

14/May
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Physical Word, Units of Measurement

Physics = The study of nature & it's law

Physical Quantity

It can be measured with the help of an instruments

Ex :- Temperature, Mass, Length, time etc

Types of physical quantity

1. → Fundamental physical quantity

↳ They are basic in nature & independent from each other [Numerical Value + Units]

Fundamental physical Quantity	MKS	CGS	FPS	SI
Length (L)	Meter	Centi-meter	Feet	Meters [m]
Mass (M)	Kilogram	Gram	Pound	Kilogram [Kg]
Time (t)	Second	Sec	Sec	Second [s]
Current (i)				Ampere [A]
Temperature (T)				Kelvin [K]
Amount of Substance				Mole [mol]
Luminous intensity (Li)				Candela [cd]

2 Derived Physical Quantity

→ It is a combination of two or more fundamental physical quantity

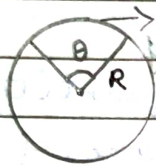
→ Ex:- Force, density, acceleration, velocity, momentum

3 Supplementary Physical Quantity

Plane Angle

Formed by intersection of 2 angle.

Circle arc length



$$\text{Angle } \theta = \frac{\text{arc length}}{\text{Radius}}$$

SI unit :- Radian

Other unit :- degree

Solid Angle

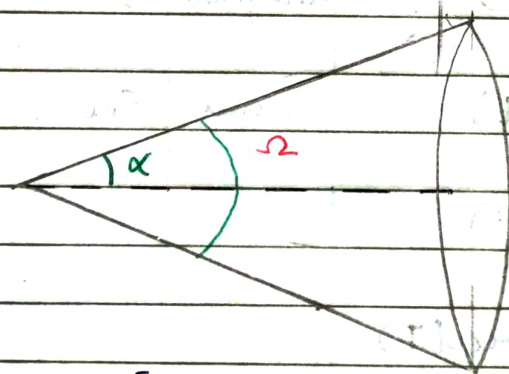
3D angle



Sphere

$$\Omega = \frac{\text{Surface Area}}{R^2}$$

SI unit :- Steradian



[α = half angle at vertex]

$$\Omega = 2\pi[1 - \cos\alpha]$$

Dimensional formula of physical quantity



$$[\text{Mass}] = [M]$$

$$[\text{Area}] = [L^2]$$

$$[\text{Volume}] = [L^3]$$

$$[\text{Density}] = [ML^{-3}]$$

$$[\text{Speed}] = \frac{\text{distance}}{\text{time}} = [LT^{-1}]$$

$$[\text{Velocity}] = [LT^{-1}]$$

$$\text{Linear Momentum} = [MLT^{-1}]$$

$$[\text{Acceleration}] = [LT^{-2}]$$

$$ML^2 - 1$$

Current = At

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$$[Force] = [MLT^{-2}]$$

$$[Work] = [ML^2t^{-2}]$$

$$[Energy] = [ML^2T^{-2}]$$

$$[Power] = [ML^2T^{-3}]$$

$$\text{Linear Impulse} = \text{Force} \times \text{time} = [MLT^{-1}]$$

$$\begin{aligned}\text{Torque} &= \text{Force} \times \text{Perpendicular distance} \\ &= [ML^2T^{-2}]\end{aligned}$$

Note :- Different physical quantities can have same dimensional formula

$$\text{Angle} \equiv [m^{\circ}c^{\circ}t^{\circ}] \rightarrow \text{Dimensionless}$$

Linear Motion

$$\frac{v}{x} \rightarrow$$

$$v = \frac{x}{t}$$

θ , Angular displacement

Angular Velocity

$$\omega = \theta/t$$

Angular Acceleration (α) = $^{\circ}/t$

$$[\omega] = [T^{-1}]$$

$$[\alpha] = [T^{-2}]$$

Angular Momentum

$\rightarrow$ Distance $\times$ linear momentum

$$\rightarrow [ML^2T^{-1}]$$

$$MLT^{-2} \times$$

$$ML$$

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

Application of dimensional analysis

$\rightarrow$ To check dimensional correctness of an eqn.

$$\text{eg :- } s = ut + \frac{1}{2}at^2$$

$$\rightarrow [L] \rightarrow [LT^{-1}][T] \rightarrow [LT^{-2}][T^2]$$

$$s = ut + \frac{1}{3}at^2 \quad \nrightarrow \quad s = ut + \frac{1}{2}at^3$$

If an equation is dimensionally correct it may or may not be actually correct.

But a dimensionally incorrect equation is always $\nrightarrow$ correct

Principle of homogenation

→ Addition or subtraction is possible for two physical quantities having same dimensional formula.

Ex: Velocity of a particle moving in a straight line is given as.

$$v = a + bt + \frac{c}{d+t}$$

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

$$LT^{-1} = [b][T]$$

$$[b] = [LT^{-2}]$$

$$[b] = LT^{-2}$$

$$[c] = [L]$$

$$LT^{-1} = \frac{[c]}{T} \Rightarrow [c] = LT$$

$$[d] = [T]$$

Ex

$$\frac{A}{v+c} + t = Bx$$

$x \rightarrow$ position

$t \rightarrow$ time

$$[A] = [L]$$

$$[B][L] = [T]v - \text{Velocity}$$

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

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

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

$$\frac{[A]}{[LT^{-1}]} = T \quad [A] = L$$

Note:-

1) Powers are dimensionless

$$2^{kg} \rightarrow x \quad 2^{kg} - v$$

2) $\sin x, \cos x, \ln x, e^x$ are dimensionless

D.Les. $\leftarrow$ Dimensionless

$$Ex: x = A \sin(Bt) \quad t \rightarrow \text{time}$$

Displacement

$$x = A \sin(Bt) \quad [Bt] =$$

$$[A] = [L]$$

$$[B][T] = m^0 L^0 T^0$$

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

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

Ex $f = \frac{ce^{-kx}}{x^2} \rightarrow \text{displacement}$
 $\downarrow$
 force
 $[C] = [ML^3T^{-2}]$
 $[K] = [L^{-1}]$

Ex $\alpha = \frac{F \sin(\beta t)}{v^2} \rightarrow \text{time}$
 $\downarrow$
 $\downarrow$
 velocity
 $[\beta] = t^{-1}$
 $[\alpha] = \frac{MLT^{-2}}{L^2T^{-2}} [ML^{-1}] = [ML^{-1}]$

2) To find dimensional formula of dimensionless constant

a) $F = G \frac{m_1 m_2}{r^2}$ $\frac{MLT^{-2} \times M \times M}{L^2}$
 $(G = M^{-1}L^3T^{-2})$ $M^{-1}L^3T^{-2}$
 $\hookrightarrow$ Gravitation force

b) $F = \frac{h\nu}{c}$
 $\downarrow$
 Energy $\downarrow$ frequency $\downarrow$
 $\downarrow$
 $\downarrow$

$ML^2T^{-2} = [h][T^{-1}]$
 $[h] = ML^2T^{-1}$

3) To find relation among various physical quantities
 $[v], [T]$

Chosen as base quantities, dimensions of mass will be

$M \propto F^x T^y v^z$
 $M \propto [MLT^{-2}]^x [T]^y [LT^{-1}]^z$

For mass $1 = x$

For length $0 = x + z \quad z = -1$

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

$0 = -2(1) + y - (-1) \quad y = 1$

If the velocity of light C , Universal Gravitational constant G & Planck constant (h) are chosen as fundamental quantities. The dimensions of mass in the new system

is $m \propto h^x c^y a^z$ C, G

$m \propto h^x c^y a^z$

$m \propto [ML^2T^{-1}]^x [LT^{-1}]^y [m^{-1}L^3T^{-2}]^z$

Light $C =$

$M = x - z$

$0 = x - z$

length $= 2x - y + 3z$

time $= -x - y - 2z$

$-(x + y + 2z)$

$2x - y + 3z$

$x - z$

$x + z + x - z = 1$

$2x = 1$

$z = -\frac{1}{2}$

$x = \frac{1}{2}$

$-\frac{1}{2} - y - 2(-\frac{1}{2})$

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

$-\frac{1}{2} + 1 = y$

$-\frac{1}{2} + 2 = \frac{1}{2} - \frac{1}{2}y$

Conversion of unit

Magnitude = $n \cdot u$
 numerical val $\times$ unit

$$n_1 u_1 = n_2 u_2$$

$$5 \text{ g/kg.}$$

Pg 23 Q 31

Sol

$$n_1 u_1 = n_2 u_2$$

$$128 \frac{\text{kg}}{\text{m}^3} = n_2 \times \frac{50 \text{g}}{25 \text{cm}^3}$$

$$\Rightarrow \frac{n_2 \times 50 \times 50 \times 10^{-3}}{25 \times 25 \times 25 \times 10^{-6}} = 128 \frac{\text{kg}}{\text{m}^3}$$

$$\Rightarrow n_2 = \frac{128 \times 25 \times 25 \times 25 \times 10^{-6} \times 10^{-3} \times 4 \times 4}{50 \times 10^{-3} \times 4 \times 4}$$

$$n_2 = 4 \times 100 \times 100 \times 10^{-3}$$

$$= 4 \times 10000 \times 10^{-3}$$

$$= 40000 \times 10^{-3}$$

$$= 40$$

5th Adv
2023
Paper - 02

$$Y = C^{\alpha} h^{\beta} G^{\gamma}$$

$$[Y] = [MLT^{-2}] = [ML^{-1}T^{-2}]$$

$$[LT^{-1}]^{\alpha} [L^2]^{\beta} [M^{-1}L^3T^{-2}]^{\gamma}$$

$$[ML^{-1}T^{-2}] = [LT^{-1}]^{\alpha} [ML^2T^{-1}]^{\beta} [M^{-1}L^3T^{-2}]^{\gamma}$$

$$1 = \beta - \gamma$$

$$-1 = \alpha + 2\beta + 3\gamma$$

$$-2 = -\alpha - \beta - 2\gamma$$

$$1 = \beta - \gamma$$

$$\beta = \gamma + 1$$

$$-1 = \alpha + 2(\beta + \gamma)$$

$$-1 =$$

$$-1 = \alpha + 2\beta + 3\gamma$$

$$-1 = \alpha + 2(\gamma + 1) + 3\gamma$$

$$-1 = \alpha + 2\gamma + 2 + 3\gamma$$

$$-1 = \alpha + 5\gamma + 2$$

$$\alpha = -3 - 5\gamma$$

$$-2 = +3 + 5\gamma - 2\gamma$$

$$-2 - 3 = 3\gamma$$

$$-5 = 3\gamma$$

$$-2 = -(-3 - 5\gamma) - (\gamma + 1) - 2\gamma$$

$$-2 = +(3 + 5\gamma) - \gamma - 1 - 2\gamma$$

$$-2 = 3 + 5\gamma - 3\gamma - 1$$

$$-2 = 2 + 2\gamma$$

$$-4 = 2\gamma$$

$$\gamma = -2$$

$$\alpha = -3 - 5(-2)$$

$$\alpha = -3 + 10$$

$$\alpha = 7$$

$$\beta = \gamma + 1$$

$$\beta = -2 + 1$$

$$\beta = -1$$

$$A) \alpha = 7, \beta = -1, \gamma = -2$$

Pg 24
H2O3

$$r_2 = \frac{n}{m^2} v$$

$$a_2 = \frac{a_1}{mn}$$

$$L_2 T_2^{-1} = \frac{n}{m^2} L_1 T_1^{-1} \text{ --- (1)}$$

$$L_2 T_2^{-2} = \frac{L_1 T_1^{-2}}{mn}$$

$$\frac{L_2}{L_1} = \frac{n}{m^2} \left(\frac{T_1}{T_2} \right)^{-1}$$

$$\frac{L_2}{L_1} = \left(\frac{1}{mn} \right) \left(\frac{T_1}{T_2} \right)^{-2}$$

$$\frac{L_2}{L_1} = \frac{n}{m^2} \left(\frac{T_2}{T_1} \right)$$

$$= \frac{1}{mn} \left(\frac{T_2}{T_1} \right)^2$$

$$\frac{T_2}{T_1} = \frac{L_2}{L_1} \left(\frac{m^2}{n} \right)$$

$$= \frac{1}{mn} \left(\frac{L_2^2}{L_1^2} \right) \frac{m^4}{n^2}$$

$$\frac{T_2}{T_1} = \frac{n^3}{m^3} \times \frac{m^2}{n}$$

$$= \frac{L_2}{L_1} \times \frac{mn \times n^2}{n^3} \times \frac{n^3}{m^3}$$

$$= \frac{n^2}{m}$$

$$L_2 = \frac{n^3}{m^3} \times L_1$$

Significant Figures → How accurate the nu. is

↳ ~~a = 31.2~~ → It tells how accurate a nu. is
↳ Rules:

1. All non-zero digits are considered significant
e.g :- 1.57 → 3 SF. 2173 → 4 SF

2. All zeroes appearing b/w 2 non zero digit are considered significant
e.g :- 101 → 3 SF 1001 → 4 SF

3. The trailing zeroes in a nu. without decimal is not considered significant :-
e.g :- 100 → 1 SF 1010 → 3 SF

4. The trailing zeroes with the nu. with decimal is considered significant.
e.g :- 1.00 → 3 SF 2.3010 → 5 SF

5 If a nu. is less than 1, the zeros / zeros the left of the first non-zero digit is / are not considered significant

e.g:- $0.0125 \rightarrow 3 \text{ SF}$ $0.012500 \rightarrow 5 \text{ SF}$

6 If a nu. is given in $a \times 10^b$ (Scientific Notation) SF is calculated based on base a

e.g:- 0.25×10^5 ; $1.67 \times 10^{-27} \text{ Kg}$
 $\downarrow$ $\downarrow$
 2 SF 3 SF

7 Some nu. are exact that appear in mathematical formulae have infinite SF

e.g:- Perimeter of square = $4a$ $\leftarrow$ Infinity SF

Note: Changing units does affect SF

e.g $2.400 \text{ cm} = 24.00 \text{ mm}$
 $= 0.02400 \text{ m}$

Q Find SF

1. $0.00602 \rightarrow 3 \text{ SF}$

2. $0.00602 \times 10^{-5} \rightarrow 3 \text{ SF}$

* Rounding Off.

If the nu. to be rounded off is more than 5, the preceding digit is added +1.

Ex:- $1.376 \rightarrow 1.38 \rightarrow$ Round off to 3 SF

If the nu. to be rounded off is less than 5, the preceding digit remains unchanged
 $1.3474 \rightarrow 1.35$

If the nu. to be rounded off is 5, if the preceding digit is odd, add +1, or if the preceding digit is even it remains unchanged.

$$3.745 \rightarrow 3SF \rightarrow 3.74$$

$$3.775 \rightarrow 3SF \rightarrow 3.78$$

Ex: $2.520 \rightarrow 2F \rightarrow 2.5$

Rules for Arithmetic Operation with SF

1 Addition / Subtraction

→ When two quantities are added / subtracted, there should be as many decimal places retained in the final result as are there in the nu. with least decimal places

Q Find the value of $9.99m - 0.0099m$

$$\begin{array}{r} 9.99 \\ - 0.0099 \\ \hline 9.9801 \end{array}$$

2Q Multiple of Division

→ The final result should contain least no. of SF out of the two

$$\frac{4.11}{1.2} = 3.425 = 3.4$$

Ex: D of a circle is $2.16cm$ find Radius

$$\frac{2.16}{2} = 1.08m \rightarrow \text{Infinity set}$$



3 Error

→ It is the deviation from true value

→ True Value :-

Value printed on a product

Calculation of errors

1. Absolute error -

$$| \text{Observed value} - \text{True value} |$$

2. Mean Absolute error =

Avg of all absolute error

3. Relative error / fractional error

$$\frac{\text{Mean Absolute error}}{\text{True value}}$$

4. Percentage error = Relative error $\times 100\%$

Q. The length of a rod as measured in the experiment is found to be 2.48m, 2.46m, 2.49m, & 2.46m. Find the avg. length & Absolute error in each of the question & % error.

Sol

$$\frac{9.80}{5} = 1.96$$

$$\frac{12.38}{5} \rightarrow 2.4764$$

$$\begin{array}{r} 2.48 \\ 2.46 \\ 2.49 \\ 2.46 \\ \hline 9.80 \\ 2.4764 \\ \hline 12.29 \end{array}$$

Absolute Error

$$| 2.48 - 2.4764 | = 0.004$$

$$| 2.46 - 2.4764 | = 0.016$$

$$| 2.49 - 2.4764 | = 0.014$$

$$| 2.46 - 2.4764 | = 0.016$$

$$| 2.46 - 2.4764 | = 0.016$$

$$\text{Mean Absolute Error} = \frac{0.004 + 0.016 + 0.014 + 0.016 + 0.014}{5}$$

$$= \frac{0.064}{5} = 0.0128$$

$$\% \text{ error} = \frac{0.0128}{2.476} \times 100$$

8. A student in the laboratory measures thickness of a wire using screw gauge. The readings are 1.22 mm, 1.23 mm, 1.19 mm + 1.20 mm. The % error is $x\%$

The value of x is $\frac{121}{121}\%$

Sol

$$\begin{array}{r} 1.22 + 1.23 + 1.19 + 1.20 \\ \hline 4 \\ \hline 4.84 \end{array} \quad \begin{array}{r} 1.22 \\ 1.23 \\ 1.19 \\ 1.20 \\ \hline 4.84 \end{array}$$

Absolute error

$$\begin{array}{l} |1.22 - 4.84| = 3.62 \quad 0.01 \\ |1.23 - 4.84| = 3.61 \quad 0.02 \\ |1.19 - 4.84| = 3.65 \quad 0.02 \\ |1.20 - 4.84| = 3.64 \quad 0.01 \end{array}$$

Mean Absolute error :-

$$\frac{3.62 + 3.61 + 3.65 + 3.64}{4}$$

$$\frac{0.01 + 0.02 + 0.02 + 0.01}{4}$$

$$\frac{0.06}{4} = 0.015$$

$$\% \text{ error} = \frac{0.015}{1.21} \times 100 = \frac{1.500}{1.21}$$

VIP

Combination Of Error.

1. Due to addition

$$Z = A + B$$

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

↓ ↓ ↓ ^{Mean} ↓

Max. error Error Error [Absolute error]

in Z in A in B

Ex :- $l_1 = (2 \pm 0.2) \text{ cm}$

$$l_2 = (3 \pm 0.3) \text{ cm}$$

$$Z = l_1 + l_2$$

$$\Delta Z = 0.5$$

$$Z = 5 \pm 0.5 //$$

2. Due to Subtraction

$$Z = A - B$$

$$A = 3 \pm 0.3 (2.7 - 3.3)$$

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

$$B = 2 \pm 0.2 (1.8 - 2.2)$$

$\Delta \rightarrow$ Max error in Z

True Value $(A - B) = 1$

Note :- Error always added

X (3. Due to multiplication) X. Shifted to next page

The initial & final temperature of water as observed are $(40.6 \pm 0.2)^\circ\text{C}$ & $(78.3 \pm 0.3)^\circ\text{C}$ Find

2. $37.7 \pm 0.5 //$

3.

Due to $\times$.

$$z = A \cdot B$$

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

$$\frac{dz}{dt} = A \frac{dB}{dt} + B \frac{dA}{dt}$$

$$dz = A dB + B dA$$

$$\text{divided by } z : \frac{dz}{z} = \frac{A dB}{AB} + \frac{B dA}{AB}$$

$$\frac{dz}{z} = \frac{dB}{B} + \frac{dA}{A}$$

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

4

Due to $\div$

$$z = \frac{A}{B}$$

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

$$\frac{dz}{dt} = B \frac{dA}{dt} - A \frac{dB}{dt}$$

$$B^2$$

$$dz = \frac{dA}{B} - \frac{A}{B^2} dB \quad] \text{ Divided by } z$$

$$= \frac{dA}{\frac{B \times A}{B}} - \frac{A}{\frac{B^2 \times A}{B}} dB$$

$$\Rightarrow \frac{dz}{z} = \frac{dA}{A} + \frac{dB}{B}$$

Errors Always +

Q The Resistance R equals $\frac{V}{I}$, where $V = [50 \pm 2]$,
 $I = [20 \pm 0.2] A$. The % error in R is x%.

Sol

$$\frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$$

$$= \frac{2}{50} + \frac{0.2}{20}$$

$$= \frac{40 + 10}{1000}$$

$$= \frac{50}{1000} \times 100$$

$$= 5\%$$

— || Error due to Power || —

$$Z = \frac{P \cdot Q}{C \cdot R}$$

$$\frac{\Delta Z}{Z} = P \frac{\Delta A}{A} + Q \frac{\Delta B}{B} + R \frac{\Delta C}{C}$$

$$\% \text{ error in } Z = \frac{\Delta Z}{Z} \times 100$$

$$= P(\% \text{ error in } A) + Q(\% \text{ error in } B) + R(\% \text{ error in } C)$$

Q The max. error in the measurement of Resistance, current & time for which current flows in an electrical circuit are 1%, 2% & 3% respectively. The max % error in the detection of the dissipated heat will be.

Sol

$$Q = i^2 R t$$

$$100 \times \frac{\Delta Q}{Q} = \left(2 \frac{\Delta I}{I} + \frac{\Delta R}{R} + \frac{\Delta t}{t} \right) \times 100$$

$$\begin{array}{r} 0.250 \\ 00 \\ 107 \\ \hline 10.0 \end{array}$$

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$$= (2 \times 2 + 1 + 3) \cdot \% \Rightarrow 8 \cdot \%$$

Ex A cylindrical wire a mass $(0.4 \pm 0.01)g$ has length $= (8 \pm 0.04)cm$ $r = (6 \pm 0.03)mm$. The max error in its density will be .

Sol) Density = $\frac{\text{Mass}}{\text{Vol.}} = \frac{m}{\pi r^2 l}$

$$\frac{\Delta \rho}{\rho} = \frac{\Delta m}{m} + 2 \frac{\Delta R}{R} + \frac{\Delta l}{l}$$

$$= \frac{0.01}{0.4} + 2 \frac{(0.03)}{6} + \frac{0.04}{8}$$

$$= \frac{0.01}{0.4} \times 100 + \frac{0.06}{6} \times 100 + \frac{0.04}{8} \times 100$$

$$= 2.5 + 1 + 0.5 = 4 \cdot \%$$

Application of Physics

1) Resistors in Series combination.

$$R_s = R_1 + R_2$$

2) Resistors in parallel combination

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{\Delta R_{ep}}{R_{ep}^2} = \frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}$$

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

$$\frac{dR_{ep}}{R_{ep}^2} = \frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}$$

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{\Delta f}{f^2} = \frac{\Delta v}{v^2} + \frac{\Delta u}{u^2}$$

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\frac{\Delta f}{f^2} = \frac{\Delta v}{v^2} + \frac{\Delta u}{u^2}$$

Q. 2 Resistors $R_1 = (4 \pm 0.8)\Omega$ & $R_2 = (4 \pm 0.4)\Omega$ connected in parallel. The equivalent resistance of their combination will be

Sol: $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}$

$$R_{eq} = 2$$

$$= \frac{0.8}{4^2} + \frac{0.4}{4^2}$$

$$= \frac{0.8}{4} + \frac{0.4}{4}$$

$$= \frac{1.2}{4}$$

$$4^0 = 0.3$$

$$4 \times 0.3$$

$$8 \times 0.85 \times 100$$

$$7.5$$

$$2.5$$

$$\begin{array}{r} 0.85 \times 40 \\ 000 \\ 340 \\ \hline 34.00 \end{array}$$

$$\begin{array}{r} 0.1 \times 40 \\ 0.4 \end{array}$$

$$2.5 \times 3$$

$$7.5$$

$$2.5 \times 4$$

$$10.0$$

$$\begin{array}{r} 14 \\ 85 \\ \hline 7.5 \\ \hline 77.5 \end{array}$$

b) Error in Area & Volume,

$$S = 4\pi r^2$$

$$V = \frac{4}{3} \pi r^3$$

$$\frac{dS}{S} = 2 \frac{dr}{r}$$

$$\frac{dV}{V} = 3 \frac{dr}{r}$$

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

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

Ex The radius of a sphere is measured to be (7.50 ± 0.85) cm. Suppose the % error in its vol. is x . Find x (nearest int.).

$$\begin{aligned} S &= 4\pi r^2 \\ \frac{\Delta V}{V} &= 3 \times \frac{0.85}{7.50} \times 100 = \frac{2.5 \times 4}{10.0} \times 100 = 100 \\ &= 34.7\% \end{aligned}$$

Time period of simple pendulum

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

$$\frac{\Delta T}{T} = \frac{1}{2} \frac{\Delta l}{l} + \frac{1}{2} \frac{\Delta g}{g}$$

$$\frac{\Delta T}{T} \times 100 = \frac{1}{2} \frac{\Delta l}{l} \times 100 + \frac{1}{2} \frac{\Delta g}{g} \times 100$$

% error in Time period

$$g = \frac{4\pi^2 l}{T^2}$$

$$\frac{\Delta g}{g} \times 100 = \frac{\Delta l}{l} \times 100 + \frac{2\Delta T}{T} \times 100$$

$$l = \frac{4\pi^2 g T^2}{g}$$

$$\frac{\Delta l}{l} \times 100 = \frac{\Delta g}{g} \times 100 + \frac{2\Delta T}{T} \times 100$$

$$\frac{2.5 \times 31}{7.5}$$

Ex If % error in length of a pendulum & time period of it, are 2% & 3% respectively. Find % error in acceleration due to gravity

$$\text{Sol } \frac{\Delta g}{g} \times 100 = 2\% + 2(3\%)$$

$$= 2 + 6$$

$$= 8\%$$

The energy of a system is given $E(t) = \alpha^3 e^{-\beta t}$, where t is the time & $\beta = 0.3 \text{ sec}^{-1}$. The error in the measurement of α & t are 1.2% & 1.6% respectively. At $t = 5 \text{ sec}$

$$\text{Sol } E(t) = \alpha^3 e^{-\beta t}$$

$$= \alpha^3 e^{-0.3t}$$

$$\frac{dE}{d\alpha} = \alpha^2 e^{-0.3t}$$

$$= 2\alpha + (0.3) \frac{dt}{dt} + e^{-0.3t} 3\alpha^2 \frac{d\alpha}{d\alpha}$$

$$= 2\alpha + 0.3t$$

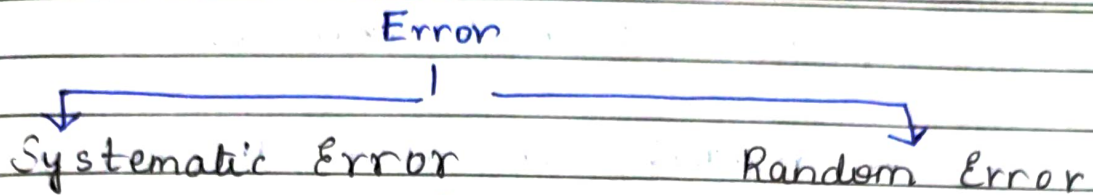
$$\frac{dE}{E} = \frac{\alpha^2 e^{-0.3t} (0.3) dt}{\alpha^3 e^{-0.3t}} + \frac{e^{-0.3t} 3\alpha^2 d\alpha}{\alpha^3 e^{-0.3t}}$$

$$\frac{dE}{E} = 0.3 \frac{dt}{t} + 3 \frac{d\alpha}{\alpha}$$

$$\frac{dE}{E} \times 100 = 0.3 \frac{dt}{t} \times t \times 100 + 3 \frac{d\alpha}{\alpha} \times 100$$

$$= 0.3 \times 1.6 \times 5 + 3 \times 1.2$$

$$= 6\%$$



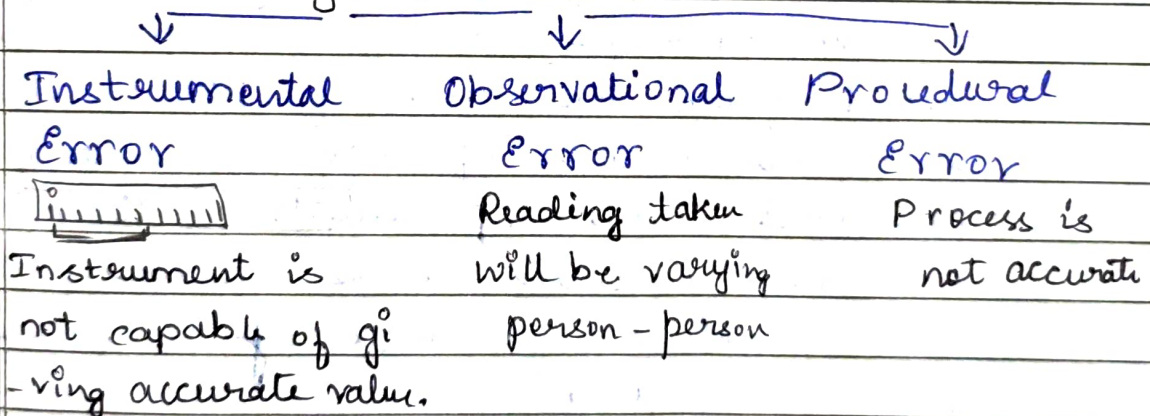
Systematic Error

- Cause of error is known
- Prevention is possible

Random Error

- Cause of error is not known
- Prevention is not possible
- Error is minimised by taking more no. of observation.

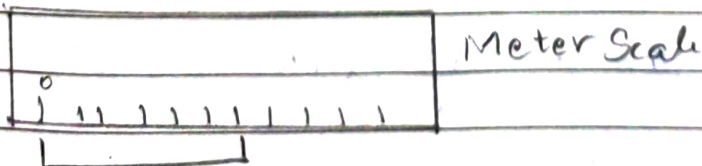
Systematic Error



Least count of an instrument

- It is the smallest measurement that can be made with the help of the instrument
- LC is taken as maximum possible error.

Look



Digital Instrument Truncation.

→ A digital stopwatch displaying 12.34 s has a least count of 0.01 sec

→ To actual time can be anywhere b/w 12.340

→ Max error = $12.350 - 12.340$
= 0.01

Resolution

→ Resolution of 0.1 sec means the smallest measurement from a watch is 0.1 sec

In an experiment to find acceleration due to gravity (g) using simple pendulum time period of 0.5 sec is measured from the time of 100 oscillations with the watch of 1 sec resolution is measured value of length is 10 cm known to 1 mm accuracy. The accuracy of determination of g is found to be 2.1%. Find g .

Qd)
$$\frac{\text{Total time } t}{n \rightarrow \text{no. of oscillations}} = T = 2\pi \sqrt{\frac{l}{g}}$$

$$\frac{t^2}{n^2} = 4\pi^2 \frac{l}{g}$$

$$\rightarrow g = 4\pi^2 \frac{l}{t^2} \cdot n^2$$

$$\frac{\Delta g}{g} \times 100 = \frac{\Delta l}{l} \times 100 + 2 \frac{\Delta t}{t}$$

$$= \frac{1 \text{ mm}}{100} \times 100 + 2 \times \frac{1}{70} \times 100$$
$$= 1 + 2.86 = 2.86 \approx 2.9\%$$