Date
Page No.

UNIT - 1
PHYSICAL WORLD AND MEASUREMENT

* Physics → Greek word
English translation → Measurement of Natural Phenomenon
(Measurements started with trading.)

Scale → Any device that can measure a definate physical quantity.

Fundamental Physical Quantity →

(i) Which cannot interchange
(ii) Hypothetical
(iii) They have no formula
(iv) They are self made
(v) 7 fundamentals

* formula → structure of composition

(1.) Mass → Quantity of material in a substance
(2.) Distance → Seperation between 2 points
(3.) Time → duration between any 2 events
(4.) Electric Current → Flow of charge per unit time
(5.) Luminous Intensity → Measurement of glow
(6.) Temperature → degree of hotness or coldness
(7.) Quantity of Matter → Number of gas molecules.

Fundamental Units → Representatives of fundamental physical Quantities

F.P.Q	F.P.U	Dimension
Mass	Kg	[M]
Distance	m	[L]
Time	second - s	[T]
Electric current	Amp	[A]
Luminous Intensity	Candela	[Cd]
Temperature	K	[θ] Theta
Quantity of Matter	mole	—

Deriviative Physical Quantity → Physical quantities made of fundamental Phy. Quantities

(1.) **Area** → $l \times b = m \times m = m^2 = [L^2]$

(2.) **Volume** → $area \times h = m^2 \times m = m^3 = [L^3]$

(3.) **Mass Density** →
- Linear mass density $= \frac{kg}{m} = [ML^{-1}]$
- Area mass density $= \frac{kg}{m^2} = [ML^{-2}]$
- Volume mass density $= kgm^{-3} = [ML^{-3}]$

(4.) **Velocity** → $\frac{distance}{time} = ms^{-1} = [LT^{-1}]$

(5.) **Linear Momentum** → $mass \times velocity = kg \times ms^{-1} = [MLT^{-1}]$

(6.) **Acceleration** → $\frac{Velocity}{time} = \frac{d}{t} \times \frac{1}{t} = ms^{-2} = [LT^{-2}]$

Date / /
Page No.

(7.) Force → mass × acceleration = $kgms^{-2}$ = $[MLT^{-2}]$ Newton SI, Dyne

(8.) Work → force × distance = $kgms^{-2} \times m$ = $[ML^2T^{-2}]$ Joule SI, Erg

(9.) Torque → Unit and dimension same as work $[ML^2T^{-2}]$

(10.) Energy (any type) → Unit and dimension same as work $[ML^2T^{-2}]$

(11.) Power → $\frac{\text{Work}}{\text{time}} = \frac{kgm^2s^{-2}}{s} = kgm^2s^{-3} = [ML^2T^{-3}]$ Watt SI

(12.) Pressure → $\frac{\text{force}}{\text{area}} = \frac{kgms^{-2}}{m^2} = kgm^{-1}s^{-2} = [ML^{-1}T^{-2}]$

(13.) Modulus of Elasticity
Yong Modulus
Modulus of rusidity
Bulk modulus
Stress → Same as pressure $[ML^{-1}T^{-2}]$

(14.) Strain → $\frac{\Delta l}{l} = \frac{\text{Change in dimension}}{\text{dimension}} = [L^0]$

(15.) Frequency → Reciprocal of time = $\frac{1}{s} = s^{-1} = [T^{-1}]$ Hertz SI unit

★ Dimension → Gives info about how many units are present
Different physical Quantities can have same units and dimensions

Supplimentary Physical Quantities → Physical Quantities which have no natural unit

(1.) Angle → $\frac{\text{arch}}{\text{radius}}$ = radian

(2.) Solid Angle → $\frac{\text{area}}{\text{radius}^2}$ = staradian

★ Imp

Applications of Dimensions → Uses of dimensions

(i) To know the correctness of any formula →

Q1. $F = mvr$ F = force, m = mass, v = velocity
r = radius

$[MLT^{-2}] = [M] \times [LT^{-1}] \times [L]$
$[MLT^{-2}] \neq [ML^2T^{-1}]$ Hence incorrect formula

Q2. $F = \frac{mv^2}{r}$

$[MLT^{-2}] = [M] \times [L^2T^{-2}] \times [L^{-1}]$
$[MLT^{-2}] = [MLT^{-2}]$ Hence correct formula

Q3. $K = \frac{1}{2} mv^2$

$[ML^2T^{-2}] = [M] \times [L^2T^{-2}]$
$[ML^2T^{-2}] = [ML^2T^{-2}]$ Hence correct formula

★ Imp. 5marks

(ii) To derive any formula →

Q1. Centripetal force (F) depends on mass (m), velocity (v), radius (r). Derive formula of (F) by using Dimention method.

(i) Rough Formula → $F = k\, m^a v^b r^c$ —(i) eq.
k ↓ Dimensionless constant

a, b, c are powers

★ Constants in formule
$f = \frac{1}{2} mv^2 \Rightarrow \frac{1}{2}$
$a = \pi r^2 \Rightarrow \pi$
$f = ma \Rightarrow 1$

★ formula is relation between 2 or more Physical Quantities

Date
Page No.

(ii) R·D·O B·S → Right Dimension of Both sides

$[MLT^{-2}] = [M]^a \times [LT^{-1}]^b \times [L]^c$
$[MLT^{-2}] = [M^a L^{b+c} T^{-b}]$

(iii) Compare the Powers →

$M^a = M^1$ $\qquad L^{b+c} = L^1$ $\qquad T^{-b} = T^{-2}$
$a = 1$ $\qquad b+c = 1$ $\qquad \cancel{-}b = \cancel{-}2$
$2+c = 1$
$c = -1$

(iv) Put value of a, b, c in eq ① →

$F = k\, m^1 v^2 r^{-1}$
$F = k \frac{mv^2}{r}$

★ Demerits of this method →

(i) Cannot find k (constant)
(ii) Cannot find formula with more than 4 Quantities
(iii) Cannot derive formula with addition and substraction ($v = u + at$)

* k can be found out by practical method.

(iii) To convert one unit system to another unit system →

Principle → $\boxed{n_1 u_1 = n_2 u_2}$

$\boxed{\text{Product of magnitude to unit is constant}}$

Date ____ Page No. ____

Q. Convert 36 km/h into m/s. $n_1 = 36$

$$n_1 u_1 = n_2 u_2$$
$$36 [L_1 T_1^{-1}] = n_2 [L_2 T_2^{-1}]$$
$$n_2 = \frac{36 [L_1 T_1^{-1}]}{[L_2 T_2^{-1}]}$$
$$n_2 = 36 \times \left[\frac{L_1}{L_2}\right] \times \left[\frac{T_1}{T_2}\right]^{-1}$$
$$n_2 = 36 \times \left[\frac{km}{m}\right] \times \left[\frac{hour}{sec}\right]^{-1}$$
$$n_2 = 36 \times \frac{1000 \cancel{m}}{1 \cancel{m}} \times \left[\frac{3600 \cancel{sec}}{1 sec}\right]^{-1}$$
$$n_2 = \frac{\cancel{36} \times 1\cancel{000}}{\cancel{3600}}$$
$$n_2 = 10$$

36 km/h = 10 m/s

Q2. Convert 10 m/s⁻² into km/min².

$n_1 u_1 = n_2 u_2$ $n_1 = 10$ $n_2 = ?$

$$n_2 = \frac{10 \times [L_1 T_1^{-2}]}{[L_2 T_2^{-2}]}$$
$$n_2 = 10 \times \left[\frac{L_1}{L_2}\right] \times \left[\frac{T_1}{T_2}\right]^{-2}$$
$$n_2 = 10 \times \left[\frac{m}{km}\right] \times \left[\frac{s}{min}\right]^{-2}$$
$$n_2 = 1\cancel{0} \times \frac{1 \, m}{100\cancel{0} \, m} \times \frac{360\cancel{0} \, s}{1 \, s}$$
$$n_2 = 36$$

$$10 \, ms^{-2} = 36 \, km \, min^{-2}$$

(iv) Homogenity in Dimension → Similar units can be added subtracted etc.

Van der Waal equation

$$\left(P + \frac{a}{V^2}\right)(V-b) = RT$$

P = Pressure
V = Volume
a, b = ?

D. of b = $[L^3]$ (Same as volume)

$$\frac{a}{V^2} = P \Rightarrow a = PV^2$$

D. of a = $[ML^{-1}T^{-2}][L^3]^2$
a = $[ML^5T^{-2}]$

Error → Uncertainity in any physical measurement

least Count → Smallest measurement that can be taken on a scale

Error → 0 < Error ≤ least count

(i) Carelessness
(ii) ~~De~~formed scale
(iii) Automatic Error

Calculation of Error →

(1) True value $x = \frac{x_1 + x_2 + x_3 + \cdots + x_n}{n}$

(2) Absolute error $\Delta x_1 = |x - x_1|$ $\quad \Delta x_n = |x - x_n|$
Absolute error $\Delta x_2 = |x - x_2|$

(3.) Mean absolute error $\Delta x = \frac{\Delta x_1 + \Delta x_2 + \ldots \Delta x_n}{n}$

Date
Page No.

(4) Fractional Error $= \frac{\Delta x}{x}$

(5) Percentage Error $= \frac{\Delta x}{x} \times 100$

Q. Calculate the following for 1.1, 1.2, 1.3, 1.4, 1.5.

Sol. True Value $x = \frac{1.1 + 1.2 + 1.3 + 1.4 + 1.5}{5}$

$= \frac{\cancel{6.5}^{13}}{\cancel{5}} \Rightarrow 1.3$

Absolute error $\Rightarrow \Delta x_1 = |1.3 - 1.1| = 0.2$

$\Delta x_2 = |1.3 - 1.2| = 0.1$

$\Delta x_3 = |1.3 - 1.3| = 0$

$\Delta x_4 = |1.3 - 1.4| = 0.1$

$\Delta x_5 = |1.3 - 1.5| = 0.2$

mean absolute error $\Delta x = \frac{0.2 + 0.1 + 0 + 0.1 + 0.2}{5}$

$= \frac{0.6}{5} \Rightarrow 0.12$

Fractional error $= \frac{0.12 \times 10}{1.3 \times 10\cancel{0}} \Rightarrow \frac{12}{130} = 0.092$

Percentage error $= \frac{0.12}{1.3\cancel{0}} \times 10\cancel{0} \Rightarrow \frac{120}{\cancel{13}}$ 9.23 %

✱ $\boxed{\text{Error} = \frac{\text{Least Count}}{\text{Measured Value}}}$ (Single Value Questions)

✱ Least Count =

Date
Page No.

Measured Value with error → $\boxed{x \pm \Delta x}$

1.3 ± 0.92

Q1. 25 oscillations of a pendulum are measured in 20s. Calculate % error in the measurement.

Sol^n) Measured Value = 20 sec
Least count = 1 sec

$$\% \text{ Error} = \frac{1}{\cancel{20}} \times \cancel{100}^{5} \Rightarrow 5\%$$

Errors in Derivative Quantities → Depends on the fundament Phy. Qua.

$$\boxed{S = a + b}$$

$$\frac{\Delta S}{S} = \frac{\Delta a}{a} + \frac{\Delta b}{b}$$

* Error calculated in terms of individual Quantities

$$\boxed{S = ab^2} \qquad \frac{\Delta S}{S} = \frac{\Delta a}{a} + \frac{2\Delta b}{b}$$

Q2. Write fractional error formula for $A = \pi r^2$

$$\frac{\Delta A}{A} = \frac{2\Delta r}{r}$$

Q. Write % error formula for $V = \frac{4}{3}\pi r^3$

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

Date ___
Page No. ___

Q3. A sphere has radius $r = (10 \pm 2)$ cm. Calculate % error in calculation of sphere's area.

$A = 4\pi r^2 \qquad r = 10 \qquad \Delta r = 2$

$\frac{\Delta A}{A} \times 100 = 2 \times \frac{\Delta r}{r} \times 100$

$A\% = \frac{2 \times 2}{1\cancel{0}} \times 10\cancel{0} = 40\%$

Q4. A physical quantity S is given by $S = (a^2 b^3)/c^4$. Calculate % error when a, b, c is 1%, 2% and 3%.

$\frac{\Delta S}{S} \times 100 = 2\left(\frac{\Delta a}{a} \times 100\right) + 3\left(\frac{\Delta b}{b} \times 100\right) + 4\left(\frac{\Delta c}{c} \times 100\right)$

$\frac{\Delta S}{S} \times 100 = 2 \times 1 + 3 \times 2 + 4 \times 3$

$= 2 + 6 + 12$

$= 20\%$ Ans

Q5. Write area of sphere with error $R = (10 \pm 2)$ cm.

$A = 4\pi r^2 \qquad r = 10 \qquad \Delta r = 2$

$= 4\pi \times 100 \text{ cm}^2$

$= 400\pi \text{ cm}^2$

Error $\frac{\Delta A}{A} = 2 \times \frac{\Delta r}{r}$

$\Delta A = 2 \times \frac{2}{1\cancel{0}} \times 40\cancel{0}\pi \text{ cm}^2 = 160\pi$

Area with Error $= (400\pi \pm 160\pi) \text{ cm}^2$

Significant figure → In any measurement, the no. of digits useful and 2 doubtful

55 → 2 significant figure

5.5 → 2

5×10^3 → 1

Date / /
Page No.

Accuracy and Precision →

52.3 True Value

measured value
51.9
52.2 → most acurate
51.29 → most precise
52.29 → most precise and most acurate

* Accuracy means Closeness of any measured value to the true value.
* Precision gives more info