❖ What is Science?

The word science is derived from a Latin verb **"scientia"** which means **"to know"** the man has always been curious to more and more about think that surround him ours is of an science all the useful thing are the gifts of science.

The science is defined as the classified knowledge of facts and gained through observation, experiment, generalization, correlation etc.

- **Branch of Science:-** There are two types; 1. Physical Science
  2. Biological Science

1. Physical Science

It is the branch of science which deals with nonliving thing .In this branch like physics, chemistry, astrophysics etc.

2. Biological Science

It is the branch of science which deals with living organism. In this branch like botany, zoology, marine biology etc are including.

➢ What is Physics?

- The branch of physics is derived from a Greek word "fuses" which means "nature" hence physics is defined as the science of nature and natural phenomena related to it.
- Physics may also be defined as the branch of science dealing with matter its energy and different propertied involved in it.

➢ What is Matter and Energy?

Matter: - Matter is anything having same mass and occupies same place in nature.

Energy: - Energy is capacity and ability number of facts. Such as kinetic energy, potential energy, heat energy, light energy, sound energy, magnetic energy etc.

Branch of Physics: - Broadly Physics classified into two branches these are

1. Classical Physics
2. Modern Physics

1. Classical Physics

Classical Physics dealing with macroscopic phenomena.

It is also subdivide into three types.

(i) Mechanics (ii) Electro magnetism (iii) Thermodynamic.

(i) Mechanics

It deals with motion of object at low speed.

(ii) Electromagnetism

It deals with electricity magnetism and electro magnetism radiation.

(iii) Thermodynamic

It deals with temperature, heat and different properties related to it.

❖ **Modern Physics**

Modern Physics dealing with microscopic phenomena.

It is also sub divided into two types.

These are 1.Relativity
2. Quantum mechanics

1. Relativity

It deals with the motion of material objects whose speed relativity to the speed of light.

2. Quantum

It deals with the microscopic behaviour subatomic particles.

❖ **Natural of Force in Nature:-**Following are four different forces in nature

1. Gravitational Force

2. Electro-magnetic Force

3. Strong nuclear Force

4. Weak nuclear Force

1. Gravitational Force

The force of attraction between the earth and any other body of this universe is called Gravitational Force or force of gravity.

Example: - i**.** we remained the entire surface on the earth due to force of gravity between earth and us.

ii. The moon orbits around the earth due to force of gravity between the man and earth.

2. Electromagnetic Force

The force of attraction or repulsion between any two electro charges on magnetic force pluses is called Electromagnetic Force.

EX:-i. The motion of an electron around the nucleons of an atom is due to electromagnetic force.

ii. The comb after combing dry hair attraction small paper piece due to electromagnetic force.

3. Strong nuclear Force

The protons and neutrons bounded to gather in the nucleus by strong nuclear force.

4. Weak nuclear Force

The force between the element particles emitted during a ratio active decay of radioactive substance is knowledge as Weak nuclear Force.

- **Physical quantities:-**

Quantities which are measured directly or indirectly and which are deal in study of physics are called physical quantities.

EX:-Mass, Length, Velocity, Charge, Temperature etc.

Types of physical or classification of physical quantities: - All the physical quantities are classified into two types

1. Elementary or basic or fundamental physical quantities.

2. Derived or compound physical quantities.

1. Fundamental physical quantities.

The physical quantities which are in depend on each and having unique is called fundamental physical quantities.

Following are the seven fundamental physical quantities. 1. Mass 2. Length 3. Time 4. Electric current 5. Temperature 6. Luminous Intensity 7. Amount of substance

In mechanics mass, length, and time are taken as fundamental physical quantities.

2. Derived physical quantities.

Any physical quantities which can be derived from the fundamental physical quantities by multiplying or dividing then is called as derived physical quantities or compound physical quantities.

EX:-Velocity, Force, Work, Power etc.

Explanation:-Velocity = $\frac{\text{Displacement}}{\text{Time}}$ or $\frac{\text{Length}}{\text{Time}}$

Since, the physical quantity "velocity" is derived from fundamental physical quantities like length and time hence velocity is called derived physical quantities.

Mass: - i. Mass of body is defined as the quantity of matter contained in the body.

ii. Mass of the body never be zero.

ii. Mass of a body is defined in two us.

1. Inertial mass
2. Gravitational mass

iv. Inertial mass and gravitational mass are equal.

v. Mass of a body is measurement in kilogram (kg).

Length:-i. The extent of separation or the distance between two points in space is called Length.

ii. Length is measured in meter.

Time:-

i. According to Einstein time is simply what a clock reads.

ii. Time is measure of duration between the occurrence of two natural events or phenomena.

iii. Time is measured in second.

Physical Measurement:-

Physical measurement means comparison of a physical quantity with another homogeneous quantity of same kind take as standard to minds in the given physical quantity.

Units:-The quantity as a standard of measurement is called unit.

Measurement:-The measurements of a physical quantities two things are required.
1. Unit
2. Numerical value or the number

i.e. Physical quantity = Numerical value × unit

Ex.:- length of a rod 5metre.

Ans: - physical quantity= length

Numerical value = 5 Unit= metre

❖ Fundamental units

The units of fundamental physical quantity like mass, length, time, current, temperature, luminous intensity and amount of substance.

Fundamental units are so named because there are independent of each other.

❖ Derived units

The units of derived physical quantity which can be expressed in terms of fundamental units are called derived units.

Ex.:- Velocity = $\frac{\text{Displacement}}{\text{Time}}$

Unit of velocity = $\frac{\text{Metre}}{\text{Second}}$

Hence metre and second are fundamental units.

$\frac{\text{Metre}}{\text{second}}$ is derived Physical units.

❖ **System of unit's:-**Following system of measurements is commonly in use.

1. M.K.S (Metre- Kilogram-Second) System or Metric System
2. C.G.S (Centimetres-Gram-Second) System or French System.
3. F.P.S (Foot –Pound –Second) System or British System
4. S.I unit (International System of units)

1. M.K.S system:-The unit of length = metre (m)

The unit of mass = kilogram (kg)

The unit of time = second(s)

2. C.G.S system:-In this system the unit of length = centimetre (cm)

The unit of mass = gram (g)

The unit of time = second(s)

3. F.P.S system:-The unit of length = foot (f)

The unit of mass = pound (p)

The unit of time = second(s)

4. S.I units:-The international system (S.I) of units, adopted in general conference on weight s and measures in 1960 and finally refined in 1971 is a complete and coherent system of units for all the physical quantities. It is a decimal system which is widely used in scientific world. This system is the modified of M.K.S system, S.I system is also called rationalized M.K.S. system.

Fundamental Physical quantities	**S.I unit**	**symbols**
Mass(M)	Kilogram	Kg
Length(L)	Metre	M
Time (T)	Second	S
Current	Ampere	A
Temperature	Kelvin	K
Luminous intensity	Candela	Cd
Amount of substance	Mole	Mol

Supplementary physical quantities	**S.I units**	**symbols**
Plane angle	Radian	rd
Solid angle	Steradian	sd

2. Derived unit

Derived physical quantity	**Expression in term fundamental quantity**	**S.I unit or M.K.S system**
Speed	$\frac{L}{T}$	$\frac{\text{metre}}{\text{second}}$
Acceleration	$\frac{L}{T^2}$	$\frac{\text{metre}}{\text{second}^2}$
Force	$\frac{ML}{T^2}$	$\frac{\text{Kilogarm} \times \text{metre}}{\text{second}^2}$
Power	$\frac{ML^2}{T^3}$	$\frac{\text{kilogram} \times \text{metre}^2}{\text{second}^3}$
Work	$\frac{ML^2}{T^2}$	$\frac{\text{kilogram} \times \text{metre}^2}{\text{second}^2}$

Ex:-Momentum = Mass× velocity

$$\Rightarrow M\times\frac{L}{T} = \frac{ML}{T} = \frac{\text{kilogram}\times\text{metre}}{\text{second}}$$

Impulse = Force× time

$$\Rightarrow \frac{ML}{T^2}\times T = \frac{ML}{T} = \frac{\text{kilogram}\times\text{metre}}{\text{second}}$$

Torque = force × distance

$$\Rightarrow \frac{ML}{T^2}\times L = \frac{ML^2}{T^2} = \frac{\text{kilogram}\times(\text{metre})^2}{\text{second}^2}$$

❖ Advantages of S.I Units or M.K.S system

1. Coherent system of units:-

S, I unit or M. K.S system is called coherent system of unit all the derived units are obtained by multiply or dividing the certain set of fundamental of units.

2. Rational system of unit:-

S.I unit or M.K.S system is called rational system of units because such system uses only 1unit for a given physical quantities.

Ex:-A. Unit of work is joule B. Unit of force is Newton

3. Metric system:-

S.I. system or M.K.S. system is called metric system because all multiples or submultiples can be expressed as the power. Metric prefix for multiples or sub multiply in power of 10

- **Multiples**

prefix	value	Abbreviation symbols
Deca	10^1	D
Hecto	10^2	H
Kilo	10^3	K
Mega	10^6	M
Giga	10^9	G
Tera	10^{12}	T
Peta	10^{15}	P
Exa	10^{18}	E

- **Sub-multiples**

Prefix	Value	Abbreviation symbol
deci	10^{-1}	d
centi	10^{-2}	c
milli	10^{-3}	m
micro	10^{-6}	μ
nano	10^{-9}	n
pico	10^{-12}	p
femto	10^{-15}	f
atto	10^{-18}	a

- **Practical units of macroscopic length:-**Macroscopic length means very large length.

To measure macroscopic length following three particle units are used.

1. Astronomical units (A.U)

2. Light year (L.Y)

3. Parallactic second (par.sec)

1. Astronomical units (A.U)

The average distance between the earth and sun is called astronomical units.

1. A.U = 1.496×10^{11}Metre $\cong 1.5\times10^{11}$M

2. Light year (L.Y)

The distance travelled by light in vacuum in 1 year is called as light year.

1light year = speed of light in vacuum× 1year

Speed of light in vacuum = 3×10^{8} metre/second

Time = 1year = $365\frac{1}{4}$day

= $365\frac{1}{4}\times24\times60\times60$ second

1light year = $3\times10^{8}\times365\frac{1}{4}\times24\times60\times60 = 9.46\times10^{15}$metre

3. Parallactic second (par.sec)

It is the distance at which an arc of length equal to one astronomical unit subtends an angle of 1sec .

It is denoted by par sec

1par sec = 3.084×10^{16}metre

- **Relation between light year and astronomical unit:-**

1A.U=1.46×10^{11}m/s $\cong 1.5\times10^{11}$........... (1)

1L.Y= 9.46×10^{15}metre ………… (2)

Dividing in equation (2) by (1) we get

$$\frac{1L.Y}{1A.U} = \frac{9.46\times10^{15}}{1.5\times10^{11}} = 6.3\times10^{4}$$

- **Relation between light year and par .sec**

$1L.Y= 9.46\times10^{15}$ metre…………….. (1)

$1PAR.SEC =3.084\times10^{16}$ metre……………. (2)

Divide in equation (2) by (1) we get

$$\frac{1par.sec}{1l.y} = \frac{3.084\times10^{16}}{9.46\times10^{15}} = 3.26$$

- **Relation between par .sec and astronomical unit**

$1PAR.SEC =3.084\times10^{16}$………………. (1)

$1A.U = 1.5\times10^{11}$…………….......... (2)

Divide in equation (1) by (2) we get

$$\frac{1par.sec}{1a.u} = \frac{3.064\times10^{16}}{1.5\times10^{11}} = 2.07\times10^{5}$$

Unit of microscopic length:-To measure microscopic length (very small length) following units are use. 1. Angstrom (A^0)

$1A^0 = 10^{-10}$metre

2. Micron (μ)

$1\mu =10^{-6}$ metre

3. Fermi (fm)

$1fm =10^{-15}$ metre

Units of angle and their conversion

Angle is usually measure in units, degree, radian, minutes and second.

$360 = 2\pi$ radian

$$1^0 = \frac{2\pi}{360} = \frac{\pi}{180} = 1.744\times 10^{-2}\text{radian}$$

$60\text{minute} = 1^0$

$60\text{minute}=1.744\times 10^{-2}$radian

$$1\text{minute} = \frac{1.744\times10^{-2}}{60}\text{ radian} = 2.91\times 10^{-4}\text{ radian}$$

$$1\text{minute} = 60\text{second}$$

$$60\text{second} = 1\text{minute}$$

$$60\text{second} = 2.91\times 10^{-4}\ \text{radian}$$

$$1\text{second} = \frac{2.91\times10^{-4}}{60}\ \text{radian} = 4.85\times 10^{-6}\ \text{radian}$$

SYMBOLS

UNIT	**SYMBOL**	**UNIT**	**SYMBOL**
Meter	M	Hertz	Hz
Kilogram	Kg	Joule	J
Second	S	Watt	W
Ampere	A	Coulomb	C
Kelvin	K	Weber	Wb
Candela	Cd	Ohm	Ohm
Radian	Rd	Volt	V
Steradian	Sr	Farad	F
Newton	N	Henry	H

Dimension: - The dimension of a physical quantity may be defined as the power to which the fundamental quantity is raised to represent the physical quantity.

The symbol "[ ]" is read as "dimension of" .

Dimension of mass = [M]

Dimension of length = [L]

Dimension of time = [T]

- **Dimensional Formula:-**It is expressions which shows us how and which of the fundamental quantity of are involved in making physical quantity.

It is denoted by dimensional of $[M^a L^b T^c]$

Where a,b,c are powers of fundamental quantities .

Ex.:- The dimension formula of Speed = $\frac{\text{distance}}{\text{time}}$

$\Rightarrow \frac{\text{length}}{\text{time}} = \frac{L}{T} = [M^0 L^1 T^{-1}]$

The dimensional formula of Area = length ×breath

$\Rightarrow L \times L = L^2 = [M^0 L^2 T^0]$

- **Dimensional Equation: -** It is an equation, equating the physical quantity with its dimensional formula.

Following are dimensional equation of different physical quantities.

1. Volume = length ×breadth× thickness

$V = L \times L \times L = L^3$

$[V] = [M^0 L^3 T^0]$

2. Velocity = $\frac{\text{displacement}}{\text{time}}$

$[V] = \frac{L}{T} = [M^0 L^1 T^{-1}]$

3. Acceleration = $\frac{\text{veolcity}}{\text{time}}$

$[a] = \frac{V}{T} = \frac{\frac{L}{T}}{T} = \frac{L}{T^2} = [L^1 T^{-2}]$

$[a] = [M^0 L^1 T^{-2}]$

4. Force = mass × acceleration

$F = m \times a = m \times \frac{L}{T^2} = \frac{ML}{T^2}$

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

5. Work= force ×displacement

$[W] = \frac{ML}{T^2} \times L$

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

6. Momentum = mass × velocity

$P = m \times \frac{L}{T} = \frac{ML}{T}$

$[p] = [M^1 L^1 T^{-1}]$

7. Power = $\frac{\text{work}}{\text{time}}$

$P = \frac{W}{T} = \frac{F \times S}{\text{time}}$

$P = \frac{\frac{ML}{T^2} \times L}{T} = \frac{ML^2}{T^3}$

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

8. Kinetic energy ($E_{.k}$) = $\frac{1}{2}mv^2$

$E_{.k} = \frac{ML^2}{T^2}$

$[E_{.k}] = [M^1 L^2 T^{-2}]$

9. Potential energy (E_p)= mgh

$E_p = M \times \frac{L}{T^2} \times L$

$E_p = \frac{ML^2}{T^2}$

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

10. Density = $\frac{\text{mass}}{\text{volume}}$

$D = \frac{M}{V} = \frac{M}{L^3}$

$[D] = [M^1 L^{-3} T^0]$

11. Impulse = force × time

$I = F \times T = \frac{ML}{T^2} \times T$

$I = \frac{ML}{T}$

$[I] = [M^1 L^1 T^{-1}]$

12. Pressure = force / area

$P = \frac{F}{a} = \frac{\frac{ML}{T^2}}{L^2}$

$P = \frac{ML}{T^2} \times \frac{1}{L^2}$

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

13. Torque = force × distance

$T = \frac{ML}{T^2} \times L = \frac{ML^2}{T^2}$

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

- **Principle of Homogeneity:-**

In a physical equation, in dimensions of all the terms must be the similar or homogenous.

Ex: - consider a physical equation V = u + at

The dimension formula of 1st term $[V] = [M^0 L^1 T^{-1}]$

The dimension formula of 2nd term $[u] = [M^0 L^1 T^{-1}]$

The dimension formula of 3rd term $[at] = [M^0 L^1 T^{-2}][T]$

$[at] = [M^0 L^1 T^{-1}]$

Since dimension formula of all the terms are the same there for equation is correct.

- **Classification of physical quantities on the basic of dimension :**

1. Dimensional Variables

The physical quantities which posses dimension and have variable values are called dimensional variables.

Ex: - velocity, force, work, area, momentum etc.

2. Non- Dimensional Variables

The physical quantities which have non-dimensional and have variable values are called Non –dimensional variables.

Ex: - specification, strain, angle, sinθ, cosθ etc.

3. Dimensional Constant

The physical quantities which posses dimensions and have constant variable values are called dimensional constant.

1. Gravitational constant(G)
2. Planck's constant (h)
3. Steffens constant (σ)
4. Boltzmann's constant (k)
5. Velocity of light (c)

4. Non-Dimensional Constant

The physical quantities which do not possess dimensions and have constant values are called non-dimensional constant.

Ex.: - Natural number 1, 2, 3 …π, θ etc.

- **Application (Or) Uses of Dimensional Analysis:-**The dimensional analysis can be used as follow.
  1. Conversion of one system of units into another.
  2. Checking the correctness of physical equation.
  3. Deriving relationship among physical quantities.

1. Conversion of one system of units into another.

To convert the unit of physical quantity from one system to another we use dimensional analysis us explained below.

Problem: - Let us convert a force of 1 Newton into dyne.

M.K.S OR S.I SYSTEM	FORCE	C .G .S SYSTEM
M_1=1kg L_1=1metre T_1=1second n_1= 1	$[M^1L^1T^{-2}]$	M_2=1gram L_2=1c.m T_2=1second n_2= ?

Since the physical quantities is the same in both systems.

$$n_1 \times [M_1^1 L_1^1 T_1^{-2}] = n_2 \times [M_2^1 L_2^1 T_2^{-2}]$$

$$n_2 = n_1 [M_1^1 L_1^1 T_1^{-2}] \backslash [M_2^1 L_2^1 T_2^{-2}]$$

$$= n_1 [\frac{M1}{M2}]^1 [\frac{L1}{L2}]^1 [\frac{T1}{T2}]^{-2}$$

$$= 1 [\frac{1kg}{1g}]^1 [\frac{1m}{lcm}]^1 [\frac{1s}{1s}]^{-2}$$

$$= 1 [\frac{1000g}{1g}]^1 [\frac{100m}{lcm}]^1 [1]^{-2}$$

$$= 1 \times 1000 \times 100 \times 1$$

$$n_2 = 10^5{}_{dyne}$$

$$1newton = 10^5 dyne$$

Problem2. Let us convert a work of 5 joule into erg .

M.K.S OR S.I SYSTEM	Work	C .G .S SYSTEM
$M_{1=}$1kg L_1=1metre $T_{1=}$1second $n_{1=}$ 5	$[M^1 L^2 T^{-2}]$	$M_{2=}$1gram L_2=1c.m $T_{2=}$1second $n_{2=}$?

Since the physical quantities is the same in both systems.

$$n_1[M_1^1 L_1^1 T_1^{-2}] = n_2[M_2^1 L_2^1 T_2^{-2}]$$

$$n_2 = n_1 [M_1^1 L_1^2 T_1^{-2}] \backslash [M_2^1 L_2^2 T_2^{-2}]$$

$$= n_1 [\frac{M1}{M2}]^1 [\frac{L1}{L2}]^2 [\frac{T1}{T2}]^{-2}$$

$$=5 [\frac{1000g}{1g}]^1 [\frac{100m}{lcm}]^2 [1]^{-2}$$

$$=5 \times 1000 \times 10000 \times 1$$

$n_2 = 5 \times 10^7$ dyne

2. Checking the correctness of a given physical quantities.

To checking the correctness of a physical quantities fast up all the dimensional formula of every terms are written .Apply principle of homogenate, if the dimensional formula of every terms are equal than the given relation is correct .

Ex.1 $S = ut + ½at^2$

The dimensional formula of 1st term 's' = $[M^0L^1T^0]$
The dimensional formula of 2nd term 'ut' = $[M^0L^1T^{-1}]$ $[T^1]$ = $[M^0L^1T^0]$

. The dimensional formula of 3rd term ½at² = $\frac{L}{T^2} \times T^2$ = $[M^0L^1T^0]$

As dimensional formula of every terms are equal than given relation is correct.

Ex.2 $v^2 = u^2+2as$

The dimensional formula of 1st term 'v^2' = $[M^0L^2T^{-2}]$
The dimensional formula of 2nd term 'u^2' = $[M^0L^2T^{-2}]$

The dimensional formula of 3rd term '2as' = $\frac{L}{T^2} \times L$ = $[M^0L^2T^{-2}]$

As dimensional formula of every terms are equal than given relation is correct.

Ex3:- check the correctness of following physical

(i) $T=2\pi\sqrt{\frac{l}{g}}$

(ii) $F=\frac{mv^2}{r}$

(i)Dimensional Formula of 1st term [T] = $[M^0L^0T^1]$

Dimensional Formula of 2nd term $[2\pi\sqrt{\frac{l}{g}}] = [T^2]^{\frac{1}{2}}$ = $[M^0L^0T^1]$

As dimensional formula of every terms are equal given relation is correct.

(ii)Dimensional Formula of 1st term [F] = $[M^1L^1T^{-2}]$

Dimensional Formula of 2nd term $[\frac{mv^2}{r}] = [\frac{M^1(L^1T^{-1})^2}{L}]$ = $[M^1L^1T^{-2}]$

As dimensional formula of every terms are equal given relation is correct.

3. Derive relation among physical quantities.

We can derive expression for the physical quantities using the principal of homogenate of we know the various factor open which the physical quantities depends.

Ex1. Derive a mathematical expression for time period (T) depends upon mass of the body (m), length of the pendulum (*l*), acceleration due to gravity (g).

Ans:-Here, Given that the time period of simple pendulum (t)

Mass of the body (m)

Length of the pendulum (*l*)

Acceleration due to gravity (g)

$T \propto m^a$ $T \propto l^b$ $T \propto g^c$

Combining all the above factors $T \propto m^a l^b g^c$

$T = K m^a l^b g^c$ …………..(1)

Where K is the proportionality constant and it is assumed to dimension less.

Dimension of all the factors.

L. H .S (T) = $[M^0L^0T^{1}]$

R .H .S = $[m^a l^b g^c]$

$= [m^a l^b (\frac{L}{t^2})^c] = [m^a l^b \frac{l^c}{t^{2c}}]$

$= [m^a l^{b+c} T^{-2c}]$

Apply law of homogenate

L. H .S = R .H .S

$[M^0L^0T^1] = [m^a l^{b+c} T^{-2c}]$

a=0, - 2c = 1 b + c= 0

c = -½ b - ½ =0 b= ½

Substituting a, b, c in equation (1) we get

$$T = K\,[m^{a}\, l^{b}\, g^{c}]$$

$$=K\,[m^{0}\, l^{½}\, g^{-½}]$$

$$=K\,[m^{0}\, l^{½}\, \frac{1}{g^{½}}]$$

$$=K\,[\frac{l^{½}}{g^{½}}]=K\,[\frac{l}{g}]^{1/2}$$

$$=K\sqrt{\frac{l}{g}}$$

Experimentally it has been founded that the value of K=2π

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Ex.2 Centripetal force depends upon the speed (ϑ), radius of the circle(r) and mass of the body (m) found a mathematical expression for centripetal force and dimensional analysis.

Ans: - centripetal force (F)

Mass of the body (m)

Radius of the circle(r)

Let $F \propto m^{a}$ $\quad F \propto \vartheta^{b}$ $\quad F \propto r^{c}$

Then by law of combination of variables

$$F= k\, m^{a}\vartheta^{b}r^{c}$$

When 'k 'is a dimensionless constant.

Now dimension of L.H.S=$[F]$= $[MLT^{-2}]$

Dimension of R.H.S = $[\, M^{a}(LT^{-1})^{b}\,(L)^{c}\,]=[M^{a}L^{b+c}T^{-b}]$

Equation the dimension of L.H.S and R.H.S we obtain

a=1 b+c=1 -b=-2

2+c=1 c=-1 b=2

Hence equation (1) takes the form $F=K\frac{m\vartheta^{2}}{r}$

Limitation or Defects of Dimensional Analysis

1. To give no information the proportionality constant

2. It can used to derive formula involving logarithm numerical trigonometry or extensional function,

3. It doesn't specify the physical quantity, have been same dimension.

4. It can be used for deriving expansion for a physical quantity which depends upon more than three physical relations.

Significant Figures: The number of meaningful digits in a number is called the number of significant figures.

From the above example, we have the following rules.

i) All the non zero digits in a number are significant.
ii) All the zeroes between two non zeroes digits are significant, irrespective of the decimal point.
iii) If the number is less than 1, the zeroes on the right of decimal point but to the left of the first non zero digit are not significant.
iv) The zeroes at the end without a decimal point are not significant.
V) The trailing zeroes in a number with a decimal point are significant.
The number is expressed in powers of 10 notation i.e in standard from as follows.

$$\text{Number} = M\times 10^{n}$$

Where M is at least 1 but less than 10 and n is a positive or negative integer. All digits contained in M.

Number	standard from=$M\times 10^{n}$	No of significant figures
215	2.15×10^{2}	3
3160	3.16×10^{3}	3
0.0312	3.12×10^{-2}	3
0.02018	2.018×10^{-2}	4
0.3152	3.152×10^{-1}	4
57,000	5.7×10^{4}	2
0.080	8.0×10^{-2}	2
35	3.5×10^{1}	2

Significant Figures in Algebric Operations

(i) In addition or subtraction of the numerical values the final result should retain the least decimal place as in the various numerical values.

Ex:If l_1= 4.326 m and l_2 = 1.50 m

Then, $l_1 + l_2$ = (4.326 + 1.50) m = 5.826 m

As l_2 has measured upto two decimal places, therefore $l_1 + l_2$ = 5.83 m

(ii) In multiplication or division of the numerical values, the final result should retain the least significant figures as the various numerical values.

e.g:- If length 1= 12.5 m and breadth b = 4.125 m.

Then, area A = l x b = 12.5 x 4.125 = 51.5625 m^2

As *l* has only 3 significant figures, therefore A= 51.6 m^2

Order Of Magnitude The nearest power of ten, in which a quantity can be expressed, is called as the order of magnitude of the quantity.

- For order of magnitude following two rules are important

Rule-1 if the left most digit of the quantity is less than 5(1, 2, 3, 4) the decimal is put first to its right. The number of digits right to the decimal, become the order of magnitude

Example: $4962 = 4.962 \times 10^3$

The order of magnitude of the quantity is three.

Rule-2 if the left most digit of the quantity is 5 or more (5, 6, 7, 8, 9) the decimal is put to its left. The number of digits right to the decimal, become the order of magnitude

Example: $5125 = 0.5125 \times 10^4$

The order of magnitude is 4.

Rounding off a Number:

The rounding off is made following the rules as given below:

(1) If a digit <5 is dropped than the digit preceding it is left unchanged
Ex. 5.443→5.44

(2) If a digit >5 is dropped than the digit preceding it is raised by 1
Ex. 5.446→5.45

(3) If a digit=5 is dropped than an odd digit preceding it is raised by 1, while an even digit preceding it is left unchanged.
Ex. 5.445→5.44
5.445→5.44

Accuracy:-The closeness of the observed value to the true value, of the physical quantity is known as the accuracy of the measurement.

Precision:-precision is a measure of the extend which succession measurement of a physical quantity different from one to another

The measurement said to be precession if we octane all must be same value of the physical quantity in each of the several measurement carried out with the instrument.

ERRORS:-The error in the measurement of a physical quantity each different as the difference between the true value and observed value of the physical quantity.

Error = True value-Observed value

Types of Error: - The errors in the measurement of a physical quantity are classified as follow.

Constant Error:-The errors, due to the faulty, graduation, of the scale of instrument is called constant error.

This error accurse every time a measurement is made.

Ex.-if a thermometer reads 2^0cfor ice temperature, the temperature recorded to be42^0c should be corrected to 40^0c.

Systematic Error:-The errors which are occurring by virtue of a definite rule are called systematic error.

Systematic error is following types,

1. Instrumental error

2. Personal error

3. Error due to in perfectness,

1. Instrumental Error:-These errors come to be due to faulty design of the measurement instrument, is called as instrumental error

Ex:-Zero error is an instrumental error.

2. Least count error.

2. Personal Error:-This is types of error due to some personal habit of the observer. The error in the measurement of a physical quantity due to limitation of an observer is called as personal error.

Ex:-suppose a student is measuring the time period of a simple pendulum. The student might to be stop to the stopwatch a little or little letter .The pendulum complexly one oscillation .The error comes to the time period of the pendulum, such error is called personal error.

The pendulum completely one oscillation the error comes to the time period of the pendulum; such error is called personal error.

3. Error due to imperfection:-

This type of error is due to same in perfection of the instrument.

Random Error or Accidental Error:-

(i)Error which occurs at a random manner is called random error.

(ii) Random error is due to some unknown results and some time called chance error this error can't be controlled by the observer.

(iii)These errors are not constant in magnitude but there are variables.

(iv)If an observer measures the same physical quantity several times and notes different values at each time the error is called random error.

Let x_1 x_2 x_3………$x_n$are different observation of a physical quantity. Therefore the average $\bar{X}$

$$\bar{X}=\frac{x_1+x_2+x_3\ldots\ldots\ldots x_n}{n}$$

$$\bar{X}=\frac{\sum_{i=1}^{n}x_i}{n}$$

Absolute Error:-the absolute error of a values of physical quantity in the different between main value of the physical quantity and the observed value.

It is denoted by Δx.

Let $x_1, x_2 x_3 \ldots\ldots\ldots x_n$ are different observed value of the physical quantity.

Main value $\bar{X}=\frac{x_1+x_2+x_3\ldots\ldots\ldots x_n}{n}$

$\bar{X}-x_1 = \Delta x_1$ (1st absolute error)

$\bar{X}-x_2=\Delta x_2$ (2st absolute error)

$\bar{X}-x_3=\Delta x_3$ (3rd absolute error)

Total absolute error = $\overline{\Delta x}=\frac{\Delta x1+\Delta x2+\Delta x3+\cdots\ldots\ldots+\Delta xn}{n}$

$$\overline{\Delta x} = \frac{\sum_{i=1}^{n} \Delta x_i}{n}$$

Relative Error:-the ratio of the absolute error the true value of the physical quantity is called as relative error.

It is denoted by δx_r

Relative error (δx_r) = $\frac{\overline{\Delta x}}{x}$

Percentage of Error: - Relative error$\times 100$

Therefore (δx_p)= $\frac{\overline{\Delta x}}{x} \times 100$

Mistake Error:-

Any faulty measurement that is due to the carelessness of the observer is called mistake error .we can be eliminated by care and wakefulness of the part of the observer.

Combination of Errors

❖ **Error of a sum or a difference**

When two quantities are added or subtracted, the absolute error in the final result is the sum of the absolute errors in the individual quantities.

Suppose two physical quantities A and B have measured values $A \pm \Delta A$, $B \pm \Delta B$ respectively. Where ΔA and ΔB are their absolute errors.

sum $Z = A + B$.

We have by addition, $Z \pm \Delta Z = (A \pm \Delta A) + (B \pm \Delta B)$.

The maximum possible error in Z

$$\Delta Z = \Delta A + \Delta B$$

For the difference $Z = A - B$, we have

$Z \pm \Delta Z = (A \pm \Delta A) - (B \pm \Delta B)$

$= (A-B) \pm \Delta A \pm \Delta B$

or, $\pm \Delta Z = \pm \Delta A \pm \Delta B$

The maximum value of the error ΔZ is again $\Delta A + \Delta B$

❖ **Error of a product or a quotient**

When two quantities are multiplied or divided, the relative error in the result is the sum of the relative errors in the multipliers.

Suppose $Z = AB$ and the measured values of A and B are $A \pm \Delta A$ and $B \pm \Delta B$.
Then $Z \pm \Delta Z = (A \pm \Delta A)\,(B \pm \Delta B)$

$= AB \pm B\,\Delta A \pm A\,\Delta B \pm \Delta A\,\Delta B$.

Dividing LHS by Z and RHS by AB we have,
$1 \pm (\Delta Z/Z) = 1 \pm (\Delta A/A) \pm (\Delta B/B) \pm (\Delta A/A)(\Delta B/B)$.
Since ΔA and ΔB are small, we shall ignore their product.
Hence the maximum relative error

$$\Delta Z/\,Z = (\Delta A/A) + (\Delta B/B).$$

Addition Error:-

When two physical quantities are added to get a new physical quantity the possible error of the result is always the some of the error of the individual error.

Multiplication or Product Error:-

Consider a physical quantity "x" is express x=$a^n b^m$

∴ Percentages error in x = (n × percentage error in 'a') + (m × percentage error in 'b').

Problems:-*1.The percentages error in measuring the side of cube is 1%.calculated the percentages error in determining the value of v.*

Ans:-We know the value of the cube 'v'=L× $L \times L = L^3$

The percentages error in v =3× $\%error\ in\ L$=3×1=3%

2. The percentages error in measuring length is 2.5% and percentages error in breadth is 4%. Find the percentages of area.

Ans:- Area (A) =$l \times b$

∴ Percentages error of Area = (1× %error $in\ l$) + (1×% error in b)

=1× 2.5+1× 4 =6.5%

Division Error or Quotient Error:-

Consider a physical quantity X = $\frac{a^n}{b^m}$.

∴Percentages error of X= (n×% error of a) + (m×% error of b)

Ex.3. What is the error in the determining of density if %error in measurement of length is 3%and mass is 5%.

Ans: - Given % of mass (M) =5%

The %of length (L) =3%

Density = $\frac{mass}{volume} = \frac{M}{v} = \frac{M}{L^3}$

∴ Percentages error of density = (1× %error in M) + (3×% error in L)

⇒ (1×5) +(3 ×3) =5+9 = 14%

Numerical problems