}} = \frac{L}{T} = [LT^{-1}]$ or $[M^0LT^{-1}]$

R.H.S ⇒ It Consist of two terms.

dimensional formula of ~~a~~ $u = \frac{d}{t} = \frac{L}{T} = [LT^{-1}]$ or $[M^0LT^{-1}]$

2nd term $at = \frac{v}{t} \times t = \frac{[LT^{-1}]}{[T]} \times [T]$

$= [LT^{-2}][T^1] = [LT^{-1}]$ or $[M^0LT^{-1}]$

$\therefore$ L.H.S = R.H.S

So This Relation $v = u + at$ obeys Principle of Homogeneity.

So this Relation is Correct.

* Important Points :- Following point shall be noted while obtained dimension of any physical quantity.

(i) dimensional formula is always enclosed inside the bracket eg:- $[M^aL^bT^c]$

(a) By the dimensions of a phy. qu. in mechanics we mean the way it is related to the fundamental quantities mass, length & time, these are usually denoted by [M], [L], & [T] respectively (18)

(b) Power are added in multiplication eg, $L \times L = L^{1+1} = L^2$

(c) Power are subtracted in division.

eg, $\frac{L^2}{L} = L^{2-1} = L^1$

(d) Quantity in numerator has positive power.

(e) quantity in denominator has negative power.

eg, $\frac{[L]}{[T]} = LT^{-1}$

## * Important physical Quantities :—

1. Length (l) = $[M^0 L^1 T^0]$
2. Mass (m) = $[M^1 L^0 T^0]$
3. Time (t) = $[M^0 L^0 T^1]$
4. Height or Radius or Distance or Displacement (h) (r) (s) (d) = $[M^0 L^1 T^0]$
5. Area (a) = Length × breadth
   = Length × Length
   = $[L] \times [L] = [L^{1+1}] = [M^0 L^2 T^0]$
6. Volume (v) = Length × breadth × height
   = $[L] \times [L] \times [L] = [L^{1+1+1}]$
   = $[M^0 L^3 T^0]$
7. Density ($\rho$) = $\frac{\text{mass}}{\text{volume}} = \frac{[M^1 L^0 T^0]}{[M^0 L^3 T^0]}$
   = $[M^{1-0} L^{0-3} T^{0-0}] = [M^1 L^{-3} T^0]$

8. Velocity or Speed = $\frac{\text{displacement}}{\text{time}}$ or $\frac{\text{distance}}{\text{time}}$

$= \frac{\text{length}}{\text{time}} = \frac{M^0 L^1 T^0}{M^0 L^0 T^{-1}} = [M^0 L^1 T^{-1}]$

9. ~~Acceleration~~ (a) = $\frac{\text{velocity}}{\text{time}} = \frac{[M^0 L^1 T^{-1}]}{[M^0 L^0 T^1]}$

$= [M^0 L^1 T^{-1-1}] = [M^0 L^1 T^{-2}]$

10. Momentum (P) = Mass × Velocity

$= [M^1 L^0 T^0] \times [M^0 L^1 T^{-1}]$

$= [M^{1+0} L^{0+1} T^{0-1}] = [M^1 L^1 T^{-1}]$

11. Force (F) = Mass × Acceleration

$= [M^1 L^0 T^0] \times [M^0 L^1 T^{-2}]$

$= [M^{1+0} L^{0+1} T^{0-2}] = [M^1 L^1 T^{-2}]$

12. Impulse (I) = Force × time

$= [M^1 L^1 T^{-2}] \times [M^0 L^0 T^1]$

$= [M^{1+0} L^{1+0} T^{-2+1}] = [M^1 L^1 T^{-1}]$

13. Work (W) = Force × distance

$= [M^1 L^1 T^{-2}] \times [M^0 L^1 T^0]$

$= [M^{1+0} L^{1+1} T^{-2+0}] = [M^1 L^2 T^{-2}]$

14. Power (P) = $\frac{\text{Work done}}{\text{Time taken}} = \frac{[M^1 L^2 T^{-2}]}{[M^1 L^0 T^1]}$

$= [M^{1-0} L^{2-0} T^{-2-1}] = [M^1 L^2 T^{-3}]$

15. Energy (E)

(a) Kinetic energy (K.E) = $\frac{1}{2}mv^2$

$= [M^0L^0T^0][M^1L^0T^0][M^0L^1T^{-1}][M^0L^1T^{-1}]$

$\left[\because \frac{1}{2} \rightarrow \text{dimensionless Constant}\right]$

$= [M^{0+1+0+0}\ L^{0+0+1+1}\ T^{0+0-1-1}] = [M^1L^2T^{-2}]$

(b) Potential energy (P.E) = mgh

$= [M^1L^0T^0][M^0L^1T^{-2}][M^0L^1T^0]$

$[g \rightarrow$ acceleration due to gravity

$\therefore$ dimension of acceleration

$= [M^{1+0+0}\ L^{0+1+1}\ T^{0-2+0}] = [M^1L^2T^{-2}]$

16. Pressure $= \frac{\text{Force}}{\text{Area}} = \frac{[M^1L^1T^{-2}]}{[M^0L^2T^0]}$

$= [M^{1-0}\ L^{1-2}\ T^{-2-0}] = [M^1L^{-1}T^{-2}]$

## * Limitations of Dimensions :—

(a) The limitations of dimensions and dimensional method are given below :—

1. It gives no information about dimensionless Constant.