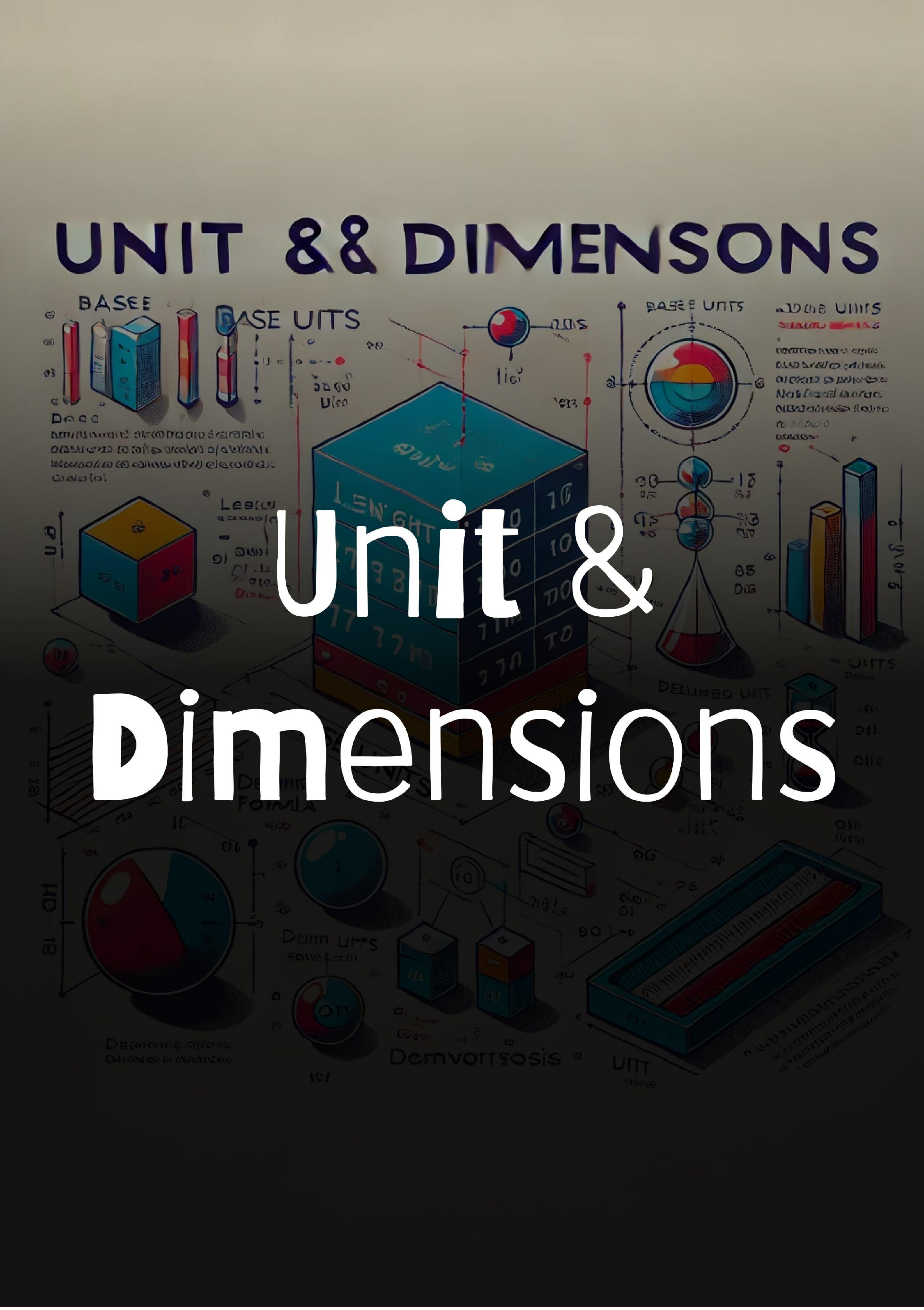


Unit & Dimensions

Units and Measurement

Physical Quantity :- A Quantity that can be measured is called as Physical Quantity

Ex- length, Mass, velocity, temperature, area, volume, density etc. are measurable quantities.

Non-Physical Quantity :- A Quantity that can not be measured is called as non-Physical Quantity.

Ex- Sound, light, goodness, love, hatred like etc

* Inertia is not a Physical Quantity.

* Inertia ∝ Mass → Inertia can be compare but can't be measured.

Fundamental Physical Quantities

↳ Group of physical Quantities which are independent from each other.

Mass → Kg
Length → m
Time → S
Temperature → K
Amount of Sub. → mol
Electric Current → Amp
Luminous intensity → Cad

Supplementary Physical Quantity

Angle (θ) → radian

- Have unit but does not have dimension.

Solid Angle(Ω) → steradian

* Derived Physical Quantities

Velocity $= \frac{\text{Length}}{\text{time}} = m/sec$

Acceleration $= \frac{\text{Velocity}}{\text{time}} = \frac{\text{length}}{(\text{time})^2} = m/s^2$

force $= ma = mv/t = ml/t^2 = kgm/s^2$

What is a Physical Quantity? (Fundamental)

→ A Physical Quantity which does not depend on any other physical quantity for its measurement is called a fundamental physical Quantity.

Fundamental Physical Quantity independent upon each other.

Fundamental Quantities

(A) can I assume velocity, Power and force is a group of fundamental Physical Quantity

Ans - $P = Fv$ होता है then No

(B) Mass / force / acc^n ⟶ No can't be consider as fundamental P.Q.

Velocity / Mass / Power → can be considered as Fundamental Quantity.

Que- Which of the following group of Physical Quantity can be considered as a group of Fundamental Physical Quantity.

[✓ (a) force / Mass / time] (b) Mass / Force / acceleration
(c) Velocity / momentum / mass (d) velo. / time / displacement

* Some Derived Quantities

Velocity (m/s) → Velocity = Displacement / time

Acceleration (m/s^2) → Acceleration = Velocity / time

Work (Kg-m^2/s^2) or joule → Work = force × Displacemen

Que- Acceleration is a derived Physical Quantity, Which depends on ____ fundamental quantitie

[✓ (a) 2] (b) 3 (c) 5 (d) zero

Que- charge is a ________ Quantity

(a) Fundamental [✓ (b) derived]
(c) Non-Physical (d) Supplementary Quanti

Measurable Quantity is Physical Quantity

Ex- mass, length, time, area, force, Pressure etc.

Measurement of a Physical Quantity = Magnitude × unit

Measurement = nu = constant

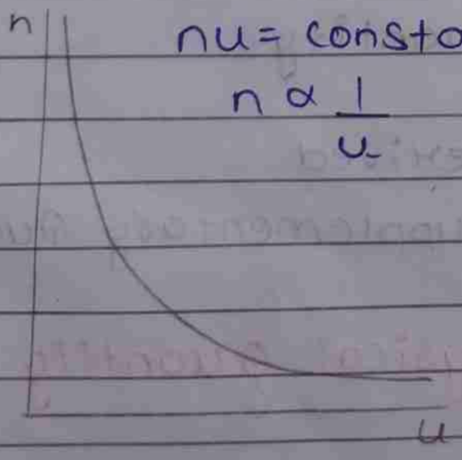
$l = 5 m = 500 cm$

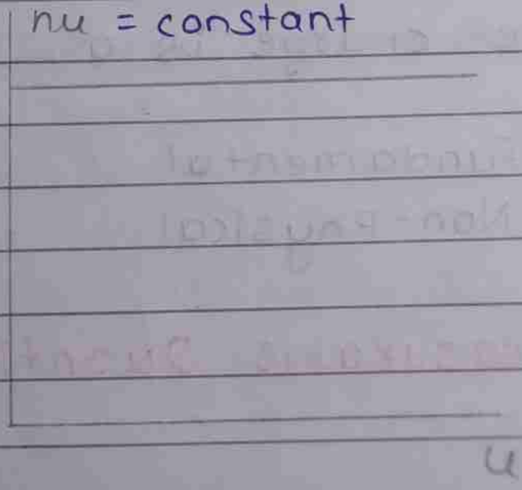
* Relation b/w Magnitude & unit of a Physical Quantity

→ The no. value obtained on measuring a Physical Quantity is inversely proportional to its unit

$\rightarrow nu = \text{constant}$
$\rightarrow n \propto 1/u$
$\rightarrow n_1 u_1 = n_2 u_2$

→ Where n_1 and n_2 are the numerical values of U_1 and U_2 are the units of same Physical Quantity in different systems.





Q- convert 50 m/s speed in c.G.s. Unit.

$$\text{speed} = 50\ m/s \qquad (nu = \text{constant})$$

$$n_1 u_1 = n_2 u_2$$
$$S.I \qquad C.G.S.$$

$$50\ m/\cancel{s} = n_2\ cm/\cancel{s}$$
$$50 \times 100\ \cancel{cm} = n_2\ \cancel{cm} \rightarrow n_2 = 5 \times 10^3$$

Que- convert 5 g/cm³ volume is M.K.S. Unit

$$\text{Density} = \frac{\text{Mass}}{\text{volume}} \qquad 5 = \frac{n_2 \times \cancel{10^3}}{\cancel{10^6}}$$

$$n_1 u_1 = n_2 u_2 \qquad n_2 = 5 \times 10^3$$

$$5 \times \frac{\text{gram}}{cm^3} = \frac{n_2\ kg}{m^3}$$

$$5\ \frac{\text{gram}}{\cancel{cm^3}} = \frac{n_2 \times 10^3\ \text{gram}}{(10^2\ \cancel{cm})^3}$$

Que- convert 1 newton into 1 Dyne

S.I unit - force ($1N = kg\,m/s^2$)

$$n_1 u_1 = n_2 u_2$$
$$1\,N = n_2\ \text{dyne}$$

$$1\ \frac{kg\,m}{\cancel{s^2}} = n_2\ \frac{\text{gram} \times cm}{\cancel{s^2}}$$

Energy - S.I → Joule

↓

$kg\,m^2/s^2$

$1\ \text{Joule} = 10^7\ \text{erg}$

$$1\times10^3\ \cancel{gram}\times10^2\ \cancel{cm} = n_2\ \cancel{gram}\times\cancel{cm}$$

$$n_2 = 10^5$$

Que- In new system of unit, unit of length is x cm then find value of 8 m³ volume in new system of unit.

Length = x m (new system of unit)

$$n_1u_1 = n_2u_2$$

$$8m^3 = n_2\ (xm)^3$$

$$8\ \cancel{m^3} = n_2\ x^3\ \cancel{m^3}$$

$$n_2 = (8/x^3)$$

Que- In new system of unit, unit of length is 10 cm, unit of time is 2 sec. unit of mass is 5 kg then Find value of 5 J energy in new system of unit

$$\underbrace{n_1u_1}_{S.I.} = \underbrace{n_2u_2}_{C.G.S}$$

$$\frac{5kg\ m^2}{s^2} = \frac{n_2\ kg'\ m'^2}{s'^2}$$

$$\frac{5kg\ m^2}{s^2} = \frac{n_2\times5kg\times(10\ cm)^2}{(2s)^2}$$

$$5m^2 = \frac{n_2\times5\times10^2\ cm^2}{4}$$

$$(10^2 cm)^2 = \frac{n_2\times10^2}{4}\ cm^2$$

$$10^4 = \frac{n^2\times10^2}{4}$$

$$n_2 = 4\times10^2 = 400$$

Que - In MR system of unit, unit of mass is 5kg unit of length is 2m and unit of time is 10se then find value 4N force in M.R. system of unit

force $\quad kg' = 5kg,\ m' = 2m,\ s' = 10s$

$n_1 u_1 = n_2 u_2$

$4N = n_2 u_2$ $\quad 4 \times 10\cancel{0} = 1\cancel{0} n_2$

$\frac{4 kg m}{s^2} = n_2 \frac{kg' m'}{s'^2}$ $\quad n_2 = 40$

$\frac{4 kg m}{s^2} = \frac{n_2 \times 5kg \times 2m}{(10s)^2}$

* Unit

→ Measurement of any Quantity involves comparison with a certain basic arbitarily chose internationally accepted reference standard called unit.

→ The units for the fundamental Quantities are called fundamental units.

→ The units of all other physical quantities can be expressed as combination of the fundamental units are called derived units

→ In some wrong ways units were considered where physical quantities used to be measured

→ Length was measured with the help of a hand

* characterstics of a Unit

→ The unit must be of suitable size and easily available.

→ A unit should be easily available and reproducible at any place required

→ The unit must be universally accepted.

→ A physical unit must be invariable and well defined

Que- Which of the Following is a characterstic of unit

(a) The unit must be universally accepted.
(b) It must be invariable and well defined.
(c) It must be of suitable size and easily available.
(d) All of above

* Symbol For Dimensions of Fundamental Quantities

Length : L
Mass : M
Time : T
Temperature : K or θ
Current : I or A

Luminous Intensity : Cd
Amount of substance : mol

* Measurements   Dimensional Formula

Dimensional formula of a Physical Quantity (P) is

$P = [M^x L^y T^z]$ Ex- Velocity - $\frac{\text{Length}}{\text{Time}} = \frac{L}{T}$

· Dimension of velocity is 1 in length and -1 in time   → $M^0 L^1 T^{-1}$

Where x, y and z are dimensions of fundamenta quantities M, L and T respectively.

1. Area = $l^2 = M^0 L^2 T^0 = L^2$.

2. volume = $4/3 \pi r 3 = L^3$

3. Velocity = LT^{-1}

4. Acceleration = $\frac{\text{Velocity}}{\text{Time}} = \frac{L^1 T^{-1}}{T}$ => LT^{-2}

5. Force = ma = MLT^{-2}

6. Energy = $ML^2 T-2$
(Work)

7. Power = $\frac{\text{Work}}{\text{Time}} = ML^2 T^{-3}$

Momentum - $P = mv = MLT^{-1}$ $\Big\}$ Same Dimension

Impulse - $I = \Delta P = MLT^{-1}$

Angular momentum - $L = rp = ML^2T^{-1}$

→ also called moment of force

Torque - $\tau = rF = ML^2T^{-2}$ (Energy, Work)

Angular displacement = $M^0L^0T^0$ (Dimension less)

Angular Velocity - $\omega = \frac{\theta}{T} = T^{-1}$ (Frequency)

Angular Acceleration - $\alpha = \frac{\omega}{T} = \frac{T^{-1}}{T} = T^{-2}$

Density - $\left(\frac{\text{Mass}}{\text{Volume}}\right) = ML^{-3}$

Moment of Inertia = ML^2

Linear Mass Density = $\frac{\text{Mass}}{\text{Length}} = M^1L^{-1}$ (Mass gradient)

Charge - I time - A^1T^1

Charge density - $\frac{Q}{\text{volume}} = \frac{A^1T^1}{L^3} = A^1L^{-3}T^1$

Linear charge density - $\frac{Q}{\text{Length}}$

Area charge density - $\frac{Q}{\text{Area}}$

* Physical Quantities having same dimensional formula

→ Distance, Displacement, radius, light year, wave length, radius of gyration, Focal length, parsec, astronomical unit - $[L]$

escape velocity, Drift velocity

→ speed, velocity, velocity of light, velocity of sound, terminal velocity, avg. velocity, orbital velocity - $[LT^{-1}$

→ Acceleration, Avg. Acceleration, acceleration due to gravity, intensity of gravitational field, centripetal acceleration $[LT^{-2}]$

→ Impulse, change in momentum $[MLT^{-1}]$

→ force, weight, Tension, Thrust, Gravitational force, spring force, Electrostatic force, Magnetic force, Normal reaction friction

Weight → $[M^1L^1T^{-2}]$

Ex - Determine the dimension of temperature gradient.

$$\text{Temperature Gradient} - \frac{\text{Temperature}}{\text{Distance}}$$

Temp. Gradient - K^1L^{-1}

Velocity Gradient - $\frac{V}{L} \Rightarrow \frac{LT^{-1}}{L} = T^{-1}$

↓

same as frequency

Gravitational Constant (G)

$$F = \frac{G m_1 m_2}{r^2}$$

$$G = \frac{Fr^2}{m^2} = \frac{MLT^{-2}L^2}{M^2}$$

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

force constant (spring constant)

$(F = Kx)$

$$K = \frac{F}{x} = \frac{MLT^{-2}}{L} = MT^{-2}$$

Que- The density of a material in CGS system of units is 4 $g cm^{-3}$. In a system of unit in which unit of length is 10 cm and unit of mass is 100 g, the value of density of material will be

(a) 0.04
(b) 0.4
[✓ (c) 40]
(d) 400

$n_1 u_1 = n_2 u_2$

density $= \frac{4g}{cm^3}$

$$\frac{4\cancel{g}}{\cancel{cm^3}} = n_2 \times \frac{100\cancel{g}}{10^3 \cancel{cm^3}}$$

$$n_2 = 40$$

Assertion- Work = Torque is dimensionally correct but not physically.

Reason- Dimensional correctness of an equation ensures its physical correctness

(A) A (B) B [✓ (c) C] (d) D

work $= MLT^{-2} \times L = ML^2T^{-2}$
Torque $= r \times F = ML^2T^{-2}$

* shake is a unit of time.
* sec. is a unit of time.

Assertion: Astronomical unit, light year and parsec measures distance.

Reason: Each has dimension of distance.

✓ (A) 2. (B) 3. (C) 4. (D)

Assertion: The unit vectors $\hat{i}, \hat{j}, \hat{k}$ have units of distance and dimensions $[M^0L^1T^0]$

Reason: The product of a scalar and a vector is a new scalar.

1. (A) 2. (B) 3. (C) 4. (D)

→ Unit vector does not have unit.
→ Have only direction and magnitude one.

* Thermal Conductivity

$$\frac{Heat}{t} = \frac{AK(\Delta T)}{l}$$

$$\frac{ML^2T^{-2}}{T} = \frac{L^2K\theta^1}{L^1}$$

$$ML^1T^{-3}\theta^{-1} = K$$

watt = $m^1 K^1$ kelvin

K = watt / m kelvin
↑
Unit of Thermal conductivity.

* Dimension of Electric resistance

$$H = I^2 R t$$

$$ML^2T^{-2} = A^2 R T^{-1}$$

$$R = ML^2T^{-3}A^{-2}$$

* Self - Induction

$E = \frac{1}{2} L I^2 \longrightarrow L = \frac{E}{I^2} = ML^2T^{-2}A^{-2}$

* Permeability

$f = \frac{\mu_0}{2\pi} \frac{I_1 I_2 d}{d} \rightarrow \mu_0 = \frac{F}{I^2} = MLT^{-2}A^{-2}$

* Plank's constant

$E = hf \rightarrow h = \frac{E}{f} = \frac{ML^2T^{-2}}{T^{-1}}$

$(f = 1/T)$

$\rightarrow h = ML^2T^{-1}$

Angular Momentum - $L = rP = L(MLT^{-1})$

$= ML^2T^{-1}$

Heat - ML^2T^{-2}

specific Heat capacity $\frac{dQ}{\Delta T M} = S = \frac{\cancel{M}L^2T^{-2}}{\theta \cancel{M}}$

$$S = L^2T^{-2}\theta^{-1}$$

Latent Heat (θ) = ML → $L = \frac{\theta}{M}$ = $\frac{ML^2T^{-2}}{M}$

$L = L^2T^{-2}$

Gas constant → $PV = nRT$ → $R = \frac{PV}{nT}$

→ $\frac{Energy}{n\,Tem} = \frac{ML^2T^{-2}}{mol\,K}$

$PV = \frac{F}{Area} \times Volume = Energy$

* Unit of Permitivity → $\varepsilon_0 / \varepsilon_m$

Unit = $\frac{C^2}{NM^2}$, $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$

$E_0 = \frac{q^2}{Fr^2} = \frac{A^2T^2}{MLT^{-2}L^2}$ → $E_0 = M^{-1}L^{-3}A^2T^4$

Relative Permitivity → $\varepsilon_r = \frac{\varepsilon_m}{\varepsilon_0}$ = Unit and Dimensionless

Dimension of stress

Energy density ; $\frac{1}{2}\varepsilon_0E^2$; $\frac{B^2}{2\mu_0}$; Young Modulus

; $\frac{1}{2}$ stress x strain ; Bulk Modulus; Shear Modulus ; Pressure

MON TUE WED THR FRI SAT SUN

Pressure $= \frac{\text{Force}}{\text{Area}} = \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$

↳ (stress)

Energy Density $= \frac{\text{Energy}}{\text{Volume}} = \frac{ML^2T^{-2}}{L^3} = ML^{-1}T^{-2}$

Stress $= Y$ strain

↑ Young Modulus

strain ↳ Dimensionless

Pressure = Stress = Energy Density

* The MR *

Resistance $= R = \omega L = \frac{1}{\omega C}$

$R = \frac{L}{T} = \frac{T}{C} \rightarrow \boxed{T = \frac{L}{R}}$

$R = \frac{L}{T}$	$R = \frac{T}{C}$	$\frac{L}{T} = \frac{T}{C}$
$T = \frac{L}{R}$	$T = RC$	$T^2 = LC$ $T = \sqrt{LC}$
$f = \frac{R}{L}$	$f = \frac{1}{RC}$	$f = \frac{1}{\sqrt{LC}}$

→ Magnetic field / Magnetic flux

$F = qVB$

$B = \frac{F}{qV} = \frac{MLT^{-2}}{LT^{-1}\,AT}$

$= MA^{-1}T^{-2}$

$F = BIL$

$B = \frac{F}{IL} = \frac{MLT^{-2}}{AL}$

$= MA^{-1}T^{-2}$

→ coefficient of Viscosity

$F = 6\pi \eta r V_T$ (stocks Law)

$\eta = \frac{F}{rV_T} = \frac{M\cancel{L}T^{-2}}{\cancel{L}\,LT^{-1}} = ML^{-1}T^{-1}$

→ capacitance

$U = \frac{q^2}{2C} \rightarrow C = \frac{q^2}{U} = \frac{A^2T^2}{ML^2T^{-2}} = M^{-1}L^{-2}T^4A^2$

→ Force

$F = Kx\,;\ qVB\,;\ qE\,;\ 6\pi\eta r V_T\,;\ \frac{Gm_1m_2}{r^2}\,;\ \frac{q^2}{4\pi\varepsilon_0 r^2}\,;\ \frac{\mu_0 I^2 d}{4\pi r}$

; (S = surface Tension) MN

Electric field

$F = qE \rightarrow E = \frac{F}{q} = \frac{MLT^{-2}}{AT} \rightarrow E = MLT^{-3}A^{-1}$

Energy (ML^2T^{-2})

Electric Dipole moment

Magnetic Dipole Moment

Torque; $\vec{P}\cdot\vec{E}$; $\vec{M}\cdot\vec{B}$; $\frac{1}{2}LI^2$; $\frac{1}{2}CV^2$; VIt; I^2Rt;

$\frac{1}{2}kx^2$; Vq; mV (gravitational potential)

Electric Potential	Energy = $\left(\frac{1}{2}\times \text{stress}\times \text{strain}\times \text{volume}\right.$

→ Angular momentum and Plank's constant have same dimensional formula $[ML^2T^{-1}]$

→ Electric field and Potential gradient have same dimensional formula $[MLT^{-3}A^{-1}]$

→ surface Tension, Surface energy, force gradient, and spring constant have same dimensional formula $[ML^0T^{-2}]$

→ Acceleration and Gravitational field intensity have same dimensional formula $[M^0LT^{-2}]$

* Dimension Less Physical Quantity

Angle / solid Angle / strain = $\Delta l / l$

→ Poisson's ratio, refractive index, coefficient of friction, Distance gradient

→ Trigonometry formula/ exponential functions, relative permittivity, efficiency, ratio, pure no. specific gravity (Relative density)

→ current gain / Power gain, magnification, magnetic suspceptibility

Que- The pair of quantities having same dimension is

(a) Impulse and surface Tension
(b) Angular momentum and work
[✓ (c)] Work and Torque
(d) Young's modulus and Energy

Que- If the dimensions of a physical Quantity are given by $M^a L^b T^c$, then the physical Quantity will be

(a) velocity if $a=1, b=0, c=-1$
(b) acceleration if $a=1, b=0, c=-2$
(c) force if $a=0, b=-1, c=-2$
[✓ (d)] Pressure if $a=1, b=-1, c=-2$

Que- Which two of the following five physical parameters have the same dimensions?

1. Energy density
2. refractive index
3. Dielectric constant
4. Young modulus
5. Magnetic field

[✓ (a) 1 and 4] (b) 1 and 5 (c) 2 and 4 (d) 3 and 5

Que- which pair do not have equal dimensions?

(a) Energy and Torque
[✓ (b) Force and impulse]
(c) Angular momentum and Planck's constant
(d) Elastic modulus and pressure

Que- which of the following is a dimensional constant?

(a) Relative density [✓ (b) Gravitational constant]
(c) Refractive index (d) Poisson's Ratio

Assertion: The dimensional formula for product of resistance and conductane is same as for dielectric constant.

Reason: Both have dimensions of time constant

1. (A) 2. (B) [✓ 3. (C)] 4. (D)

A physical Quantity does not have dimension then that physical Quantity must be unitless

→ wrong

Ex- Angle, Solid Angle Dimensionless but have unit

A physical Quantity have unit then may have dimension

→ True

Que-Assertion - The dimensional formula for product of resistance and conductance is same as for dielectric constant.

Reason: Both have dimensions of time constant

1. (A) 2. (B) 3. (C) 4. (D)

Plane and solid Angle

→ Have unit but dimensionless.

Dimension :-	May or May not have Dimension.	Must be Dimension-Less	A P.Q. does not have dimension	A P.Q. have dimension
Unit	A P.Q. have unit	A P.Q does not have unit.	May or May not have unit	Must have unit.

$C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ $\sqrt{\mu_0 \varepsilon_0} = (\mu_0 \varepsilon_0)^{1/2} = \frac{1}{c} = L^{-1}T^{1}$

* Principle of Homogenity

Physical Quantity of same Dimension can be equate, added and subtract

Que- If Velocity $V = \alpha t + \beta x - \gamma x t$, then find dimension of α, β and γ

$$V = \alpha t + \beta x - \gamma x t$$

$$V = \alpha t = \beta x = \gamma x t$$

$V = \alpha t$	$V = \beta x$	$V = \gamma x t$
$\alpha = \frac{V}{t} = LT^{-2}$	$\beta = \frac{V}{x} = \frac{\cancel{L}T^{-1}}{\cancel{L}} = T^{-1}$	$\gamma = \frac{V}{xt} = \frac{LT^{-1}}{LT} = T^{-2}$

Que- If A and B have different physical Quantity, then which is correct

(a) $A+B$ [✓ (b)] A/B (c) $A-B$ (d) $A/A+B$

Que- The velocity v of a particle at time t is given by $v = at + \frac{b}{t+c}$, where a, b and c are constants. The dimensions of a, b and c are

(a) $[L]$, $[LT]$ and $[LT^{-2}]$ [✓ (b)] $[LT^{-2}]$, $[L]$ and $[T]$
(c) $[L^2]$, $[T]$ and $[LT^{-2}]$ (d) $[LT^{-2}]$, $[LT]$ and $[L]$

#

$K.E. = \frac{1}{2} mv$ → Dimensionally wrong
→ Physically wrong

$K.E. = \frac{3}{2} mv^2$ → Dimensionally correct
→ Physically wrong

$K.E. = \frac{1}{2} mv^2$ → Dimensionally correct
→ Physically correct

#

$S = ut + \frac{1}{2} at^2$ → Dimensionally wrong
→ Physically wrong

$S = ut + \frac{3}{2} at^2$ → Dimensionally correct
→ Physically wrong

Torque = 3 work → Dimensionally correct
Physically correct

Physical Equation	Must be physically wrong	May or May not be Phy. correct	Eqn is Phy. wrong then?	Eqn is Physically correct then?
Dimension	Eqn is dimensionally wrong?	Eqn is dimensionally correct then physically?	Dimensionally may be correct	Dimensionally must be correct

$S_{nth} = u + \frac{a}{2}(2n-1)$

Dimensionally correct

Que - The time dependence of a Physical Quantity P is given by $P = P_0 \exp(-at^2)$, where a is a constant and t is the time. The constant a

a) is dimensionless   [✓ b)] has dim^n $[T^{-2}]$
c) has dim^n $[T^2]$ d) has dim^n of P

Que - If A and B are different Physical Quantity having diff. dim^n then mark incorrect option

[✓ a)] $A + B$ c) $A - B^2$
b) A / B d) $AB + A$

Que - Different Physical Quantity can have same dim^n ?

→ yes   Ex- work $= \vec{F} \cdot \vec{s}$; Torque $= \vec{r} \times \vec{F}$
Energy $= 1/2\, mv^2$

Que - Two Quantity have different dimension, Can't be same Physical Quantities?

→ NO

Physical Quantity

1. Dimensionless constant → π, ε_r (for a medium)

2. Dimensional constant → G, ε_0 (air)

3. Dimensionless variable → coefficient of variation
Angle

4. Dimensional variable → velocity, time, length

Que- which of the following is a dimensional constant

(a) Relative density [✓ (b)] Gravitational constant
(c) Refractive index (d) Poisson's ratio

Que- on the basis of dimⁿ, decide which of the following relation for dispm of a particle is correct.

a) $y = a \sin(2\pi t/T)$ b) $y = a \sin(vt/\lambda)$
c) $y = \sqrt{2} a \sin(2\pi t/T) \cos(2\pi x/\lambda)$ [✓ d)] $y = x/t \sin(\lambda t)$

Que- If force $f = A\sqrt{x} + Bt$, then find dimⁿ of A and B

$$F = A\sqrt{x} = Bt$$

$$\frac{F}{\sqrt{x}} = A$$

$$A = \frac{MLT^{-2}}{L^{1/2}}$$

$$A = ML^{1/2}T^{-2}$$

$$F = Bt$$

$$B = \frac{F}{T} = \frac{MLT^{-2}}{T}$$

$$= MLT^{-3}$$

Que- velocity $v = \frac{\alpha}{\beta} e^{-\alpha t}$, then find dimⁿ of α and β

$$V = \frac{\alpha}{\beta} e^{-\alpha t}$$

For dimension of β

$V = \frac{\alpha}{\beta}$

$\beta = \frac{\alpha}{V} = \frac{T^{-1}}{LT^{-1}} = L^{-1}$

$\alpha t = 1$

$\alpha = \frac{1}{t} = T^{-1}$

Que - Velocity $V = \frac{\alpha}{\beta + \sqrt{density}}$, find dim^n of α and β

$V = \frac{\alpha}{\beta + \sqrt{\rho}}$

$V = \frac{\alpha}{\sqrt{\rho}}$

$\alpha = V\sqrt{\rho}$
$= LT^{-1} M^{1/2} L^{-3/2}$
$= M^{1/2} L^{-1/2} T^{-1}$

density $= \rho = \frac{M}{V}$
$= ML^{-3}$

$\beta = \sqrt{\rho}$

$\beta = (ML^{-3})^{1/2}$

$\beta = M^{1/2} L^{-3/2}$

Que- $\int \frac{dx}{\sqrt{2ax - x^2}} = b$, Find dim^n of a and b if x are distance

$2ax = x^2$
$ax = x^2$
$a = x = L^1$

$\frac{x}{\sqrt{x^2}} = b$

$\frac{x}{x} = b$

$M^0 L^0 T^0 = b$

Que- $(at-x)^2 \times C = D$; Find dimn of 'a' ?

$$at = x$$

$$a = \frac{x}{t} = LT^{-1}$$

Que- If y = Force and x = Velocity then find dimensio of dy/dx

$$\frac{dy}{dx} = \frac{y}{x} = \frac{MLT^{-2}}{LT^{-1}} \Rightarrow MT^{-1}$$

Que- If force on object is directly proportional to square of velocity then find dimension of proportional constant.

$$F \propto V^2 \rightarrow F = \beta V^2$$

$$\beta = \frac{F}{V^2} \Rightarrow \frac{MLT^{-2}}{L^2T^{-2}} \Rightarrow ML^{-1}$$

Application of Dimensional Analysis

1. If time period of simple pendulum depends on length of pendulum and accn due to gravity then derive formula of time in terms of l and g using dimensional analysis

$T \propto l^a$ $T \propto g^b$ $T = l^a g^b$ $T = l^{1/2} g^{-1/2} \Rightarrow \sqrt{\frac{l}{g}}$	$T = L^a (LT^{-2})^b$ $T = L^a L^b T^{-2b}$ $M^0L^0T^0 = L^{a+b}T^{-2b}$	$a+b=0$ $a = -b$ — (i) $-2b = 1$ $b = -1/2$ $a = \frac{1}{2}$

2. If length & acc^n taken as fundamental physical quantity then express dimension of time in terms of them.

$T = l^a g^b \rightarrow M^0 L^0 T^1 = L^a (LT^{-2})^b$

$a = \frac{1}{2}, \; b = \frac{-1}{2}$

$T = l^{1/2} g^{-1/2}$

3. In new system of unit of length is 2m and unit of acc^n is $8 \, m/s^2$ then find unit of time in new system.

$l' = 2m$ $\rightarrow T = l^a g^b$

$g = 8 \, m/s^2$ $\quad T = \sqrt{\frac{l}{g}} \rightarrow T = \sqrt{\frac{2}{8}}$

~~Dim~~n

$nu =$ constant

(Not applicable)

$= \sqrt{\frac{1}{4}} \Rightarrow \frac{1}{2}$ sec

Que - If Force (F), acc^n (a) and time (t) is used as fundamental physical quantities, then find dim^n of length in terms of them

a) $F^0 a^1 T^2$
b) $F a^2 T^2$
c) $F a^2 T^0$
d) $F^0 a^1 T$

$l = F^x a^y t^z = f^0 a^1 t^2$

$M^0 L^1 T^0 = (MLT^{-2})^x (LT^{-2})^y T^z$

$M^0 L^1 T^0 = M^x L^{x+y} T^{-2x-2y+z}$

$x = 0 - (i)$

$x + y = 1$
$y = 1$

$-2x - 2y + z = 0$
$-2 + 2 = 0$
$z = 2$

MR*

$l = L^1 = F \overset{LT^{-2}}{\overset{\uparrow}{a}} \overset{T^2}{\overset{\nearrow}{t}}$

Que- If dimensions of critical velocity V_c of a liquid flowing through a tube are expressed as $(\eta^x \rho^y r^z)$ where η, ρ, r are the coefficient of viscosity of liquid, density of liquid and radius of the tube respectively, then the value of x, y and z are given by

a) 1, 1, 1
~~b)~~ 1, -1, -1
c) -1, -1, 1
d) -1, -1, -1

$$V_c = \eta^x \rho^y r^z$$

$$M^0 L T^{-1} = (ML^{-1}T^{-1})^x (ML^{-3})^y L^z$$

Que- If force depends on normal reaction and coefficient of friction then derive relation using dimensional analysis

$F = N^a \mu^b$ (Not possible)

$a = 1, b = 0$ wrong

$F = \mu N$ correct

Que- If time of simple pendulum depends on l, g and 2π then find T in terms of them

$T = 2\pi\sqrt{\frac{l}{g}}$ Dimensionless constant can't be derive

Que- If force, velocity, time and energy taken as fundamental physical quantities then find dimension of power

$l = F^x V^y T^z p^t$

$$M^0 L^1 T^0 = (MLT^{-2})^x (LT^{-1})^y (T^z)(ML^2T^{-3})^t$$

$x + t = 0$ | $x + y + 2t = 1$ | $-2x - y + z - 3t = 0$

Not possible to find

Limitation of Dimensional Analysis

1. It is not use to derive dimensionless Proportional Constant.
2. It cannot derive dimensionless function like $\sin\theta$, $\cos\theta$, $\tan\theta$, e^x etc.
3. If physical quantity depends upon two physical Quantities Of Same dimension.
4. It can not derive formula which have '+' and '-' term.

$$Ex: S = ut + \frac{1}{2}at^2$$

5. We equate the power of M, L and T. So, it only work when quantity depends only on three Physical Quantity.

Ex- If force depends upon energy, velocity, time, work, then can't be derive any other Physical Quantity.

Que- Which of the following equation can be derived dimensionally.

a) $S = Vt - \frac{1}{2}at^2$ b) $V^2 = u^2 - 2as$

c) $h = \frac{\omega^2 r^2}{2g}$ d) $v = \frac{d}{t}$

Que- which of the following equation Can be derived dimensionally

Date: __/__/__

MON TUE WED THR FRI SAT SUN

(a) $F = 6\pi \gamma n$

(b) $\theta = \omega t$

(c) $\frac{d\theta}{dt} = \rho A V$

(d) $P = \rho g h$

True / false

1. Dimensionally correct ean must be physically correct - False.
2. Dimensionally incorrect must be Physically correct - False
3. Physically incorrect equation may be dimensionally correct - True
4. Physically correct may be dimensionally correct - False

Significant Figures (DIGITS)

→ All the certain digits and the one uncertain digit are called the significant digits

Ex: 2404 → significant figure = 4

Significant figure indicate precision in the measurement.

→ choice of change in different unit does not effect the significant digit.

Rules to find Significant digit:

1. All Non-zero are significant
2. All zero b/w non-zero are significant.
3. The trailing zero without decimal point is insignificant.
4. After decimal place, all zero are significant
5. If no. is less than one, the zero on the left of the 1st non-zero digit are insignificant.

Ex - 0.004870

S.F = 4

6. The exact numbers are infinite significant digit.

Ex - Two phone | 25 pen | 35 student

Que - No. of S.F. in 3.04×10^{23} is

Ans - 3

Que - No. of S.F. in 0.01020 is

Ans - 4

Que - No. of S.F in (i) 0.03800
(ii) 90.00

(i) 4
(ii) 4

Que - Given P = 0.0030 m, Q = 2.40 m and R = 3000 m the number of significant figures in P, Q, R respecti

(a) 1, 2, 1 [✓ (b) 2, 3, 1]
(c) 4, 2, 1 (d) 4, 2, 4

Addition or Subtraction → Don't count S.F.

- Final result is written in minimum decimal places

A = 5.2 m → A + B = 5.2 + 7.21
B = 7.21 m = 12.41 m (wrong) = 12.4 (correct)

Multiplication or Division

- Final result is written in minimum significant figures

A = 15.5 m → $\frac{A}{B} = \frac{15.5}{5}$ = 3.1 m (wrong) = 3 m (correct)
B = 5 m

Que- Add these three length

$l_1 = 0.307 m$, $l_2 = 0.52 m$, $l_3 = 0.4 m$

(a) 1.22 m [✓ (b) 1.2 m] (c) 1.3 m (d) 1.7 m

Que- No. of significant digit in the result of $\frac{4.327 m}{2.51}$

(a) 2 (b) 4 [✓ (c) 3] (d) 5

Que- Taking into account of the significant figures, what is the value of 9·99m - 0·0099 m

(a) 9·9801 m
[✓ (b) 9·98m]
(c) 9·980 m
(d) 9·9 m

Que- The area of rectangle of length 55·3 m and breadth 25m

(a) 1382
(b) 1382·5
[✓ (c) 14×10^2]
(d) 138×10^1

Rounding off

1. If digit to be removed is less than 5 then there is no change in primary no.

2. If digit is to be removed is greater than 5 then previous number increases by 1.

3. If digit is 5, then previous number remains same if even and increase by 1 then if odd

①	②	③	④
2·36$\underline{3}$m	2·36$\underline{8}$ m	2·37$\underline{5}$ m	2·36$\underline{5}$m
2·36m	2·37 m	2·38 m	2·36 m

Que- Find round off value of $x = 16·351$

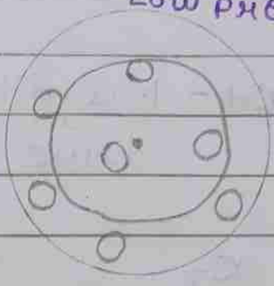
(a) 16
(b) 16·33
(c) 16·3
[✓ (d) 16·4]

Que- Find round off value of $x = 3.250$ upto 2 digit

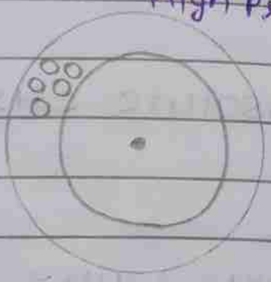
✓(a) 3.2 (b) 3.25 (c) 3.5 (d) 3

Accuracy - It is the measure of how close the measured value is to the true value

Low acc. Low pre.

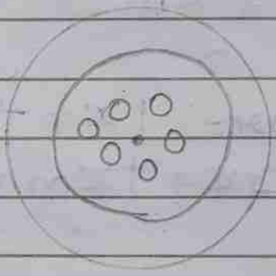


Low acc. High pre.

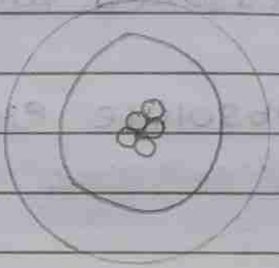


closeness of true and measured value is accuracy

Precision - It tells us to what resolution or limit the quantity is measured



High acc. Low pre.



High acc. High pre.

Que- If true value of length is 6.57 m then which of the following reading is most accurate and most precise

(a) 6.52 m (b) 6.61 m (c) 6.513 m (d) 6.68 m

most accurate - (b)
most precise - (c)

Que- Which of the following reading is most accurate ??

(a) 2.4m (b) 2.41 m (c) 2m (d) 2.413 m

If true value is not given then most Precision is most accurate

Absolute Error - Magnitude of difference between true value and measured value.

True value = x_T
Measured value = x_m

Absolute error = $|x_T - x_m|$
$\Delta x = |x_m - x_T|$

- → Absolute error cannot tell about accuracy of measurement.
- → Always positive
- → Unit same as Physical Quantity (Jiska error Calculate kia hai)

- → Least count of Instrument can be taken as absolute error.

$l = 7\ mm \rightarrow \Delta l = 1 mm$

$l = 4.3\ mm \rightarrow \Delta l = 0.1 mm$

$l = 3.67\ mm \rightarrow \Delta l = 0.01 mm$

$mass = 4.87\ kg \rightarrow \Delta l = 0.01 kg$

$l = 3.478\ cm \rightarrow \Delta l = 0.001\ cm$

Relative Error - Tell us accuracy of measurement.

Relative error = $\left[\frac{\Delta x}{x_T}\right]$

Unitless
and Dimensionless

Percentage Error

percentage error = $\left(\frac{\Delta x}{x_T}\right) \times 100$

Example

Absolut error	Absolut error
$(\Delta x) = 2\,cm$	$\Delta x = 1\,km$
$x_T = 5\,cm$	$x_T = 6400\,km$
Relative error $= \frac{\Delta x}{x_T} = \frac{2\cancel{cm}}{5\cancel{cm}}$	Relative error $= \frac{\Delta x}{x_T} = \frac{1\,\cancel{km}}{6400\,\cancel{km}}$
Percentage error $= \frac{2}{5} \times 100$	Percentage error $= \frac{1\,\cancel{km}}{6400\,\cancel{km}} \times 100$
$= 40\,\%$	$= 1/64\,\% \Rightarrow 0.015\%$

Que - If measured length of rod are 4.42 m, 4.43 m, 4.44 m, 4.45 m, 4.46 m, then find

(i) True length of rod

(ii) Absolute error

(iii) %age error

$$l_T = \frac{4.42m + 4.43m + 4.44m + 4.45m + 4.46m}{5}$$

$$l_T = 4.44\ m$$

$$\Delta l_1 = |l_T - l_m| = |4.44 - 4.42|$$

$$\Delta l_{mean} = \frac{0.02 + 0.01 + 0.02 + 0.01}{5}$$

$$\Delta l_{mean} = \frac{0.06}{5}$$

$\Delta l_1 = 0.02$
$\Delta l_2 = 0.01$
$\Delta l_3 = 0$
$\Delta l_4 = 0.01$
$\Delta l_5 = 0.02$

Percentage error $= \frac{\Delta l}{l} \times 100 = \frac{0.06}{5 \times 4.44} \times 100 = 0.27\%$

Que - If absolute error and actual value of a number are 5, 15 respectively then relative error is

a) [✓ 1/3]
b) 3/2
c) 3
d) 100/3

Relative error $= \frac{\Delta l}{l}$

$$= \frac{5}{15} = \frac{1}{3}$$

Error → Difference b/w True & measured value

↓

Differentiation (if difference is very small)

$y = A + B$

$$\frac{dy}{dt} = \frac{dA}{dt} + \frac{dB}{dt}$$

$dy = dA + dB$

$y = A + B$

$\boxed{\Delta y} = \Delta A + \Delta B$

↳ maxm permisible absolute error

Error Propogation in Mathematical Formula

Two Physical Quantity having True value A and B or Absolute error in A and B are ΔA and ΔB

$y=A+B$	$y=A-B$	$y=AB$	$\left(\frac{\Delta y}{y}\right)=\left(\frac{\Delta A}{A}\right)+\left(\frac{\Delta B}{B}\right)$
$Y_T = A+B$	$\Delta Y=\Delta A+\Delta B$	Diffⁿ of Y w.r.t 't'	
$\Delta y=\Delta A+\Delta B$	Relative error in y	$\frac{dy}{dt}=\frac{dA}{dt}B+A\frac{dB}{dt}$	$\Delta y=y\left(\frac{\Delta A}{A}+\frac{\Delta B}{B}\right)$
Relative error in y		$\Delta y=\Delta AB+A\Delta B$	$y=\frac{A}{B}$ (MR*)
$\frac{\Delta y}{y}=\frac{(\Delta A+\Delta B)}{(A+B)}$	$\frac{\Delta y}{y}=\frac{\Delta A+\Delta B}{A\pm B}$	divide by y both side	$\frac{dy}{dt}=\frac{B\frac{dA}{dt}+A\frac{dB}{dt}}{B^2}$
% error $=\frac{\Delta y}{y}\times 100$	$\frac{\Delta y}{y}\times 100=\frac{\Delta A+\Delta B}{A-B}\times 100$	$\frac{\Delta y}{y}=\frac{\Delta A\cancel{B}}{A\cancel{B}}+\frac{\Delta B\cancel{A}}{\cancel{A}B}$	$dy=\frac{dA}{B}+\frac{A\,dB}{B^2}$
(MR*)			divided by y both side
$y=A+B$	$y=A-B$	$y=A\cdot B$	$\frac{dy}{y}=\frac{dA}{\frac{A\times\cancel{B}}{\cancel{B}}}+\frac{A}{\cancel{B^2}}\cdot\frac{dB}{\frac{A}{\cancel{B}}}$
$\Delta y=\Delta A+\Delta B$	$\Delta Y=\Delta A+\Delta B$	$\frac{\Delta y}{y}=\frac{\Delta A}{A}+\frac{\Delta B}{B}$	
$\frac{\Delta y}{y}=\frac{\Delta A+\Delta B}{A+B}$	$\frac{\Delta y}{y}=\frac{\Delta A+\Delta B}{A-B}$	$\Delta y=y\left(\frac{\Delta A}{A}+\frac{\Delta B}{B}\right)$	$\frac{dy}{y}=\frac{dA}{A}+\frac{dB}{B}$

If constant is multiplied with the function

$Y = 4A$	$Y = A^n$
Diffn of y w.r.t 'time'	Diffn of y w.r.t 'A'
$\frac{dy}{dt} = 4\frac{dA}{dt}$	$\frac{dy}{dA} = \frac{dA^n}{dA}$
	$\frac{dy}{dA} = nA^{n-1}$
$dy = 4dA$	
Divided by y both side	$\frac{dy}{y} = \frac{nA^{n-1}dA}{A^n} = \frac{ndA}{A^{n-n+1}}$
$\frac{dy}{y} = \frac{\cancel{4}dA}{\cancel{4}A} \rightarrow \frac{dy}{y} = \frac{dA}{A}$	$\frac{dy}{y} = n\frac{dA}{A}$

Que- If $l_1 = (10 \pm 2)$ cm and $l_2 = (20 \pm 1)$ cm
Find $l = l_1 + l_2$ with error

$l_1 = 10 \qquad \Delta l_1 = 2$

$l_2 = 20 \qquad \Delta l_2 = 1$

Result $= (\underset{\text{True Value}}{x_T} \pm \underset{\text{Absolute Value}}{\Delta x})$

$l = l_1 + l_2 \qquad \Delta l = \Delta l_1 + \Delta l_2$

$l = 20 + 10 \qquad = 2 + 1$

$= 30 \qquad = 3$

$l = (30 \pm 3)$ cm

$\rightarrow$ % error $= \frac{\Delta l}{l} \times 100$

$= \frac{3}{30} \times 100 \Rightarrow 10\%$

Que- Value of $A = (10 \pm 0.1)m$ and $B = (20 \pm 0.5)m$ then Find

(i) $x = B + A$ (ii) $y = B - A$

(iii) $z = B \cdot A$ (iv) $m = B/A$

(i) $x = B + A$

$x = 20 + 10 = 30$

$\Delta x = \Delta B + \Delta A$

$= 0.5 + 0.1$

$\Delta x = 0.6$

$\frac{\Delta x}{x} = \frac{0.6}{30}$

(ii) $y = B - A$

$y = 20 - 10 = 10$

$\Delta y = \Delta A + \Delta B$

$= 0.1 + 0.5 = 0.6$

$\frac{\Delta y}{y} = \frac{0.6}{10}$

(iii) $Z = B \cdot A$

$\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$

$= \frac{0.1}{10} + \frac{0.5}{20}$

$\frac{0.2 + 0.5}{20}$

$\left[\frac{\Delta Z}{Z} = \frac{0.7}{20} = \frac{7}{200}\right]$

$100 \times \frac{\Delta Z}{Z} = \frac{7}{200} \times 100$

$= 3.5\%$

(iv) $m = B/A$

$m = 20/10 = 2$

$\frac{\Delta m}{m} = \frac{\Delta B}{B} + \frac{\Delta A}{A}$

$\frac{\Delta m}{m} = \frac{0.5}{20} + \frac{0.1}{10}$

$\frac{\Delta m}{m} = \frac{0.7}{20}$

$\frac{\Delta m}{m} \times 100 = \frac{0.7}{20} \times 100 = 3.5\%$

$\Delta m = m\left(\frac{0.7}{20}\right) =$

$= \frac{2 \times 0.7}{20} \rightarrow \Delta m = 0.07$

Que- If the error in the measurement of radius of a sphere is 2% then the error in the determination of volume of sphere will be

a) 2% $\quad V = \frac{4}{3}\pi r 3 \rightarrow 100 \times \frac{dV}{V} = 3\left[\frac{\Delta r}{r} \times 100\right]$

b) 4%

[✓ c) 6%] $\quad = 3 \times 2$

d) 8% $\quad = 6\%$

Que- The radius of a sphere is (5.3 ± 0.1) cm. The percentage error in its volume is

a) $\frac{0.1}{5.3} \times 100$ $\quad V = \frac{4}{3}\pi r 3$

[✓ b) $3 \times \frac{0.1}{5.3} \times 100$] $\quad 100 \times \frac{dV}{V} = \frac{3\Delta r}{r} \times 100$

c) $\frac{3}{2} \times \frac{0.1}{5.3} \times 100$ $\quad = 3 \times \frac{0.1}{5.3} \times 100$

d) $6 \times \frac{0.1}{0.3} \times 100$

Que- A force F is applied on a square area of side L. If the percentage error in the measurement of L is 2% and that in F is 4%. What is the maximum percentage error in pressure?

$P = F/A$

a) 2% $\quad P = F/l^2$

b) 4% $\quad \frac{\Delta P}{P} = \frac{\Delta F}{F} + 2\frac{\Delta l}{l}$

c) 6%

[✓ d) 8%] $\quad = 4 + 2 \times 2$

$= 8\%$

Que- A rectangular Plate has length (2 + 0·02) cm and width (1 ± 0·01) cm. The maximum percentage error in the measurement of its area is

a) 1%.
[✓ b) 2%.]
c) 3%.
d) 5%.

Area = length × breadth

$$100 \times \frac{\Delta A}{A} = \left(\frac{\Delta l}{l} + \frac{\Delta b}{b}\right) \times 100$$

$$= \left(\frac{0.02}{2} + \frac{0.01}{1}\right)100$$

$$= (0.01 + 0.01) \times 100$$

$$= 0.02 \times 100 = 2\%$$

Que- $y = \sin\theta$; where percentage error in angle is 2% then find percentage error in y at $\theta = 30°$

$y = \sin\theta$

diffn of 'y' w.r.t θ

$$\frac{dy}{d\theta} = \cos\theta$$

$$dy = \cos\theta \, d\theta$$

dividing by y both side

$$\frac{dy}{y} = \frac{\cos\theta \, d\theta}{\sin\theta}$$

$$100 \times \frac{\Delta y}{y} = \cot\theta \, d\theta \times 100$$

$$= \cot\theta \times 2\theta$$

$$\frac{\Delta\theta}{\theta} \times 100 = 2$$

$$\theta = 30° = \pi/6$$

$$\cot 30° \times 2 \times \frac{\pi}{6}$$

$$= \frac{\sqrt{3}\pi}{3}$$

$$= \frac{\pi}{\sqrt{3}}$$

Que- If $A = (6 \pm 1)$ and $B = (4 \pm 2)\,m$ then find $Z = 2A + B$ with absolute error (MR Problem)

$A = (6 \pm 1)\,m$

$B = (4 \pm 2)\,m$

$\boxed{Z = 2A + B}$

$Z = 2 \times 6 + 4$

$Z = 16$

Absolute Error

$$\Delta Z = 2\Delta A + \Delta B$$
$$= 2 \times 1 + 2$$
$$= 2 + 2$$
$$= 4$$

$$\Delta Z = (16 \pm 4)\,m$$

$$\rightarrow \frac{\Delta Z}{Z} = \frac{4}{16} \Rightarrow \frac{1}{4}$$

Que- Find Absolute error in Z

$$Z = \frac{4A^{1/2}\sqrt{B}}{C^{1/3}D}$$

$$\left(\frac{\Delta Z}{Z}\right) = \left(\frac{1}{2}\frac{\Delta A}{A} + \frac{1}{2}\frac{\Delta B}{B} + \frac{1}{3}\frac{\Delta C}{C} + \frac{\Delta D}{D}\right)$$

$$\Delta Z = Z\left(\frac{1}{2}\frac{\Delta A}{A} + \frac{1}{2}\frac{\Delta B}{B} + \frac{1}{3}\frac{\Delta C}{C} + \frac{\Delta D}{D}\right)$$

Que- If $y = \frac{A}{A+B}$ then find % error in y if

$A = (10 \pm 2)\,m$ and $B = (20 \pm 1)\,m$

$$y = \frac{A}{A+B}$$

$$y = \frac{A}{Z}$$

$$Z = A + B$$
$$= 10 + 20 = 30$$

$$\Delta Z = \Delta A + \Delta B$$
$$\Delta Z = 2 + 1$$
$$= 3$$

$$\frac{\Delta y}{y} = \frac{\Delta A}{A} + \frac{\Delta Z}{Z}$$

$$100 \times \frac{\Delta y}{y} = \frac{\Delta A}{A} \times 100 + \frac{\Delta Z}{Z} \times 100$$

$$\frac{2}{10} \times 100 + \frac{3}{30} \times 100$$

$$= 30\ \%$$

Que - Two resistance R_1 and R_2 connected in series and Parallel combination then percentage error in both combination.

Series combination

$$R_{eq} = R_1 + R_2$$

$$\Delta R_{eq} = \Delta R_1 + \Delta R_2$$

$$\frac{\Delta R_{eq}}{R_{eq}} = \frac{\Delta R_1 + \Delta R_2}{R_1 + R_2}$$

Parallel combination

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

diffn w.r.t 't'

$$\frac{+1}{R_{eq}^2} \frac{dR_{eq}}{dt} = \frac{+1}{R_1^2} \frac{dR_1}{dt} + \frac{+1}{R_2^2} \frac{dR_2}{dt}$$

$$\frac{dR_{eq}}{R_{eq}^2} = \frac{dR_1}{R_1^2} + \frac{dR_2}{R_2^2}$$

$$\Delta R_{eq} = R_{eq}^2 \left(\frac{dR_1}{R_1^2} + \frac{dR_2}{R_2^2} \right)$$

Que - Two resistance $R_1 = (20\Omega + 2\Omega)$ and $R_2 = (5 \pm 1\Omega)$ are connected in parallel then find %age and absolute error in Req

$$\frac{1}{Req} = \frac{1}{R_1} + \frac{1}{R_2} \rightarrow \frac{1}{20} + \frac{1}{5} = \frac{1+4}{20} = \frac{5}{20} =$$

$$Req = 4\,\Omega$$

$$\frac{\Delta Req}{Req^2} = \frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2} \rightarrow \Delta Req = 16\left(\frac{2}{400} + \frac{1}{25}\right)$$

$$= 16\left[\frac{2+16}{400}\right)$$

$$\Delta Req = \frac{16\times 18}{400}$$

$$100\times\frac{\Delta Req}{Req} = 4\left(\frac{2}{400} + \frac{1}{25}\right)\times 100$$

$$= 4\left(\frac{2\times 100}{400} + \frac{100}{25}\right)$$

$$= 4\left(\frac{1}{2} + 4\right)$$

$$= 4\left(\frac{9}{2}\right)$$

$$= 18\,\%.$$

Que- If mass of object is measured 5.4 gram then Find % error in the measurement of mass.

$M_{measured} = 5.4\,g$

Not correct

$$\frac{\Delta m}{m}\times 100 = \frac{0.1\,g}{5.4\,g}\times 100$$

$$\frac{0.1}{5.4}\times 100$$

$$\frac{100}{54} = 1.8\,\%.$$

Que- If percentage error in the measurement of momentum is 50%. then percentage error in K.E. (m = constant)

$K.E. = \frac{P^2}{2m}$

$100 \times \frac{\Delta K.E.}{K.E.} = 2\left(\frac{\Delta P \times 100}{P}\right)$

$= 2 \times 50$

$= 100\%$ (wrong)

P_T = True

$P_M = P_T + 50\%.\ P_T$

$P_M = P_T + \frac{50}{100} P_T \quad = \frac{3}{2} P_T$

$K.E_T = P_T^2$ — (i)

$K.E_m = P_m^2$ — (ii)

% error in K.E. $= \frac{|K.E_T - K.E_m|}{K.E._T} \times 100$

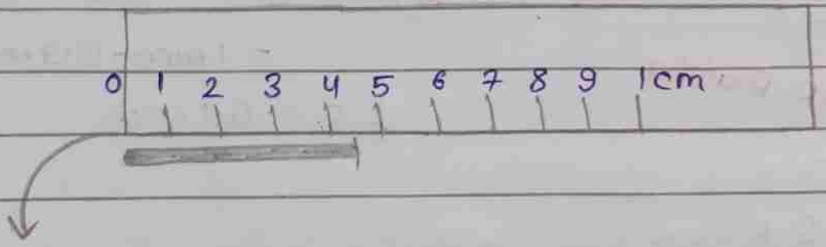
$= \frac{P_T^2 - 9/4\, P_T^2}{P_T^2} \times 100$

$\left(\frac{3}{2} P_T\right)^2 = \frac{9}{4} P_T^2$

Measuring Instrument

Metre Scale

Least count = L.C. = minimum reading that can be taken by this instrument is 1mm

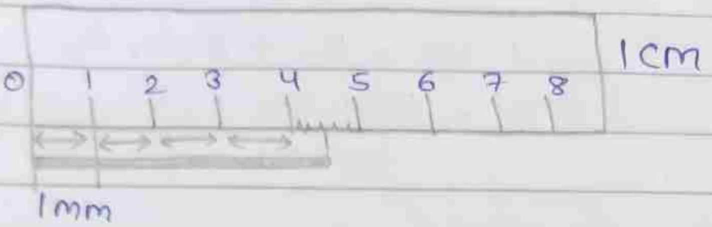


1 M.S.D = 1 metre scale division = 1 mm = 0.1cm = 0.001m

Length of Rod - Reading = (lmeasured ± Δl)

= 4 mm ± 1 mm

= (4 ± 1) mm



10 division = 1 cm

10 mm = 1 cm

1 M.S.D = 1 mm = L.C = minm Reading that can be taken

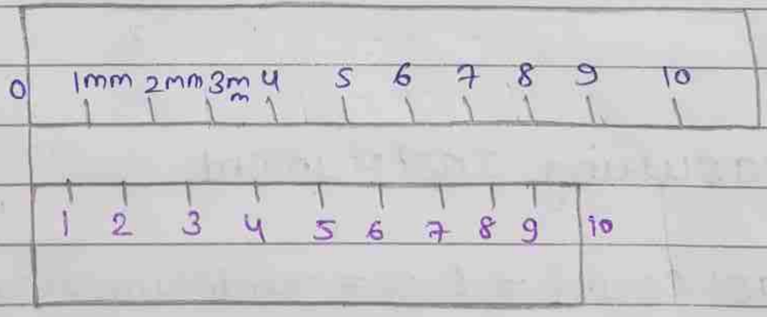
1 M.S.D = 1mm

Metre scale (main scale) Fixed

10 Division = 9 mm

1 Division = $\frac{9 \text{ mm}}{10}$

1 Division = 0·9 mm



1 V.S.D = 0·9 mm

$\boxed{L.C = 1\ M.SD - 1\ V.SD}$ → L.C = 1 M.SD - 1 V.SD

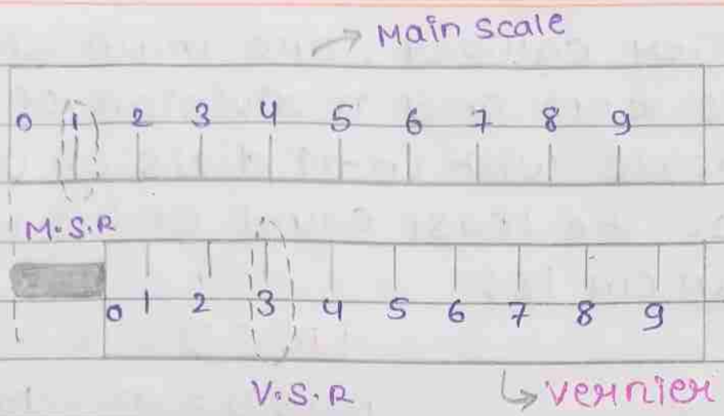
= 1 mm - 0·9 mm

L.C = 0·1 mm

MR Ratta

$\boxed{\text{Reading} = M.S.R + V.S.R (L.C)}$

Que-



Length of Rod = Reading = [M.S.R + V.S.R (L.C)]

$= 1mm + 3 \times 0.1 mm$

$= 1.3 mm$

Final Reading = 1.3 mm ± 0.1 mm

$= (1.3 \pm 0.1) mm$

Que- least count of main scale of vernier callipers is 1mm and 4 main scale division. coinside with 6 vernier scale division then L.C. of vernier scale.

1 M.S.D = 1mm

4 M.S.D = 6 V.S.D

$1 V.S.D = \frac{4 M.S.D}{6}$

$L.C. = 1 M.S.D - 1 V.S.D$

$= 1 M.S.D - \frac{4 M.S.D}{6}$

$= \left(1 - \frac{4}{6}\right) 1 M.S.D$

$= \frac{2}{6} \times 1 mm$

$= \frac{1}{3} mm$

Que- In a vernier calliper, one main scale division is x cm and n division of vernier scale coincide with (n-1) division of the main scale. The least count of the vernier calliper in cm is:

a) $\left(\frac{n-1}{n}\right)x$

b) $\frac{nx}{(n-1)}$

[✓ c) x/n]

d) $x/n-1$

$1\ M.S.D = x\ cm$

$n V.S.D = (n-1) M.S.D$

$L.C = 1\ M.S.D - 1\ V.S.D$

$= x\ cm - \left(\frac{n-1}{n}\right)x\ cm$

$x\ cm\left(1 - \frac{n-1}{n}\right) = x\ cm\left(\frac{n-n+1}{n}\right) = \frac{x}{n}\ cm$

Que- If measured length of Rod is 1.56 cm then instrument used is

a) metre scale

[✓ b) vernier calliper]

c) Screw Gauge

d) None

$l = 1.56\ cm$

$= 1.56 \times 10\ mm$

$= 15.6\ mm$

$L.C = 1\ mm$

$L.C = 0.1\ mm$

$L.C = 0.01\ mm$

Que- If x vernier scale division is equal to Y main scale division where 1 M.S.D is 1 cm there find L.C.

$$\begin{cases} X\ V.S.D = Y\ M.S.D \\ 1\ M.S.D = 1\ cm \end{cases}$$

$$L\cdot C = 1\ M\cdot S\cdot D - 1\ V\cdot S\cdot D$$

$$= 1\ M\cdot S\cdot D - \frac{y}{x}\ M\cdot S\cdot D$$

$$L\cdot C = \left(\frac{x-y}{x}\right) cm$$

Que- Write down name of measuring instrumen For given measurement

(1) 87·3 mm - Vernier Calliper

(2) 0·831 cm - ~~Significant Figures~~ Screw Gauge
(8·31 mm)

(3) 6·7 cm - metre scale
(67 mm)

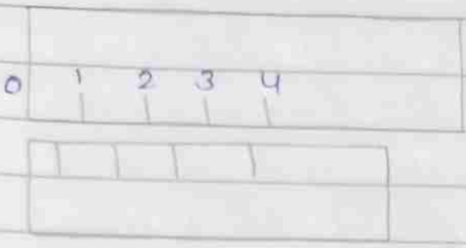
(4) 6·7 mm - Vernier Calliper

(5) 8·53 cm - Vernier calliper
(85·3 mm)

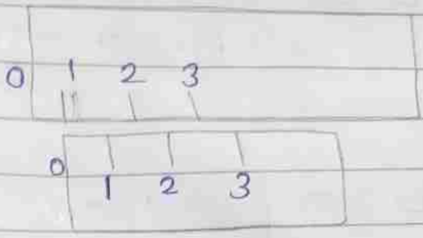
(6) 8·96 mm - ~~Significant figure~~ Screw Gauge

(7) 9·812 cm - Screw Gauge
(98·12 mm)

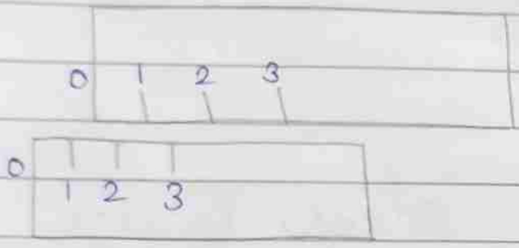
Zero Error → When in normal condition zero of main scale is not coincing with zero of vernier scale.



zero error = 0



zero error = +ve
↓
when zero of vernier is right side of zero of main scale.



zero error = -ve

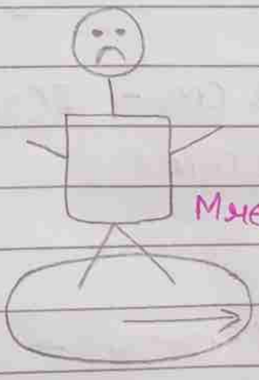
* zero error always subtracted from reading with proper sign.

* True Reading = 40kg - 20kg
= 20 kg

Mreading = 40 kg

zero error = 20 kg

True reading of mass = 40 - (-20 kg)
= 60 kg



Mreading = 40 kg

zero error = -20 kg

Screw Gauge

Distance on main scale in 1 Rotation

Pitch = 1mm

Minimum measurement that can be taken

$$L.C. = \frac{\text{Pitch}}{\text{No. of circular Division}}$$

$$L.C = \frac{1\ M.S.D}{\text{No. of Circular Division}}$$

no. of division = 100
1 M.S.D = 1mm

$$L.C = \frac{1mm}{100} = 0.01\ mm$$

Pitch = Distance moved by circular scale in one rotation

Que - A screw Gauge has least count of 0.01mm and there are 50 divisions in its circular scale. The pitch of the screw gauge is

a) 0.01 mm
b) 0.25 mm
c) 0.5 mm
d) 1.0 mm

$$L.C = \frac{\text{Pitch}}{\text{No. of division}}$$

Pitch = 1 M.S.D
↑
True

Pitch = 0.01mm × 50
= 0.5mm

Reading = M.S.R + L.C (C.S.R)
↓
circular scale reading

Positive zero - When zero of circular scale is below the reference level.

Negative zero - When zero of circular scale is above the reference level.

Error in Measurement

Systematic Error	Least count Error	Random Error
• Fixed or constant error in magnitude		• Reason is not known
• can't decrease by increasing no. of observation		• Irregular or varies in magnitude.
• Reason is known		• can be minimize by taking large no. of measurement.

Systematic Error
↓
Type
↓
1. Instrumental error (+ zero error)
2. Wrong experimental technique
3. Personal Error
(Human Error)

Random error
↓
Type
↓
Due to random change in Pressure Temperature.

→ Error can't decrease by taking large no. of observation.

→ Systematic error can be decreasing by correcting zero, by correcting experimental technique.

Que- Zero error of an instrument introduces

[✓ a) Systematic errors] b) Random errors
c) Both d) None

Que- In 5 number of observation, systematic error is 12% then Find error is 20 observation

Ans - 12% same

Que- In 5 number of observation, random error is 12% then Find error is 20 observation?

$$xn = \text{constant}$$

$$12\% \times 5 = x\% \cdot 20$$

$$x = \frac{12}{4} = 3\%$$