## FUNDAMENTAL DIMENSIONS DIMENSIONS ANALYSIS : .

Dimensional analysis is defined as a mathematical technique used in research work for design and conducting model tests.

It is particularly useful for:

- presenting and interpreting experimental data;
- attacking problems not amenable to a direct theoretical solution;
- checking equations;
- establishing the relative importance of particular physical phenomena
- physical modelling.

### Fundamental dimensions

The fundamental units quantities such as length (L), mass (M), and time (T) are fixed dimensions known as fundamental dimensions.

### Units.

Unit is defined as a yardstick to measure physical quantities like distance, area, volume, mass etc.

### Derive the dimensions for velocity.

Velocity is the distance (L) travelled per unit time (T)

Velocity = Distance/ Time = [L/T] = $LT^{-1}$.

### Dimensions of Derived Quantities.

Dimensions of common derived mechanical quantities are given in the following table.

### DIMENSIONAL HOMOGENEITY

Dimensional homogeneity means the dimensions of each terms in an equation on both sides are the same.

If the dimensions of each term on both sides of an equation are the same the equation is

| S. No. | Physical Quantity | Symbol | Dimensions |
|---|---|---|---|
| | (a) **Fundamental** | | |
| 1. | Length | $L$ | $L$ |
| 2. | Mass | $M$ | $M$ |
| 3. | Time | $T$ | $T$ |
| S.No. | Physical Quantity | Symbol | Dimensions |
| | (b) **Geometric** | | |
| 4. | Area | $A$ | $L^2$ |
| 5. | Volume | $\forall$ | $L^3$ |
| | (c) **Kinematic Quantities** | | |
| 6. | Velocity | $v$ | $LT^{-1}$ |
| 7. | Angular Velocity | $\omega$ | $T^{-1}$ |
| 8. | Acceleration | $a$ | $LT^{-2}$ |
| 9. | Angular Acceleration | $\alpha$ | $T^{-2}$ |
| 10. | Discharge | $Q$ | $L^3T^{-1}$ |
| 11. | Acceleration due to Gravity | $g$ | $LT^{-2}$ |
| 12. | Kinematic Viscosity | $\nu$ | $L^2T^{-1}$ |
| | (d) **Dynamic Quantities** | | |
| 13. | Force | $F$ | $MLT^{-2}$ |
| 14. | Weight | $W$ | $MLT^{-2}$ |
| 15. | Density | $\rho$ | $ML^{-3}$ |
| 16. | Specific Weight | $w$ | $ML^{-2}T^{-2}$ |
| 17. | Dynamic Viscosity | $\mu$ | $ML^{-1}T^{-1}$ |
| 18. | Pressure Intensity | $p$ | $ML^{-1}T^{-2}$ |
| 19. | Modulus of Elasticity | $\begin{cases} K \\ E \end{cases}$ | $ML^{-1}T^{-2}$ |
| 20. | Surface Tension | $\sigma$ | $MT^{-2}$ |
| 21. | Shear Stress | $\tau$ | $ML^{-1}T^{-2}$ |
| 22. | Work, Energy | $W$ or $E$ | $ML^2T^{-2}$ |
| 23. | Power | $P$ | $ML^2T^{-3}$ |
| 24. | Torque | $T$ | $ML^2T^{-2}$ |
| 25. | Momentum | $M$ | $MLT^{-1}$ |

## DIMENSIONAL HOMOGENEITY

Dimensional homogeneity means the dimensions of each terms in an equation on both sides are the same.

If the dimensions of each term on both sides of an equation are the same the equation is known as dimensionally homogeneous equation.

Example:

$$S = ut + \frac{1}{2}at^2$$

$$[S] = L$$

$$[ut] = [LT^{-1}T] = [L]$$

$$\left[\frac{1}{2}at^2\right] = [LT^{-2}T^2] = [L]$$

It is a dimensionally homogeneous equation

## DIMENSIONLESS NUMBERS

In fluid mechanics, Dimensionless numbers or non-dimensional numbers are those which are useful to determine the flow characteristics of a fluid. Inertia force always exists if there is any mass in motion. Dividing this inertia force with other forces like viscous force, gravity force, surface tension, elastic force, or pressure force, gives us the dimensionless numbers.

Dimensionless Numbers in Fluid Mechanics

Some important dimensionless numbers used in fluid mechanics and their importance is explained below.

1. Reynolds Number
2. Froude Number
3. Weber Number
4. Mach Number
5. Euler's Number

**1. Reynolds number**

Reynolds number is the ratio of inertia force to the viscous force. It describes the predominance of inertia forces to the viscous forces occurring in the flow systems.

**Froude number**

Froude number is the ratio of inertia force to the gravitational force. Froude number is significant in case of free surface flows where the gravitational force is predominant compared to other forces.

**Weber number**

Weber number is the ratio of inertia force to the surface tension. The formation of droplets or water bubbles in a fluid is normally due to surface tension. If Weber number is small, surface tension is larger and vice versa.

**Mach number**

Mach number is the ratio of inertia force to the elastic force. If the Mach number is one, then the flow velocity is equal to the velocity of sound in the fluid. If it is less than one, then the flow is called subsonic flow, and if it is greater than one the flow is called

supersonic flow.

**Euler's number**

Euler number is the ratio of pressure force to the inertia force.