UNIT 1- UNIT AND MEASUREMENT

Definition of unit :

A unit is defined as the reference standard used for the measurement of physical quantity

Example. 10 metre , here 10 represents magnitude and meter represents Unit

Properties of Good unit :

1. It should be easily available
2. It should not change with space and time
3. It should be universal accepted
4. It should be comparable with another one
5. It should be easily reproducible
6. It should be well defined

Types of unit :

The units are classified into two categories

1. Fundamental
2. Derived

Physical Quantities:

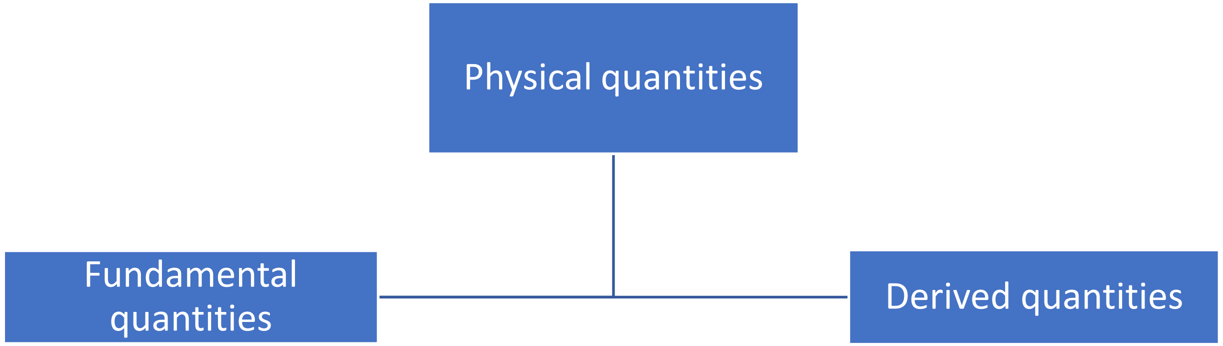
Definition of physical quantities: A physical quantity is defined as any quantity that can be measured

Ex. Mass ,length, time ,Force

OR

It is a property of material or a system and it can be measured in laboratories

Types of physical quantity:



Definition of fundamental physical quantities:

A physical quantity which does not depend on any other physical quantity for its measurement.
Fundamental physical quantities use fundamental units for their measurement.

Definition of Derived Physical Quantities :

A physical quantities other than fundamental quantities which depend on one or more fundamental quantities for their measurements are called as derived quantities.

Ex. Speed= mass X acceleration

Speed is derived from 3 fundamental quantities mass , length and time

Definition of fundamental unit:

The units used to measure fundamental quantities are called fundamental units

Definition of Derived unit:

The units of derived quantities which depends on fundamental units for their measurements are called as derived units .

Fundamental Physical Quantities and its Unit

Sr No	Fundamental quantity	SI Unit	symbol
1	Length	Meter	M
2	Mass	Kilogram	Kg
3	Time	Second	S
4	Temperature	Kelvin	K
5	Electric current	Ampere	A
6	Luminous intensity	Candela	Cd
7	Amount of substance	mole	Mol

Derived physical quantities and its unit

Sr No	Derived physical quantity	Derived unit	Symbol of unit
1	Area	Square meter	m^2
2	Volume	Cubic meter	m^3
3	Density	Kilogram per cubic meter	$\frac{kg}{m^3}$
4	Velocity	Meter per second	m/s
5	Acceleration	Meter per square second	m/s^2
6	Force	Newton	N
7	Pressure	Newton per meter square	N/m^2
8	Speed	Meter per second	m/s
9	Work	Joule	J
10	Energy	Joule	J

Supplementary quantities and Units

Sr no	Quantity	S. I Unit	Symbol
1	Plane angle	Radian	Rad
2	Solid angle	steradian	sr

System of Units

Definition: The system of units are defined as a set of the fundamental and derived units

1) C.G.S System 2) M. K. S system 3) F. P. S system 4) S.I system

1. C. G. S System: Centimetre Gram Second system it's a system of unit in which the units of length mass and time are centimetre Gram and Second respectively

2. M.K.S System: Meter-Kilogram-Second it's a system of unit in which the units of length mass and time are Meter-Kilogram and Second respectively

3. F.P.S System: Foot- Pound- Second system it's a system of unit in which the units of length mass and time are Foot- Pound and Second

4. S.I System: International system of unit it consist of seven fundamental unit two supplementary units and large number of derived units

Different quantities and their Units

Physical quantity	CGS	MKS	FPS	SI
Length	Cm	m	Ft	m
Velocity	Cm/s	m/s	Ft/s	m/s
Force	Dyne	N	Pound force	N
Heat energy	Cal	Kcal	Btu	Joule
Speed	Cm/s	m/s	Ft/s	m/s
Area	Cm^2	m^2	Ft^2	m^2
density	Gm/cm^3	Kg/m^3	Lb/ft^3	Kg/m^3

Prefixes of SI unit

symbol	multiplier	Prefix
T	10^12	Tera
G	10^9	Giga
M	10^6	Mega
K	10^3	Kilo
h	10^2	hecto
da	10^1	Deca
d	10^{-1}	Deci
c	10^{-2}	Centi
m	10^{-3}	Milli
µ	10^{-6}	Micro
n	10^{-9}	Nano
p	10^{-12}	Pico
f	10^{-15}	femto
a	10^{-18}	auto

Dimensions and Dimensional Formulae

Definition of Dimension:

The power to which fundamental units of length mass, time, etc must be raised to represent the given physical quantity.

Example:

The dimensions of an area can be obtained as follows.

Area= length x breadth

=[L] x[L]=[L^2]

The dimensional formulae of the area in terms of the basic physical quantities length mass and time are given by Area=[$L^2 M^0 T^0$]

Application of Dimensional Formula:

1. To find the correctness of the physical equation
2. Scaling and studying of models
3. To establish the relation between related physical quantity
4. To find the conversation factor between the units of the same physical quantity in two different systems of units

Physical quantities formula dimensional formula SI unit and symbol

Sr No	Physical quantity	Formula	Dimensional formula	S.I unit symbol
1	Length	Length	$L^1 M^0 T^0$	m
2	Mass	Mass	$L^0 M^1 T^0$	Kg
3	Time	Time	$L^0 M^0 T^1$	S
4	Area	Length x breadth	$L^2 M^0 T^0$	m^2
5	Volume	L x b x h	$L^3 M^0 T^0$	m^3
6	Speed velocity)	Distance /Time	$L^1 M^0 T^{-1}$	m/s
7	Density	Mass/volume	$L^{-3} M^1 T^0$	Kg/m^3
8	Acceleration	Velocity/time	$L^1 M^0 T^{-2}$	m/s^2

9	Pressure	Force /area	$L^{-1} M^{1}T^{-2}$	N/m^2
10	Force	Mass x acceleration	$L^{-1} M^{1}T^{-2}$	N
11	Work	Force x displacement	$L^{1} M^{0}T^{0}$	J
12	K.E	½ mv^2	$L^{2} M^{1}T^{-2}$	J
13	P.E	mgh	$L^{2} M^{1}T^{-2}$	J
14	Power	Work/time	$L^{2} M^{1}T^{-3}$	J/s
15	frequency	1/time period	$L^{0} M^{0}T^{-1}$	Hz

ERROR AND ITS TYPE

Definition of error: Error is defined as the uncertainty in the measurement of a physical quantity

OR

: Difference between the true value and the measured value of the physical quantity

Types of error:

1. Instrumental error (constant error)
2. Systematic error
3. Personal error
4. Random or accidental error

Definition of instrumental error (constant error) : is defined as the cause due to faulty construction or faulty calibration of an instrument

We can minimise the error by taking the same measurement with different accurate instrument

Definition of systematic error: is defined as the error due to defective setting or adjustment of an instrument.

Ex. A systematic error is caused if the pointer of an ammeter is not pivoted exactly at the zero of the scale.

Definition of personal error: This is defined as the error due to the fault of an observer while taking a reading.

Definition of Random error: The error occurring due to different factor such as a change in temperature pressure, fluctuation in voltage while performing an experiment

Mean (True value) of the quantity : When we take sufficiently large number of readings and find their mean(Average) its known as the mean value of the measured quantity its denoted by a_m .

Example : $a_{mean} = (a_1 + a_2 + a_3 \text{------} a_n)/n$

where errors are small the mean value is also a most probable value

Absolute error: Absolute value is defined as a magnitude of difference between mean value and each individual measured value of physical quantity its denoted by $|\Delta a_n|$

Example : Thus absolute error for the measurement a_1 is $|\Delta a_1| = |a_m - a_1|$ Similarly in the measurement a_2 it is $|\Delta a_2| = |a_m - a_2|$ and so on

Mean Average absolute error: The arithmetic mean of all absolute error is called mean average absolute error in the measurement of physical quantity.

The expression for mean average absolute error is as follows : $|\Delta a_m| = \frac{|\Delta a_1| + |\Delta a_2| ---- |\Delta a_n|}{n}$

Relative error : The relative error is defined as the ratio of the mean absolute error in the measurement of a physical quantity to its most probable value

Relative error $= \frac{|\Delta a_m|}{a_m}$

Percentage error: Percentage error is defined as a relative error multiplied by 100 .

$$\frac{|\Delta a_m|}{a_m} \text{x}100\%$$

Combination error :**Case 1**: if a quantity a is given by a=b + c or a= b – c then maximum value of the error $\Delta a = \Delta b + \Delta c$
This means if two quantities are added or subtracted the absolute error in their final result is equal to the sum of absolute error in the individual quantity.

Case 2: If quantity a is given by a=b x c or a=$\frac{b}{c}$ then the expression from the maximum fractional error in a Is as follows $\frac{\Delta a}{a} = \frac{\Delta b}{b} + \frac{\Delta c}{c}$

Case 3: if the error in a is Δa then a percentage error in a^n is n ($\frac{\Delta a}{a}$) x100%

Significant figures

Definition: Significant figure is defined as a figure which is of some significance but it doesn't necessarily denote a certainty.

Rules for determining significance figure:

All the non-zero digits are significant figures

1. All the zero between non zero digit are digit are significant figures
2. If the number is less than, the zeros on the right of decimal point but to the left of non zero digit are not significant figures.0.0028 Underlined zero are not significant figures
3. The terminal, number without a decimal point are not significant figure(123m.12300cm=123000mm) has 3 significant Figures trailing zero are not significant
4. The trailing zero in number with a decimal point are significant 3.500 or 0.06900 have four significant figure.
5. The number should be generally reported in scientific notation (ie power of 10) 4.700m = 4.700x102 cm=4.700x103mm = 4.700x10-3 km Power of 10 is irrelevant to determine significant figures. However, the base number in the significant notation is significant thus there are 4 significant figures.