1. UNIT AND MEASUREMENTS

* Physical quantity → The quantity can be measured directly or indirectly is called physical quantity.

Physical quantity is expressed with the help of →

(i) Unit (u)
(ii) Numerical value (n)

Let us consider,

u_1 → Be the unit of physical quantity in 1st system of unit.

u_2 → be the unit of physical quantity in 2nd system of unit.

n_1 → be the numerical value of physical in 1st system of unit.

n_2 → be the numerical value of physical in 2nd system of unit.

$X = n_1 u_1 = n_2 u_2$

eg :— length = 100 cm
= 1 m
= $\frac{1}{1000}$ Km
= 10^{-3} Km

$n \propto \frac{1}{u}$ & $u \propto \frac{1}{n}$

* Unit :— The standard or refrence used for the measurement of physical quantity is called unit .. Ex : length - meter.

* System of unit :—

1) FPS - Foot Pound second

2) CGS - Centimeter gram second

3) MKS - Meter Kilogram second

4) SI - (International system of units) meter Kilogram second.

* Fundamental quantities & their units :-

The ~~Physical~~ fundamental quantities which does not depend on any other physical quantities are called fundamental quantities. The unit used for these fundamental quantities are called fundamental units.

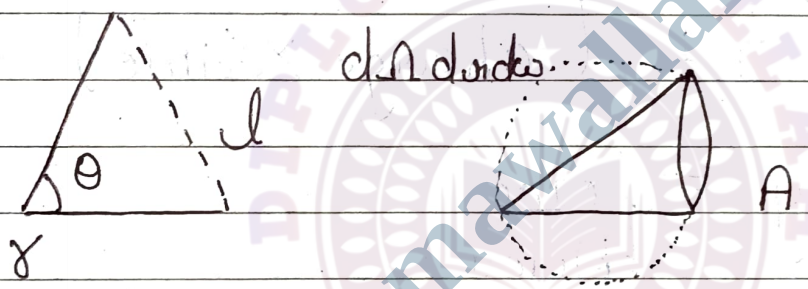
* There are seven fundamental quantities :-

S.No	Fundamental quantity	Unit	Symbols
1.	Length	meter	m
2.	Mass	Kilogram	Kg
3.	time	Second	Sec
4.	Temperature	Kelvin	K
5.	Electric current	Ampere	A
6.	Lumious intensity	Candela	cd
7.	Amount of substance	mole	mol

* Acceleration :— Shortance distance be
intial point to final po
is called acceleration. rate of change
Velocity is called acceleration.

* There are 2 supplementary quantities

S. No	Supplementary quantities	Unit	Symbol
1.	Plane angle	Radian	rad
2.	Solid angle	steradian	Sr



$$\theta = \frac{l}{r} \qquad d\Omega = \frac{dA}{r^2}$$

* Derived Quantity :— The quantities derived from the fundamental quantities are referred to as derived quantities. The units used for these derived quantities are called derived units.

Formula

1. Acceleration $= \frac{v-u}{t}$
2. Energy = Power X Time
3. Velocity $= \frac{\text{displacement}}{\text{time}}$
4. Work = force x displacement
5. Charge = It (charge x time)
6. Elasticity $= \frac{\text{force}}{\text{Area}}$
7. Power $= \frac{\text{Work}}{\text{time}}$
8. Density $= \frac{\text{Mass}}{\text{Volume}}$
9. Pressure $= \frac{\text{force}}{\text{Area}}$
10. Volume = l x b x h
11. Area = length x breath

12. Speed = $\frac{\text{distance}}{\text{time}}$, 11. Force = Mass X Acceleration

Physical quantity	Unit	Dimension
Length	m	$[L] = [M^0 L T^0]$
Mass	Kg	$[M]$
Time	Second	$[T]$
Force	$Kgms^{-2}$	$[MLT^{-2}]$
Acceleration	ms^{-2}	$[M^0 L^1 T^{-2}]$
Area	m^2	$[M^0 L^2 T^0]$
Volume	m^3	$[M^0 L^3 T^0]$
Pressure	Nm^{-2} / $Kg\,m^{-1}s^{-2}$	$[M^1 L^{-1} T^{-2}]$
Density	$Kgm^2 s^{-2}$	$[M^1 L^{-3} T^0]$
Work	$Kgm^2 s^{-2}$	$[M^1 L^2 T^{-2}]$
Power	$Kgm^2 s^{-3}$	$[M^1 L^2 T^{-3}]$

Momentum	$Kgms^{-1}$	$[M^1L^1T^{-1}]$
Speed	ms^{-1}	$[M^0L^1T^1]$
Energy	Kgm^2s^{-2}	$[M^1L^2.T^{-2}]$
Velocity	ms^{-1}	$[M^0L^1T^{-1}]$
Charge	It	$[M^0L^0A^1T^1]$
Elasticity	F/A	$[M^1L^{-1}T^{-2}]$

* Least Count :-

→ The least distance that can be measured by the instruments is called least count.

* Measuring Instruments :-

(1) Meter scale :- Range (0 - 100cm)

Least count (0.1 cm = 1mm)

Least count = 1 Main scale Discount - 1 Vernier scale Discount.

= 1 MSD - 1 VSD

* Vernier Caliper :-

$10\ VSD = 9\ MSD$

$1\ VSD = \frac{9}{10}\ MSD$

$LC = 1\ MSD - 1\ VSD$

$= \left(1 - \frac{9}{10}\right) MSD$

$= \frac{1}{10}\ MSD = \frac{1}{10} \times 0.01\ cm$

$Range = \frac{1}{10} \times 0.1\ cm$

$= 0.1 \times 0.1\ cm$

$= 0.01$ [In mm :- 0.1 mm]

* Screw gauge :-

It consists of two scale :-

(i) Linear scale
(ii) Circular scale

Range :-

Least count = 0.001 cm
in mm = 0.01 mm

* Pitch:-

→ Distance between two consequtive threads is called Pitch.

OR,

→ Linear distance covered in one complete rotation is called pitch of the screwguage.

$$\text{Least count} = \frac{\text{Pitch}}{\text{Total No. of circular scale Division.}}$$

$$= \frac{\text{Pitch}}{\text{Total no. of CSD}}$$

* Spherometer :-

It consists of two scale :-

(i) Linear scale (ii) Circular scale.

Range :—

Least count = 0.01 cm
= 0.01 mm

Least count of screw guage and spherometer is small in amount all these instrument therefore, screwguage and spherometer give more accurate reading.

* Error :—

The difference between true values and measure value is called error so that,
ERROR = True value − Measured value

* Types of Error :—

(I) Instrumental or systematic error :—
→ Due to known causes.

(II) Random Error :—
→ Due to Unknown cause.

Zero error = 0.002 cm

∴ corrected diameters will be

$x_1 = 1.223\,cm - 0.002$

$= 1.221\,cm$

$x_2 = 1.224\,cm - 0.002$

$= 1.222\,cm$

$x_3 = 1.224\,cm - 0.002$

$= 1.222\,cm$

mean value, $\bar{x} = \frac{1.221 + 1.222 + 1.222}{3}$

$= \frac{3.665}{3}$

$= 1.2217$ Ans.

1.221
1.222
+1.222
3.665

$\Delta x_1 = \bar{x} - x_1$

$= 1.2217 - 1.221$

$= 0.0007\,cm$

$\Delta x_2 = \bar{x} - x_2$

$= 1.2217 - 1.222$

$= -0.0003$

$\Delta x_3 = \bar{x} - x_3$

$= 1.2217 - 1.222$

$= -0.0003\ cm$

$$\overline{\Delta x} = \frac{|0.0007| + |-0.0003| + |-0.0003|}{n}$$

$$\overline{\Delta x} = \frac{0.0013}{3}$$

$= 0.00043\ cm$

$$\frac{\overline{\Delta x}}{x} = \frac{0.00043}{1.2217}$$

$$\frac{\overline{\Delta x}}{x} = \frac{43}{122170} \times 100$$

$= 0.035\ \%$

2. The length of the object measured by Vernier caliper is $4.78 \pm 0.01 cm$, calculate percentage error.

→ Given,

$L = 4.78\ cm$

$\overline{\Delta L} = 0.01\ cm$

$$\% \text{ error} = \frac{\overline{\Delta L}}{L} = \frac{0.01}{4.78} \times 100$$

$= 0.00203$

$= 0.0021 \times 100$

$= 0.21\ \%$

3. Calculate Percentage error in Kinetic energy of a body of mass 23 ± 0.01 gm and moving with velocity of 46 ± 0.2 cm/s $\left[KE = \frac{1}{2} mv^2 \right]$

→ Given,

$\Delta m = 0.1$

$\overline{m} = 23$

$\overline{V} = 46$

$\overline{\Delta V} = 0.2$

$\%$ Error in $KE = \frac{\overline{\Delta m}}{\overline{m}} \times 100 + 2 \times \frac{\overline{\Delta V}}{\overline{V}} \times 100$

$= \frac{0.1}{23} \times \frac{100}{10} + 2 \times \frac{0.2}{46} \times \frac{100}{10}$

$= \frac{10}{23} + \frac{4}{46}$

$= \frac{20 + 40}{46} = \frac{60}{46} = \frac{30}{23}$

$= 1.304$ Ans.

27/9/24.

Q. Radius of an Bob is measured by screw gauge is 8 ± 0.01 mm. find % error in volume of the bob.

→ Given,

$r = 8$ mm

$\Delta r = 0.01$ mm

% error in radius $= \frac{\Delta r}{r} \times 100$

$= \frac{0.01}{8} \times \frac{100}{100}$

$= \frac{1}{8}$

$= 0.125$ %

$\because$ Volume of the bob $= \frac{4}{3} \pi r^3$

$\therefore$ % error in volume of the bob.

$3 \times$ % Error in radius

$3 \times \frac{\Delta r}{r} \times 100$

3×0.125 %

0.375 %

Q. Length of a rectangular object in measured by vernier caliper is 4 ± 0.02 cm and breath is 2 ± 0.02 cm find percentage error in area rectangular object.

→ Given.

$\overline{x} = 4$

$\overline{\Delta l} = 0.02\text{cm}$

$\overline{b} = 2$

$\overline{\Delta b} = 0.02$

Since, area of rectangular object is

= length × breath

∴ % Error in length × % error in breath

$$\left(\frac{0.02}{4} \times \frac{100}{100}\right) + \frac{0.02}{2} \times \frac{100}{100}$$

$$\frac{1}{2} + 1$$

$$\frac{1+2}{2} = \frac{3}{2}$$

$$= 1.5 \text{ Ans}$$

Screw guage:— It is used to measure thickness the wire Hair and also used to measure diameter.

* Accuracy :—

→ The closeness of measured value to the true value of physical quantity is done is called 'Accuracy'.

* Precision :—

→ The limit or extand up two which measuremen of physical quantity is done is called precision.

OR

The degree to which any instrument will repeat the same value of the measurement is called precision.

* Significant figure :—

The number of digit in measurement up to which certain plus additional digit which is uncertain are called significant figure.

* Rules to identified significant figure :-

(I) All non-zero digits are significant figure. (Ex :- 1, 2, 3, 4, 5 ---- 9)

(II) Powers often not considered as significant figure. (Ex :- 3×10^8 m/s) having 1 significant figure.

(III) 0 between two non zero digit is considered as significant figure. (Ex :- 506 having 3 significant figure)

* Significant figure :-

(I) 8635000 mm = 4

(II) 12345 = 5

(III) 90.00 = 4

(IV) 90 20 m - 3

(V) 320×10^4 m = 2

(VI) 36.001 m - 5

(VII) 36.00 m - 4

(VIII) 0.0024 m - 2

(IX) 284800 m - 4

(X) 10.01 m - 4

(XI) 0.0005×10^5 m - 1

28/9/24.

* Unit for large distance :—

(1) Astronomical Unit :—

→ The average between the sun and earth is called Astronomical Unit.

$$1AU = 1.496 \times 10^{11} \text{ m}$$
$$= 1.5 \times 10^{11} \text{ m}$$

(2) Light year :—

→ The distance travelled by light in vacum in 1 year is called light year.

$$1 \text{ Light year} = 3 \times 10^8 \; 365 \times 24 \times 60 \times 60$$
$$= 94608\,000 \times 10^8 \text{ m}$$
$$= 94608 \times 10^{11} \text{ m}$$
$$= 9.56 \times 10^{15} \text{ m}$$

(3) Parsec :—

→ It is the distance at which an arc of length equal to 1 astronomical unit subtained and angle of 1 second.

10^{-15} = fm (femto) (10^{-15} = fermi)

10^{-1} = deci

10^{1} = deca

$$1 \text{ Parsec} = \frac{1 \text{ AU}}{1''}$$

$$= \frac{1.496 \times 10^{11}}{\frac{1}{360^\circ} \times \frac{\pi}{180^\circ}}$$

$$= 3.1 \times 10^{16} \text{ m}$$ Ans-

$180^\circ = \pi$ radian.

$$1^\circ = \frac{\pi}{180} \qquad = 60 \times 1' = \frac{\pi}{180}$$

$$60 \times 60 \times 1'' = \frac{\pi}{180^\circ}$$

$$1'' = \frac{1}{360^\circ} \times \frac{\pi}{180^\circ}$$

10^{0} — Base

10^{1} = deka

10^{2} = hecto

10^{3} = Kilo

10^{6} = Mega

10^{9} = Giga

10^{12} = Tera

* Unit of mass :—

$$1 \text{ amu} = \frac{1}{12} \times \text{mass of 1 atom of } {}_6C^{12}$$

$$= 1.66 \times 10^{-27} \text{ Kg}$$

Limit

* Chandrasekhar :—

ICSL = 1.4 × mass of sun

= $1.4 \times 1.989 \times 10^{30}$ kg

= 2.7846×10^{30}

* Unit of Time :—

→ Solar month time taken by earth to complete 1 rotation of sun is called solar month.

1 solar month = 365 days.

- Lunar Month :—

Time taken by moon to complete one rotation of earth is called lunar month.

1 Lunar month :- 29.5 days.

Q. Length of an object is measured by Vernier caliper by 5 times as 42.03 m, 42.02 m, 42.02 m, 42.04 m, 42.03 m find percentage error in measurement of length.

⟶ Given,

$x_1 = 42.03\ m$

$x_2 = 42.02\ m$

$x_3 = 42.02\ m$

$x_4 = 42.04\ m$

$x_5 = 42.03\ m$

$$\bar{x} = \frac{x_1 + x_2 + x_3 + x_4 + x_5}{5}$$

$$= \frac{42.03 + 42.02 + 42.02 + 42.04 + 42.03}{5}$$

$$= \frac{210.14}{5}$$

$$= 42.028\ m$$

$$\Delta x_1 = \bar{x} - x_1$$

$$= 42.028 - 42.03$$

$$= 0.008\ m$$

$$\Delta x_2 = \bar{x} - x_2$$

$$= 42.028 - 42.02$$

$$= 0.008$$

$$\Delta x_3 = \bar{x} - x_3$$

$$= 42.028 - 42.02$$

$$= 0.008$$

$$\Delta x_4 = \bar{x} - x_4$$
$$= 42.028 - 42.04$$
$$= 0.012\ m$$

$$\Delta x_5 = \bar{x} - x_5$$
$$= 42.028 - 42.03$$
$$= -0.002$$

$$\overline{\Delta x} = \frac{|\Delta x_1| + |\Delta x_2| + |\Delta x_3| + |\Delta x_4| + |\Delta x_5|}{5}$$

$$= \frac{0.002 + 0.008 + 0.008 + 0.012 + (-0.002)}{5}$$

$$= \frac{0.032}{5}$$
$$= 0.0064\ m$$

Relative error $= \frac{\overline{\Delta x}}{x}$

$$= \frac{0.0064}{42.028} \times \frac{1000}{10000}$$

$$= \frac{64}{420280} \quad \frac{92 \quad 16 \quad 8}{210140 \quad = \quad 52535}$$
$$105070$$
$$52535$$

$= 0.0001522 m$

Percentage error $= 0.000152 \times 100$

$= 0.0153 \%$ m Ans.