Chapter - 2

Units and Measurments

Q.1 What is science?

Ans Systematic Organised and logical Knowledge which is gained through observation and experiment is known as science,

There are 2 types of science -

i) Physical science
ii) Bio-logical Science

i) **Physical science** :- The science which deals with non-living thing is known as Physical science.

Example :- physics and chemistry.

ii) **Bio-logical science** :- The science which deals with living thing is known as Biological science.

Example :- Biology and Zoology.

Q.2. What is Physics?

Ans. The study of nature and natural Phenomena is known as Physics.

physics word is taken from greek word ~~to~~ Fusis which means nature. Physics is known as Bhautiki in Sanskrit.

NOTES

1> **Physical Quantity** :- The quantity which is measurable is known as physical quantity.

There are 2 types of physical quantity :-

i> Fundamental Physical Quantity → The quantity which does not depend on another physical quantity.
ii> Derived Physical Quantity.

i> Fundamental Physical Quantity :- The Physical quantities which are completly independent of each other is called fundmental physical quantity.

Example :- lenghth (m), mass (Kg), Temp.

ii> **Derived Physical Quantity** :- The physical quantities which are completly dependent to each other is known as Derived Physical quantity.

Example :- ~~Area ($l \times b = m^2$)~~ velocity, Area = $l \times b$ (m^2)

2. **Unit** :- The reference standard for the measurement of ~~a Physical~~ the given physical quantity is called the Unit of that physical quantity.

3. To express the any Physical quantity we require two things -

i) Unit
ii) Numeric Value

4. System of Unit.

① CGS System ⇒

C = centimeter → used for measure lenghth
G = Gram → used for measure mass
S = second → used for measure Time.

② FPS system ⇒

F = Foot → used for measurment of lenghth.
P = Pound → used for measurement of mass.
S = second → used for measurement of Time

③ MKS System ⇒

M = Metere → used for measurment of lenghth
K = Kilo ~~Metere~~ Gram → used for measurement of mass.
S = second → used for measurement of Time.

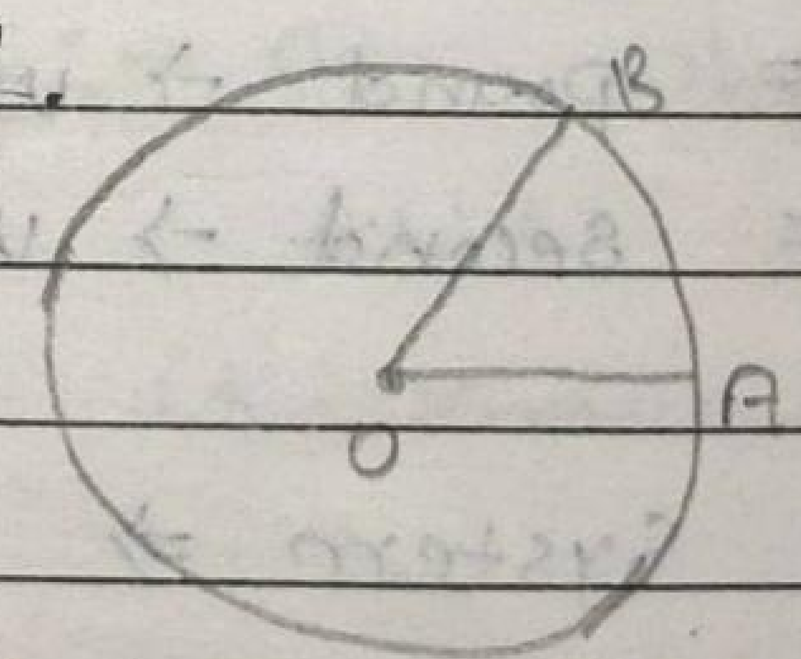
④ SI (International System of Units) ⇒

In SI system we have 7 fundamental units :-

S. NO.	Physical quantity	Unit	Symbol
1.	Lenghth	Meter	m
2.	Mass	Kilo Gram	Kg
3.	Time	Second	S
4.	Temperature	Kelvin	K
5.	Luminous Intensity	Candela	~~Cd~~ cd
6.	Electric current	Ampere	A
7.	Quantity of Matter	mole	mol.

Supplementry SI Unit

1) Plane angle → S.I unit of plane angle is "radian".

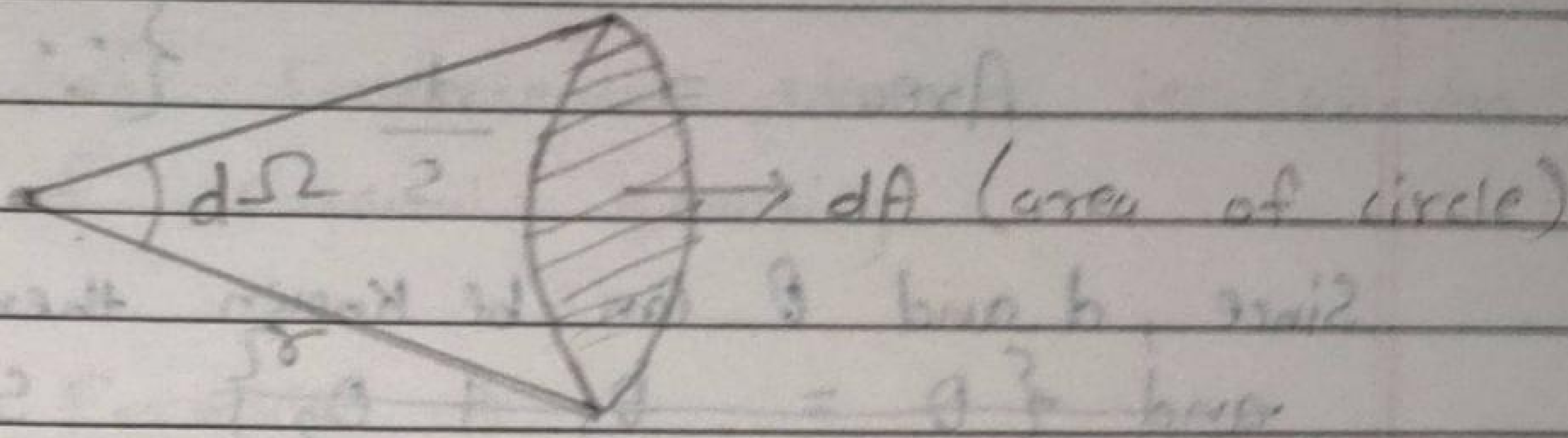


~~2) Solid angle → S.~~

⇒ formula for plane angle $= \dfrac{\text{arc}}{\text{radius}} = \dfrac{OB}{OA}$

2) Solid angle → S.I unit of solid angle is steradian and symbol of steradian is Sr.

⇒ formula for solid angle $= \dfrac{dA\ (\text{area})}{r^2}$

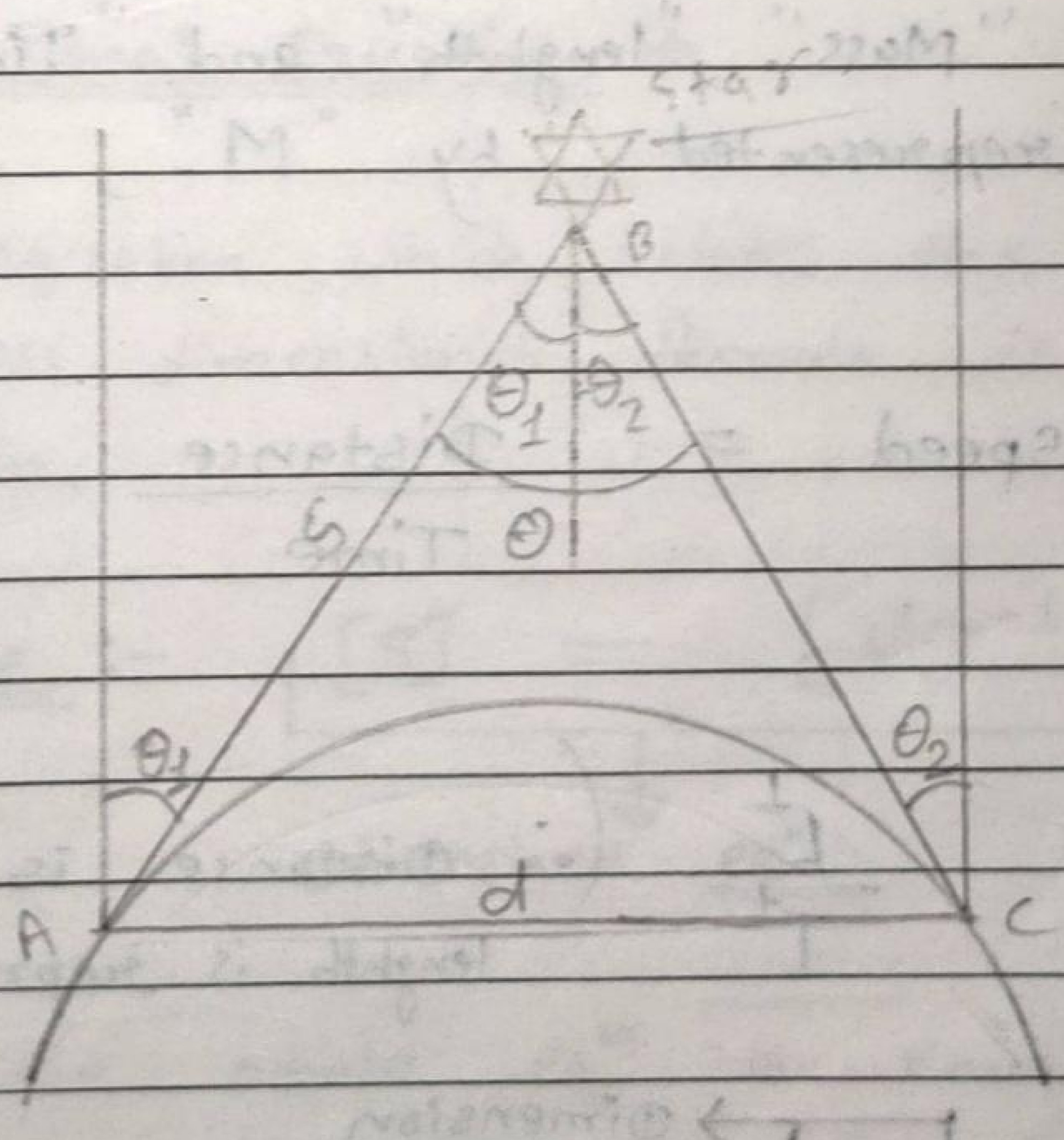


Solid angle $= \dfrac{dA \text{ (Area)}}{r^2}$

5. Parallax :- Relative shift in the position of the object due to change in observation point is called Parallax.

6. Measurement of Large Distance

i) Parallax Method $\to$ To measure the longest distance we use Parallax method.



We know that,

$$\text{Area} = \frac{\text{arc}}{\text{radius}} = \frac{AC}{AB}$$

$$Area = \frac{d}{S} \quad \{\because \theta = \theta_1 + \theta_2\}$$

Since, d and θ can be known then the value of ~~and $\{\theta = \theta_1 + \theta_2\}$~~ S i.e distance bet^n Earth and moon. can be found.

7. Dimension

i) Dimensions of physical quantity →

The dimensions of a physical quantity is defined as the powers to which the fundamental units are raised to express the given physical quantity.

Example :- "Mass", "length" and "Time" is represented by "M", "L" and "T" respectively.

$$\Rightarrow \quad speed = \frac{Distance}{Time}$$

$$\Rightarrow \quad S = \frac{L^1}{T^1}$$ ($\because$ Distance is lenghth and lenghth is represented by L)

→ Dimension

$$\Rightarrow \quad [S] = [L^1 T^{-1}]$$ (Speed is derived and distance or time is fundamental quantity)

The power of Fundamental quantity is known as Dimension of physical quantity.

ii) **Dimensional Formula →**

The expression which gives the relation of derived unit of a physical quantity with the fundamental units is termed as dimensional formula of given physical quantity.

Example :- $[S] = [L^1 T^{-1}]$ → Dimensional Formula

Here the formula present right side of equal to (=) is known as dimensional formula.

iii) **Dimensional Equation →**

The equation which relates the physical quantity with its dimensional formula is called dimensional equation.

Example :- $\underbrace{[S] = [L^1 T^{-1}]}_{\text{Dimensional eq}^n}$

Here the whole eq^n is known as dimensional eq^n.

a) Area $= \text{lenghth} \times \text{breadth}$

$= [L^1 \times L^1]$

$= [L^2]$

b) Volume $= \text{lenghth} \times \text{Breadth} \times \text{Height}$

$= [L^1 \times L^1 \times L^1]$

$= [L^3]$

c) velocity $= \dfrac{\text{Displacement}}{\text{Time}}$

$= \left[\dfrac{L^1}{T^1}\right]$

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

d) Acceleration $= \dfrac{\text{velocity}}{\text{Time}}$

$= \left[\dfrac{L^1 T^{-1}}{T^1}\right]$

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

e) Density $= \dfrac{\text{mass}}{\text{volume}}$

$= \left[\dfrac{M^1}{L^3}\right]$

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

(f) Linear Momentum = mass x velocity

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

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

(G) Force = mass x acceleration

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

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

(H) Impulse = force x Time

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

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

(I) pressure = $\frac{\text{Force}}{\text{Area}}$

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

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

(J) work = Force x displacement

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

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

(K) Power = $\frac{\text{work}}{\text{Time}}$

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

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

(L) Moment of force = force × distance

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

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

8. Checking the Dimensional Consistency of Equations :-

For checking the ~~checking of~~ correctness of any eq^n, we need to find the dimension of LHS and RHS.

For the correctness of any eq^n, the dimension of LHS and dimension of RHS should be equal. It means :-

$\Rightarrow$ $\boxed{\text{Dimension of LHS = Dimension of RHS}}$

Questions :-

Q. 1 Check the correctness of given equation :-

i) $v = u + at$

Sol. Here,

v = Final Velocity = $[LT^{-1}]$

u = Initial Velocity = $[LT^{-1}]$

a = Acceleration = $[LT^{-2}]$

t = Time = $[T]$

LHS $\Rightarrow$ v

$= [LT^{-1}]$

RHS $\Rightarrow$ $u + at$

$= [LT^{-1}] + [LT^{-2}][T]$

$= [LT^{-1}] + [LT^{-1}]$

Here Dimension of LHS is equal to dimension of RHS. So, given eq^n is correct.

IMP

ii) $s = ut + \frac{1}{2}at^2$

Sol. Here,

$s =$ displacement ~~Speed~~ $= \cancel{[LT^{-1}]}$ $[L]$

u = Initial velocity $= [LT^{-1}]$

a = Acceleration $= [LT^{-2}]$

t = Time $= [T]$

L.H.S $\Rightarrow$ s

$= \cancel{[LT^{-1}]}$ $[L]$

RHS $\Rightarrow$ $ut + \frac{1}{2}at^2$

$= [LT^{-1}][T] + [LT^{-2}][T^2]$

$= [LT^0] + [LT^0]$

$= [L \times 1] + [L \times 1]$

$= [L] + [L]$

Here the Dimension of LHS is ~~not~~ equal to dimension of RHS. so, above eq^n is ~~not~~ correct.

iii) $v^2 = u^2 + 2aS$

Sol. Here,

v = Final velocity = $[LT^{-1}]$
u = Initial velocity = $[LT^{-1}]$
a = Acceleration = $[LT^{-2}]$
S = ~~Speed~~ displacement = $\cancel{[LT^{-1}]}$ $[L]$

LHS $\Rightarrow$ v^2
$= [LT^{-1}]^2$
$= [L^2T^{-2}]$

RHS $\Rightarrow$ $u^2 + 2aS$
$= [LT^{-1}]^2 + [LT^{-2}]\,\cancel{[LT^{-1}]}\,[L]$
$= [L^2T^{-2}] + [L^2T^{-2}]$

Here the Dimension of LHS is ~~not~~ equal to Dimension of RHS. so, above eqn is ~~in~~correct.

Eg 2.15 let us Consider an eqn

$$\frac{1}{2} mv^2 = mgh$$

where m is the mass of the body, v its velocity. g is the acceleration due to gravity and h ~~is~~ is the height. check wheather this eqn is dimensionally correct.

Ans. $\frac{1}{2} mv^2 = mgh.$

LHS $\Rightarrow \frac{1}{2} mv^2$

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

RHS $\Rightarrow mgh$

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

The dimension of LHS = Dimension RHS
Hence the eq^n is dimensionally correct.

Q. - Check the correctness of eq^n -

$$G = \frac{Fr^2}{m_1 m_2}$$

Ans. $G = \frac{Fr^2}{m_1 m_2}$

R.H.S $\Rightarrow \frac{Fr^2}{m_1 m_2}$

$$\frac{[MLT^{-2}] [L^2]}{[M^2]}$$

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

Eg. 2.17 Consider a simple pendulam, having a bob attached to a string, that oscillates under the action of the force of gravity, suppose that the period of oscillation of the simple pendulam depend on its lenghth (l), mass of the bob (m) and acceleration due to gravity (g). Derive the expression ~~given~~ for its time period using method of dimensions.

Ans. The dependence of time period T on the quantities l, g and m as a product may be written as :

$$T = k\, l^x g^y m^z$$

where k is dimensionless constant and x, y and z are the exponents.

By considering dimensions on both sides. We have

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

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

on equating the dimensions on both sides

We have,

$$x+y = 0 \; ; \; -2y = 1 \; ; \text{ and } z = 0$$

So that $x = \frac{1}{2}$, $y = \frac{-1}{2}$, $z = 0$

Then, $T = K\, l^{\frac{1}{2}}\, g^{-\frac{1}{2}}$

or, $T = K\sqrt{\frac{l}{g}}$

Note that value of constant K can not be obtained by the method of dimensions. Here it does not matter if some no. multiplies the right side of this formula, because that does not affect its dimensions.

Actually, $K = 2\pi$ so that $T = 2\pi\sqrt{\frac{l}{g}}$.

or.

According to question,

$\Rightarrow T \propto l m g$

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

$\Rightarrow [T] = [L]^{a} [M]^{b} [LT^{-2}]^{c}$

$\Rightarrow [T] = [L^{1\times a}] [M^{1\times b}] [L^{1\times c}\, T^{-2\times c}]$

$\Rightarrow [T] = [L^{a}] [M^{b}] [L^{c}\, T^{-2c}]$

$\Rightarrow [T] = [L^{a} M^{b} L^{c} T^{-2c}]$

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

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

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

$\Rightarrow M^0 = M^b \Rightarrow b = 0$

$\Rightarrow L^0 = L^{a+c} \Rightarrow a+c = 0$

$\Rightarrow T^1 = T^{-2c} \Rightarrow -2c = 1$

$\Rightarrow c = \frac{-1}{2}$

$\Rightarrow \because a+c = 0$

$\Rightarrow a + \left(\frac{-1}{2}\right) = 0$

$\Rightarrow a = \frac{1}{2}$

$\therefore T = K l^a m^b g^c$

$\Rightarrow T = K l^{\frac{1}{2}} m^0 g^{-\frac{1}{2}}$

$\Rightarrow T = \frac{K l^{\frac{1}{2}}}{g^{\frac{1}{2}}}$

$\Rightarrow T = K\sqrt{\frac{l}{g}}$ Ans.

Error

Accuracy - The accuracy of a measurement is the measurement of how closed the measured value ~~of~~ is to be the true value of the quantity.

Precision - Precision is the degree of exactness or refinement of a measurement.

Error - The difference in the true value and the measured value of the physical quantity is called error of measurement.

Types of error -

Error
- systematic error
  - Instrumental error
    - Zero error
    - least count error
  - { Imperfection in experimental technique or Procedure. }
  - Personal error (parallex error)
- Random error

1) Systematic error - The errors whose causes are Called systematic error. This errors occurs only in one direction i.e Positive or Negative.

a) Instrumental error - This error is due to the fully design of measuring instrument.

i) Zero error - In vernier callipers, screw gauge, spherometer etc. in the initial state the zeros of main scale and vernier / circular scale should coincide. If they do not coincide then zero error exists.

For the removal of the errors, zero error should be substracted from the observed reading.

ii) Least Count errors - The error in measurement due to the limit of resolution of the instrument is called the least count errors.

b) Imperfection in experimental techniques or procedure -

To determine the temperature of a human body. a thermometer placed under armpit always give temp. belower the actual temp. of human body. other external conditions (such as changes in temp., humidity, wind, velocity etc.) during experiment may systematically affect the measurement.

c) Personal error – Personal errors that arise due to an individuals bias, lack of proper setting of the apparatus or individuals carelessness in taking observations without observing proper precautions.

2) Random errors – When the error is irregular and random then it is called random error. No specific cause of this error is known. If an observer different reading then such an error is called Random error.

Q. Convert SI/MKS unit of work (Joule) into CGS unit of work (erg.)

Ans.

$$\underset{(SI/mks)}{1 \text{ Joule}} = \underset{(CGS)}{\text{———— erg.}}$$

$$[M_1^1 L_1^2 T_1^{-2}] = [M_2^a L_2^b T_2^c]$$

on comparing both,

$$a = 1, \quad b = 2, \quad c = (-2)$$

with that system,

$M_1 = 1$ kg, $L_1 = 1$ m, $T_1 = 1$ sec., $n_1 = 1$
$M_2 = 1$ gm, $L_2 = 1$ cm, $T_2 = 1$ sec.

$$\Rightarrow n_2 = n_1 \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

$$\Rightarrow n_2 = 1 \left[\frac{1\,kg}{1gm}\right]^1 \left[\frac{1\,m}{1\,cm}\right]^2 \left[\frac{1\,sec.}{1\,sec.}\right]^{-2}$$

$$\Rightarrow n_2 = 1 \left[\frac{1000\,gm}{1\,gm}\right]^1 \left[\frac{100\,cm}{1\,cm}\right]^2 \left[1\right]^{-2}$$

$$\Rightarrow n_2 = 1 \times 1000 \times 10{,}000 \times \frac{1}{1^2}$$

$$\Rightarrow n_2 = 1 \times 10^7 \times \frac{1}{1}$$

$$\Rightarrow n_2 = 10^7$$

1 Joule $: 10^7$ erg. — Ans

~~Ex. 2.3.~~

Exer. 2.3. A calorie is a unit of heat (energy in transit) and it equals about 42 J, where $1\,J = 1\,kg\,m^2 s^{-2}$ suppose. we employ a system of unit of lenghth equals β ~~α~~ ~~kg~~ m and mass equals α kg and time is γ (gaama) sec. show that a calorie has a magnitude $4.2\,\alpha^{-1}\beta^{-2}\gamma^2$ in terms of the new units.

Ans. $n_2 = 4.2 \times \alpha$

$1 \text{ cal.} = 4.2 \text{ Joule}$

$1 \text{ Joule} = 1 \text{ kg } m^2/s^2 = 1 \text{ kg } m^2 s^{-2}$

mass $= \alpha$ kg, lenghth $= \beta$ m, time $= \gamma$ s

Prove : $1 \text{ cal.} = 4.2\, \alpha^{-1} \beta^{-2} \gamma^{2}$ in new unit

$1 \text{ cal.} = 4.2 \text{ J} \longrightarrow \_\_\_\_ \alpha\beta\gamma$

Here ; $n_1 = 4.2$, $a = 1$, $b = 2$, $s = -2$

$$\Rightarrow n_2 = n_1 \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

$$\Rightarrow n_2 = 4.2 \left[\frac{1 \text{ kg}}{\alpha}\right]^1 \left[\frac{1 \text{ m}}{\beta}\right]^2 \left[\frac{1 \text{ s}}{\gamma}\right]^{-2}$$

$$\Rightarrow n_2 = 4.2 \times \left[\alpha^{-1}\right] \left[\beta^{-2}\right] \left[\gamma\right]^2$$

$$\Rightarrow n_2 = 4.2\, \alpha^{-1} \beta^{-2} \gamma^{2} \text{ in new unit.}$$

Eg. 2.7. Find absolute error, relative error and % error

Measured - True.

2.63, 2.56, 2.42, 2.71, 2.80

	Measurement	Mean (T) measurement	absolute error	mean absolute error (ΔT_{mean})
1)	2.63	$\frac{13.12}{5} \Rightarrow 2.62$	① 2.63 − 2.62 = 0.01 s	$\frac{0.54}{5}$
2)			② 2.56 − 2.62 s = −0.06 s	
3)			③ 2.42 − 2.62 = −0.20 s	⇒ 0.11
4)			④ 2.71 − 2.62 = 0.09 s	
5)			⑤ 2.80 − 2.62 = 0.18 s	

Relative error	% error
$\frac{0.11}{2.62} \Rightarrow 0.04$	$0.04 \times 100 = 4\%$

Absolute error – The difference in the actual measurement of the physical quantity and the measurement done personally by the observer is called the absolute error.

Relative error – The ratio of absolute error to the actual measurement of the physical quantity is called the relative error in that Physical quantity.

$$\text{Relative error} = \frac{\text{Absolute error}}{\text{Actual value}} = \frac{\Delta T_{mean}}{T}$$

\# Absolute error → ~~Percentage error~~ → The difference in the actual measurement of the physical quantity and the measurement done personally by the observer is called the absolute error.

\# Percentage error → Relative error in terms of percentage is called % error.

Q. 4.52 cm, 4.53 cm, 4.54 cm, 4.55 cm. Find absolute error, relative error and % error.

Measurement	Mean Measurement (error)	Absolute error
1) 4.52 cm	$\frac{18.14}{4} \Rightarrow 4.53$ cm	0.01
2) 4.53 cm		0
3) 4.54 cm		0.01
4) 4.55 cm		0.02

Mean absol. error	Relative error	% error
$= \frac{0.01 + 0 + 0.01 + 0.02}{4}$	$\frac{0.01}{4.53} \Rightarrow 0.00$	$0.00 \times 100 = 0\%$
$= 0.01$		

Combination of errors -

i) Error of a sum -

True = 10.1
Measured = 10.0
error = 0.01
Then,
Correct form = 10.0 + 0.01 error

$A \Rightarrow A \pm \underset{(\text{error})}{\Delta A}$, $B \Rightarrow B \pm \Delta B$, $Z \Rightarrow Z \pm \Delta Z$

$\Rightarrow Z \pm \Delta Z = A \pm \Delta A + B \pm \Delta B$
$\Rightarrow Z \pm \Delta Z = (A + B) \pm (\Delta A + \Delta B)$

ii) Error of a difference -

$\Rightarrow Z = A - B$

$\Rightarrow Z \pm \Delta Z = A \pm \Delta A - B \pm \Delta B$

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

iii) Error of a Product -

$\Rightarrow Z = A \times B$

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

iv) Error of a Division. -

$\Rightarrow Z = \frac{A}{B}$

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

v) Error in Power -

$\Rightarrow Z = A^n$

$\Rightarrow \frac{\Delta Z}{Z} = n \frac{\Delta A}{A}$

Eg. 2.8 The temp. of two bodies measured by a thermometer are $t_1 = 20°C \pm 0.5°C$ and $t_2 = 50°C \pm 0.5°C$? calculate the temp. difference and the error theirin.

$\Rightarrow t_1 = 20°C \pm 0.5°C$

$\Rightarrow t_2 = 50°C \pm 0.5°C$

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

$\Rightarrow t \pm \Delta t = (50° - 20°) \pm (0.5° + 0.5°)$

$\Rightarrow t \pm \Delta t = 30°C \pm 1°C$ —— Ans.

Que. $\theta_1 = (16 \pm 0.5)°C$

$\theta_2 = (41 \pm 0.5)°C$

Find difference -

$\Rightarrow Z = A - B$

$\Rightarrow Z \pm \Delta Z = A \pm \Delta A - B \pm \Delta B$

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

$\Rightarrow \theta \pm \Delta\theta = (41° - 16°) \pm (0.5° + 0.5°)$

$\Rightarrow \theta \pm \Delta\theta = 25°C \pm 1°C$ —— Ans.

Eg. 2.11, Find the relative error in z,

if $z = \dfrac{A^4 B^{\frac{1}{3}}}{C D^{\frac{3}{2}}}$

$\Rightarrow \dfrac{\Delta Z}{Z} = \dfrac{4\,\Delta A}{A} + \dfrac{1}{3}\dfrac{\Delta B}{B} + \dfrac{\Delta C}{C} + \dfrac{3}{2}\dfrac{\Delta D}{D}$ - Ans.

Eg. 2.13 Find error in P in -

$P = \dfrac{a^3 \cdot b^2}{\sqrt{c} \cdot d}$

Error % in a = 1%, b = 3%, c = 4% and d = 2%.

$\Rightarrow \dfrac{\Delta P}{P} = \dfrac{3\,\Delta a}{a} + \dfrac{2\,\Delta b}{b} + \dfrac{1}{2}\dfrac{\Delta c}{c} + \dfrac{\Delta d}{d}$

$\Rightarrow \dfrac{\Delta P}{P} = \dfrac{3 \times 1}{100} + \dfrac{2 \times 3}{100} + \dfrac{1}{2} \times \dfrac{4}{100} + \dfrac{2}{100}$

$\Rightarrow \dfrac{\Delta P}{P} = \dfrac{3}{100} + \dfrac{6}{100} + \dfrac{2}{100} + \dfrac{2}{100}$

$\Rightarrow \dfrac{\Delta P}{P} = 3\% + 6\% + 2\% + 2\%$

$\Rightarrow \dfrac{\Delta P}{P} = 13\%$

Q. $x = \frac{a^2 b^3}{c \cdot \sqrt{d}}$ error in x.

$a = 4\%$, $b = 2\%$, $c = 3\%$, $d = 1\%$

$\Rightarrow \frac{\Delta x}{x} = 2\frac{\Delta a}{a} + 3\frac{\Delta b}{b} + \frac{\Delta c}{c} + \frac{1}{2}\frac{\Delta d}{d}$

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

$\Rightarrow \frac{\Delta x}{x} = \frac{8}{100} + \frac{6}{100} + \frac{3}{100} + \frac{.5}{100}$

$\Rightarrow \frac{\Delta x}{x} = 8\% + 6\% + 3\% + .5\%$

$\Rightarrow \frac{\Delta x}{x} = 17.5\%$

Eg. 2.12. The Period of oscillation of a simple Pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$. Measured value of L is 20.0 cm known to 1mm accuracy and time for 100 oscillation of the pendulam is found to be 90 s using a wrist watch of 1s resolution. What is the accuracy in the determination of g?

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

⇒ $T^2 = 4\pi^2 \left(\frac{l}{g}\right)$ (on squaring both side)

⇒ $gT^2 = 4\pi^2 (l)$

⇒ $gT^2 = l$ ($4\pi^2$ is constant and removed)

⇒ $g = \frac{l}{T^2}$

⇒ $\frac{\Delta g}{g} = \frac{\Delta l}{l} + \frac{2\Delta T}{T}$

⇒ $\frac{\Delta g}{g} = \frac{0.1}{20} + \frac{2 \times 1}{90}$ (1mm = 0.1 cm)

⇒ $\frac{\Delta g}{g} = \frac{1}{200} + \frac{2}{90}$

⇒ $\frac{\Delta g}{g} = \frac{90 + 400}{18000}$

⇒ $\frac{\Delta g}{g} = \frac{490}{18000}$

⇒ $\frac{\Delta g}{g} = 0.03$

⇒ $\frac{\Delta g}{g} = 3\ \%$

Significant figures – The no. of digits used to express accurately the measured value of the physical quantity is called the significant figures.

i) 1.234 → 4
ii) 12.34 → 4
iii) 3010.05 → 6
iv) 6.007 → 4
v) 6.320 → 4
vi) 6320 → 3
vii) 13200 → 3

Rounding off figures –

i) 25.0452 (5) → 25.045
ii) 2.09 (2) → 2.1
iii) 2.35 (2) → 2.4
iv) 2.65 (2) → 2.6

Exercise

Que. 2.1 Fill in the blanks

(a) The volume of a cube of side 1cm is equal to $\underline{10^{-6}}\ m^3$

Ans. Volume of cube $= (1\ cm)^3$

$(1\ cm)^3 \Rightarrow (10^{-2}\ m)^3$

$10^{-6}\ m^3$

Hence, answer is 10^{-6}.

(b) The surface area of a solid cylinder of radius 2.0 cm and height 10.0 cm is equal to 1.5×10^4 (mm)^2

Ans. $$\text{surface area} = 2\pi rh + 2\pi r^2$$
$$= 2\pi r(h + r)$$
$$= 2 \times \frac{22}{7} \times 2 (10 \times 10 + 2 \times 10)\ mm^2$$

$$\text{surface area} = 1.5 \times 10^4\ mm^2$$

Hence, answer is 1.5×10^4

Ans. $r = 2.0$ cm , $h = 10.0$ cm

$$\text{Curved Area} = 2\pi rh$$
$$= 2 \times \frac{22}{7} \times 2.0 \times 10.0$$
$$= 125.71\ cm^2$$
$$= 125.71 \times (10^1\ mm)^2$$
$$= 125.71 \times 10^2\ mm^2$$
$$= 1.26 \times 10^3\ mm^2$$
$$= 1.3 \times 10^4\ mm^2$$

Hence, answer is 1.3×10^4

(c) A vehicle moving with a speed of 18 km h^{-1} covers 5 m in 1s.

Ans. Given,

$v = 18$ km/h , $d = ?$, $t = 1$s

$$v = \frac{18 \times 1000}{60s \times 60s} = \frac{18 \times 10}{36}$$

$$v = 5\ m/sec.$$

$$v = \frac{d}{t} \Rightarrow d = v \times t$$

$$\Rightarrow d = \frac{5m}{sec.} \times 1 sec.$$

$$\Rightarrow d = 5m$$