

Units and Measurements

In order to make the measurement of a physical quantity we have, first of all, to evolve a standard for that measurement so that different measurements of same physical quantity can be expressed relative to each other. That standard is called a **unit** of that physical quantity.

- **System of Units:-**

- C.G.S (Centimeter-Grand-Second) system.
- F.P.S. (Foot-Pound-Second) system.
- M.K.S. (Meter-Kilogram--Second) system.
- M.K.S.A. (Meter-Kilogram-Second-Ampere) unit.

- **Dimensional Formula:-**

Dimensional formula of a physical quantity is the formula which tells us how and which of the fundamental units have been used for the measurement of that quantity.

- **How to write dimensions of physical quantities:-**

- Write the formula for that quantity, with the quantity on L.H.S. of the equation.
- Convert all the quantities on R.H.S. into the fundamental quantities mass, length and time.
- Substitute M, L and T for mass, length and time respectively.
- Collect terms of M,L and T and find their resultant powers (a,b,c) which give the dimensions of the quantity in mass, length and time respectively.

- **Characteristics of Dimensions:-**

- Dimensions of a physical quantity are independent of the system of units.
- Quantities having similar dimensions can be added to or subtracted from each other.
- Dimensions of a physical quantity can be obtained from its units and vice-versa.
- Two different physical quantities may have same dimensions.
- Multiplication/division of dimensions of two physical quantities (may be same or different) results in production of dimensions of a third quantity.

PHYSICAL QUANTITY	SYMBOL	DIMENSION	MEASUREMENT UNIT	UNIT
Length	s	L	Meter	m
Mass	M	M	Kilogram	Kg
Time	t	T	Second	Sec
Electric charge	q	Q	Coulomb	C
luminous intensity	I	C	Candela	Cd
Temperature	T	K	Kelvin	°K
Angle	q	none	Radian	None

Units and Measurements

Mechanical Physical Quantities (derived)				
PHYSICAL QUANTITY	SYMBOL	DIMENSION	MEASUREMENT UNIT	UNIT
Area	A	L^2	square meter	m^2
Volume	V	L^3	cubic meter	m^3
velocity	v	L/T	meter per second	m/sec
angular velocity	w	T^{-1}	radians per second	1/sec
acceleration	a	LT^{-2}	meter per square second	m/sec^2
angular acceleration	a	T^{-2}	radians per square second	$1/sec^2$
Force	F	MLT^{-2}	Newton	$Kg\ m/sec^2$
Energy	E	ML^2T^{-2}	Joule	$Kg\ m^2/sec^2$
Work	W	ML^2T^{-2}	Joule	$Kg\ m^2/sec^2$
Heat	Q	ML^2T^{-2}	Joule	$Kg\ m^2/sec^2$
Torque	t	ML^2T^{-2}	Newton meter	$Kg\ m^2/sec^2$

Units and Measurements

Power	P	ML^2T^{-3}	watt or joule/sec	$Kg\ m^2/sec^3$
Density	D or ρ	ML^{-3}	kilogram per cubic meter	Kg/m^3
pressure	P	$ML^{-1}T^{-2}$	Newton per square meter	$Kg\ m^{-1}/sec^2$
impulse	J	MLT^{-1}	Newton second	$Kg\ m/sec$
Inertia	I	ML^2	Kilogram square meter	$Kg\ m^2$
luminous flux	f	C	lumen (4Pi candle for point source)	cd sr
illumination	E	CL^{-2}	lumen per square meter	$cd\ sr/m^2$
entropy	S	$ML^2T^{-2}K^{-1}$	joule per degree	$Kg\ m^2/sec^2K$
Volume rate of flow	Q	L^3T^{-1}	cubic meter per second	m^3/sec
kinematic viscosity	n	L^2T^{-1}	square meter per second	m^2/sec
dynamic viscosity	m	$ML^{-1}T^{-1}$	Newton second per square meter	$Kg/m\ sec$
specific weight	g	$ML^{-2}T^{-2}$	Newton per cubic meter	$Kg\ m^{-2}/sec^2$

Electrical Physical Quantities (derived)

Units and Measurements

Electric current	I	QT^{-1}	Ampere	C/sec
emf, voltage, potential	E	$ML^2T^{-2}Q^{-1}$	Volt	$Kg\ m^2/sec^2C$
resistance or impedance	R	$ML^2T^{-1}Q^{-2}$	ohm	$Kgm^2/secC^2$
Electric conductivity	s	$M^{-2}L^{-2}TQ^2$	mho	$secC^2/Kg\ m^3$
capacitance	C	$M^{-1}L^{-2}T^2\ Q^2$	Farad	sec^2C^2/Kgm^2
inductance	L	ML^2Q^{-2}	Henry	$Kg\ m^2/C^2$
Current density	J	$QT^{-1}L^{-2}$	ampere per square meter	$C/sec\ m^2$
Charge density	r	QL^{-3}	coulomb per cubic meter	C/m^3
magnetic flux, Magnetic induction	B	$MT^{-1}Q^{-1}$	weber per square meter	$Kg/sec\ C$
magnetic intensity	H	$QL^{-1}T^{-1}$	ampere per meter	$C/m\ sec$
magnetic vector potential	A	$MLT^{-1}Q^{-1}$	weber/meter	$Kg\ m/sec\ C$
Electric field intensity	E	$MLT^{-2}Q^{-1}$	volt/meter or newton/coulomb	$Kg\ m/sec^2\ C$
Electric displacement	D	QL^{-2}	coulomb per square meter	C/m^2

Units and Measurements

permeability	m	MLQ^{-2}	henry per meter	$Kg\ m/C^2$
permittivity,	e	$T^2Q^2M^{-1}L^{-3}$	farad per meter	sec^2C^2/Kgm^3
dielectric constant	K	$M^0L^0T^0$	None	None
frequency	f or n	T^{-1}	Hertz	sec^{-1}
angular frequency	W	T^{-1}	radians per second	sec^{-1}
Wave length	l	L	Meters	M

- **Principle of homogeneity:-**

It states that “ the dimensional formulae of every term on the two sides of a correct relation must be same.”

- **Types of error:-**

(a) Constant errors:- An error is said to be constant error if it affects, every time, a measurement in a similar manner.

(b) Systematic errors:- Errors which come into existence by virtue of a definite rule, are called systematic errors.

(c) Random error or accidental error:- Error which takes place in a random manner and cannot be associated with a systematic cause are called random or accidental errors.

(d) Absolute error:- $\Delta x_i = x_i - \bar{x}$

- **Relative Error:-**

$$\delta x_r = \frac{\Delta \bar{x}}{\bar{x}}$$

- **Percentage Error:-**

$$\delta x_p = \frac{\Delta \bar{x}}{\bar{x}} \times 100$$