Physical Quantity:

The quantities which can be measured by an instruments and by means of which we can express and describes the laws of physics.

Mass of object = M   mass → physical quantity

Force = F   Force → " "

Pressure = P   pressure → " "

Electric Current = I / i   current → " "

Power = P ⇒ Power — Phy. Qu.

Electric flux = ϕ_e

Electric field = E

Types of physical quantities

1. Fundamental / Base / Absolute
2. Derived
3. Supplementary
   - ① Plane Angle
   - ② solid Angle

TYPES OF PHYSICAL QUANTITIES

FUNDAMENTAL

Certain physical quantities have been chosen arbitrarily and their units are used for expressing all the physical quantities, such quantities are known as Fundamental, Absolute or Base Quantities.

DERIVED

Physical quantities which can be expressed as a combination of base quantities are called derived quantities.

$$\text{e.g: Velocity}\left[\frac{m}{s}\right] = \frac{\text{Length [m]}}{\text{Time [s]}}$$

SUPPLEMENTRY

Besides the seven fundamental physical quantities, two supplementary quantities are also defined, they are:

- Plane angle
- Solid angle

NOTE : The supplementary quantities have only units but no dimensions.

Surname of Physical Quantities

UNITS OF PHYSICAL QUANTITIES

The chosen reference standard of measurement in multiples of which, a physical quantity is expressed is called the *unit* of that quantity.

System of Units :

1. **FPS or British Engineering system :**

   In this system length, mass and time are taken as fundamental quantities and their base units are foot (ft), pound (lb) and second (s) respectively.

2. **CGS or Gaussian system :**

   In this system the fundamental quantities are length, mass and time and their respective units are centimetre (cm), gram (g) and second (s).

3. **MKS system :**

   In this system also the fundamental quantities are length, mass and time but their fundamental units are metre (m), kilogram (kg) and second (s) respectively.

4. **International system (SI) of units :**

   This system is modification over the MKS system and so it is also known as *Rationalised MKS system*. Besides the three base units of MKS system four fundamental and two supplementary units are also included in this system.

→ 7 Fundamental + 2 Supp.

FUNDAMENTAL UNITS							
QUANTITY	(1) Length	(2) Mass	(3) Luminous intensity	(4) Amount of substance	(3) Time	(6) Electric current	(7) Temperature
UNITS	Metre	Kilogram	Candela	Mole	Second	Ampere	Kelvin
Symbol	m	Kg	Cd	Mol	S/Sec	A	K

Supplementry unit

(1) plane angle unit → Radian Symbol = rad

(2) Solid Angle , unit → Ste-radian Symbo = Sr

Derived Quantities

Area = $(\text{length})^2 = m^2$

Volume = $(\text{length})^3 = m^3$

density = $\dfrac{\text{mass}}{\text{Volume}} = \dfrac{kg}{m^3}$

distance = m

displacement = m

velocity = $\dfrac{\text{dis.}}{\text{time}} = \dfrac{m}{sec} = m\,s^{-1}$

Acceleration = $\dfrac{\text{velocity}}{\text{time}} = \dfrac{m}{s^2} = m\,s^{-2}$

Force = mass × Acc.

$= \left(kg \times m/s^2\right) = N$ (Newton)

Linear momentum = mass × velocity

$= kg \times \dfrac{m}{s}$

Impulse = Force × time

$= kg \cdot \dfrac{m}{s^{\cancel{2}}} \times \cancel{s}$

Impulse = $kg \cdot m/s$

Note: Unit of Impulse and Linear momentum are same

Unit of work = Force × displacement

$= Kg \cdot \frac{m}{s^2} \times m$

$= Kg \cdot m^2 s^{-2}$ = Joule (J)

Unit of Power $= \frac{\text{work}}{\text{time}}$

$= \frac{Kg\, m^2 s^{-2}}{s}$

$= Kg \cdot m^2 \cdot s^{-3}$

(Watt)

Ex Reln b/w P, V, n and T of ideal gas is Given by

PV = nRT Find SI unit of R

$R = \frac{PV}{nT}$

P = Pressure $= \frac{\text{Force}}{\text{Area}}$

V = volume

T = Temp

n = mole

$R = \frac{Kg \cdot m}{s^2 \cdot \cancel{m^2}} \times \frac{m^{\cancel{3}}}{moL \cdot K}$ = UNIVERSAL GAS Constant.

$R = \frac{Kg \cdot m^2}{moL \cdot s^2 \cdot K} = \frac{Kg \cdot m^2 s^{-2}}{moL \cdot K} = \frac{\text{Joule}}{moL \cdot K}$

DIMENSIONS :

x^{n} 2^{3}

Dimensions of a physical quantity are the powers (or $\boxed{\text{exponents}}$) to which the base quantities are raised to represent that quantity.

1. Dimensional formula : The *dimensional formula* of any physical quantity is that expression which represents how and which of the base quantities are included in that quantity.

It is written by enclosing the symbols for base quantities with appropriate powers in square brackets i.e. [ ]

Ex. Dim. formula of mass is $[M^1L^0\,T^0]$ and that of speed (= distance/time) is $[M^0L^1T^{-1}]$

2. Dimensional equation : The equation obtained by equating a physical quantity with its dimensional formula is called a *dimensional equation*. e.g. $[v] = [M^0L^1T^{-1}]$

For example $[F] = [MLT^{-2}]$ is a dimensional equation, $[MLT^{-2}]$ is the dimensional formula of the force and the dimensions of force are 1 in mass, 1 in length and –2 in time

① Dim. Formula of mass = [M]

② Dim. . . . . . Length = [L]

③ Dim . . . . Time = [T]

④ Dim . . . Current = [A]

⑤ Dim . . . . . . Temp = [K]

⑥ Dim. formula of Intensity = [Cd]

⑦ Dim formula Amount of Substance = [Mol]

Dim. Formula of Area (m^2) = $[M^0 L^2 T^0]$

Dim. " " Volume (m^3) = $[M^0 L^3 T^0]$

Dim " " Velocity (m/s) = $[M^0 L^1 T^{-1}]$

Dim " " Acc. (m/s^2) = $[M^0 L^1 T^{-2}]$

Dim " " Force ($Kg.\, m/s^2$) = $[M^1 L^1 T^{-2}]$

Dim " " " Work ($Kg.\,\frac{m^2}{s^2}$) = $[M^1 L^2 T^{-2}]$

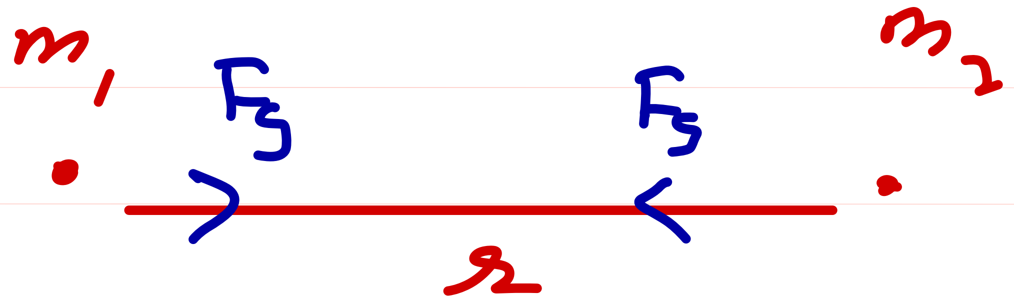
Dim. " " Electric charge = current × time

= $[M^0 L^0 T^1 A^1]$

Dim. Formula of pressure $\left(\frac{Kg \cdot m}{s^2 \cdot m^2} \right) = [M^1 L^{-1} T^{-2}]$

Dim. formula of Gravitational constant

$$F_g = \frac{G M_1 M_2}{r^2}$$



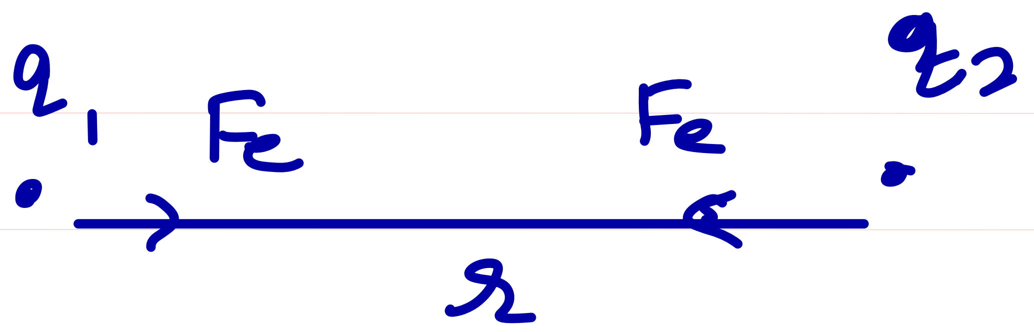
$$G = \frac{F \cdot r^2}{M_1 M_2} = \frac{\cancel{Kg} \cdot \frac{m}{s^2} \cdot m^2}{\cancel{Kg} \cdot Kg} = \frac{m^3}{Kg \cdot s^2}$$

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

NOTE All Trigo. Algebric, logarithmic, Exponential and Constants does not have Dimensions

i.e $\cos(\theta)$, $\sin\theta$, $\log(x)$, e^{3x}, π, 2, -2.5

Find Dim. formula of permitivity



$$F_e = \frac{1}{4\pi\varepsilon} \frac{q_1 q_2}{r^2}$$

ε = Permitivity of medium

$$\varepsilon = \frac{1}{4\pi} \left(\frac{q_1 q_2}{F \cdot r^2} \right)$$

$$[\varepsilon] = \frac{[A^2 T^2]}{[M^1 L^1 T^{-2} \cdot L^2]} = [M^{-1} L^{-3} T^4 A^2]$$

Physical Quantity	*Dimensional Formula*	*Physical Quantity*	*Dimensional Formula*
Area	$M^0L^2T^0$	Heat energy	ML^2T^{-2}
Volume	$M^0L^3T^0$	Entropy	$ML^2T^{-2}K^{-1}$
Density	$ML^{-3}T^0$	Specific heat	$M^0L^2T^{-2}K^{-1}$
Velocity	M^0LT^{-1}	Latent heat	$M^0L^2T^{-2}$
Acceleration	M^0LT^{-2}	Molar specific heat	$ML^2T^{-2}K^{-1}\ mol^{-1}$
Momentum	MLT^{-1}	Thermal conductivity	$MLT^{-3}K^{-1}$
Angular momentum	ML^2T^{-1}	Wien's constant	M^0LT^0K
Force	MLT^{-2}	Stefan's constant	$ML^0T^{-3}K^{-4}$
Energy, work	ML^2T^{-2}	Boltzmann's constant	$ML^2T^{-2}K^{-1}$
Power	ML^2T^{-3}	Molar gas constant	$ML^2T^{-2}K^{-1}\ mol^{-1}$
Torque, couple	ML^2T^{-2}	Electric charge	TA
Impulse	MLT^{-1}	Electric current	A
Frequency	$M^0L^0T^{-1}$	Electric potential	$ML^2T^{-3}\ A^{-1}$
Angular frequency	$M^0L^0T^{-1}$	Electric field	$MLT^{-3}\ A^{-1}$
Angular acceleration	$M^0L^0T^{-2}$	Capacitance	$M^{-1}L^{-2}T^4A^2$
Pressure	$ML^{-1}T^{-2}$	Inductance	$ML^2T^{-2}A^{-2}$
Elastic modulii	$ML^{-1}T^{-2}$	Resistance	$ML^2T^{-3}A^{-2}$
Stress	$ML^{-1}T^{-2}$	Magnetic flux	$ML^2T^{-2}A^{-1}$