

3.1 DIMENSIONS ANALYSIS : INTRODUCTION

Dimensional 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)

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

Dimensions of Derived Quantities.

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

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	ω	T^{-1}
8.	Acceleration	a	LT^{-2}
9.	Angular Acceleration	α	T^{-2}
10.	Discharge	Q	L^3T^{-1}
11.	Acceleration due to Gravity	g	LT^{-2}
12.	Kinematic Viscosity	ν	L^2T^{-1}
(d) Dynamic Quantities			
13.	Force	F	MLT^{-2}
14.	Weight	W	MLT^{-2}
15.	Density	ρ	ML^{-3}
16.	Specific Weight	w	$ML^{-2}T^{-2}$
17.	Dynamic Viscosity	μ	$ML^{-1}T^{-1}$
18.	Pressure Intensity	p	$ML^{-1}T^{-2}$
19.	Modulus of Elasticity	$\left\{ \begin{matrix} K \\ E \end{matrix} \right.$	$ML^{-1}T^{-2}$
20.	Surface Tension	σ	MT^{-2}
21.	Shear Stress	τ	$ML^{-1}T^{-2}$
22.	Work, Energy	$W \text{ or } E$	ML^2T^{-2}
23.	Power	P	ML^2T^{-3}
24.	Torque	T	ML^2T^{-2}
25.	Momentum	M	MLT^{-1}

TABLE 3.1.1 Dimensions of Derived Quantities

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.

