

Units and Measurement

Physical Quantity:-

The quantities which can be measured by an instrument and which describes the law of physical world.

Physical Quantity = numerical value $\times$ unit

$$PQ = n \times u$$

Types of Physical Quantity :-

1. Fundamental Physical Quantity

- Quantity which do not depend on any other PQ
- There are seven base units

	PQ	Unit	Symbol
1.	Length	metre	m
2.	mass	kilogram	kg
3.	Time	Second	s
4.	Temperature	Kelvin	K
5.	Electric Current	Ampere	A
6.	Luminous Intensity	Candela	cd
7.	No. of Substance	Mole	mol

2. Derived Physical Quantity

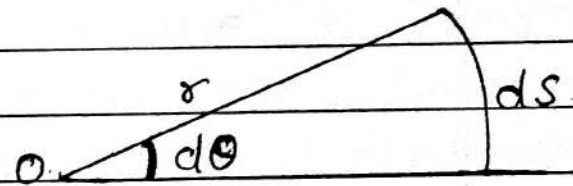
- These quantities are made up of fundamental physical quantity.

e.g. Volume = $m \times m \times m = m^3$

3. Supplementary Physical Quantity

- (i) Plane Angle $d\theta$ as the ratio of length of Arc ds to the radius r

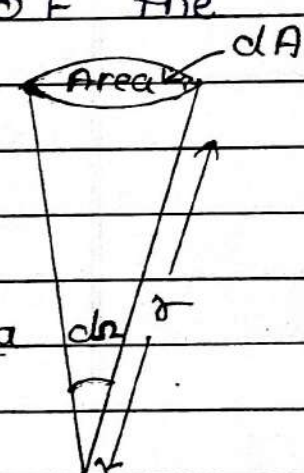
$d\theta = \frac{ds}{r}$	= $\frac{\text{arc}}{\text{radius}}$
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- (ii) Solid angle $d\Omega$ as the ratio of the intercepted area dA of the Spherical Surface.

3D angle.

$d\Omega = \frac{dA}{r^2}$	= $\frac{\text{Surface area}}{r^2}$
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Unit = Steradian (sd) or (sr)

- ★ Supplementary angles do not have any dimensions but have unit.

Dimensions of Physical Quantity

Dimension: The dimensions of a physical quantity are the powers (or exponents) to which the base quantities are raised to represent that quantity.

e.g. Volume = $m^3 = [L^3]$, here dimension of L is 3.

Dimensions are denoted by square brackets $[]$.

1. length $[L]$
2. Mass $[M]$
3. Time $[T]$
4. Temperature $[K]$
5. Electric current $[A]$
6. Luminous intensity $[cd]$
7. Amount of substance $[mol]$

- In mechanics, all physical quantities can be written in terms of dimensions $[L]$, $[M]$ and $[T]$

Example :-

$$1. \text{ Force} = m \times a = \text{kg} \times \frac{\text{m}}{\text{s}^2} = \frac{[M] \times [L]}{[T]^2}$$

$$[M'L'T^{-2}]$$

$$2. \text{ Work} = F \times S = [MLT^{-2}] \times [L] = [ML^2 T^{-2}]$$

$$3. \text{ Energy} = [ML^2 T^{-2}]$$

$$4. \text{ Power} = \text{work/time} = ML^2 T^{-2} / T = [ML^2 T^{-3}]$$

$$5. \text{ Trigonometric Ratios} = [L] / [L] = [M^0 L^0 T^0]$$

→ Trigonometric ratios, angles, numbers are dimensionless.

Dimensional formula and Dimensional Equations



Expression which shows how & which of the base quantities represent the dimensions of P.Q.



Equation obtained by equating a physical quantity with its dimensional formula.

⇒ Principle of Homogeneity of Dimension

- The dimension of each term of an equation must be same.
- We can add or subtract similar physical quantities.

A dimensionally correct equation need not be actually an exact eqⁿ, but a dimensionally wrong or inconsistent eqⁿ must be wrong.

Ques Find dimensions of a and b in
 $v = a + bt$ where ($v \rightarrow$ velocity and
 $t \rightarrow$ time)

Sol

$$v = a + bt$$

dimensions of $v =$ dimension of $\therefore$
 $L/T =$ d. of a

$$\Rightarrow \boxed{\text{d. of } a = [M^0 L T^{-1}]}$$

$$\text{d. of } bt = \text{d. of } v$$

$$\text{d. of } bt = [M^0 L T^{-1}]$$

$$\Rightarrow \boxed{\text{d. of } b = [M^0 L T^{-2}]}$$

Ques Find the dimensions of a and b in
 $P = \frac{a + t^2}{bx}$, where b ($p = \text{pressure}$,
 $t = \text{time}$, $x = \text{displacement}$)

Sol.

$$P = \frac{a + t^2}{bx}$$

d. of $a = \text{d. of } t^2$ (Principle of homogeneity of dimension)

$$\boxed{\text{d. of } a = [T^2]}$$

$$\text{d. of } p = \text{d. of } \left(\frac{a + t^2}{bx} \right) \quad \left(\text{Pressure} = \frac{\text{Force}}{\text{Area}} \right)$$

$$\frac{MLT^{-2}}{L^2} = \frac{T^2 + T^2}{b[L]}$$

$$\frac{a}{b} = \frac{T^2}{M^{-1}T^4}$$

$$\frac{MLT^{-2}}{L^2} \times [L] = \frac{T^2}{b}$$

$$\Rightarrow \boxed{\frac{a}{b} = M^{-1}T^{-2}}$$

$$MT^{-2} = \frac{T^2}{b}$$

$$\Rightarrow b = \frac{T^2}{MT^{-2}}$$

$$\Rightarrow \boxed{b = M^{-1}T^4}$$

Ques Find the dimension of α in $P = P_0 e^{\alpha t^2}$
(t = time)

Soln Power is a pure number, so $\alpha t^2 =$
dimensionless

$$\alpha T^2 = [M^0 L^0 T^0]$$

$$\boxed{\alpha = [M^0 L^0 T^{-2}]}$$

Find dimension of —

Ques β in $P = \frac{\alpha}{\beta} e^{-\alpha z / k\theta}$, where p = pressure,

z = distance, θ = temperature and
 k = Boltzmann constant ($\text{kgm}^2/\text{s}^2 \text{K}$).

Soln $P = \frac{\alpha}{\beta} e^{-\alpha z / k\theta}$

$\Rightarrow$ Power is dimensionless

$$\alpha z / k\theta = [M^0 L^0 T^0]$$

$$\alpha \times L = [M^0 L^0 T^0]$$

$$ML^2 T^{-2} \theta^{-1} \times \theta$$

$$\frac{\alpha}{MLT^{-2}} = [M^0 L^0 T^0]$$

$$\alpha = [M^0 L^0 T^0] \times [MLT^{-2}]$$

$$\boxed{\alpha = MLT^{-2}}$$

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

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

$$\beta = \frac{MLT^{-2}}{\frac{MLT^{-2}}{L^2}}$$

$$\boxed{\beta = L^2}$$

Ques $y = A \sin(\omega t - kx)$, Find dimension of A , ω & k where y = displacement, x = Distance, t = time

Solⁿ $y = A \sin(\omega t - kx)$
 $\downarrow$
 Angle (dimensionless)

$$d. \text{ of } \omega t = M^0 L^0 T^0$$

$$d. \text{ of } \omega = M^0 L^0 T^{-1}$$

$$d. \text{ of } y = d. \text{ of } A$$

$$d. \text{ of } A = [L]$$

$$d. \text{ of } kx = M^0 L^0 T^0$$

$$d. \text{ of } k = M^0 L^{-1} T^0$$

Applications of Dimensional Analysis

1. For checking the correctness of an equation.
2. For checking derivations, accuracy and homogeneity of various mathematical expressions

Que check correctness of eqⁿ

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

$$\textcircled{2} T = 2\pi \sqrt{\frac{L}{g}}$$

$$[M^0 L^1 T^0] = \frac{L}{T} \times T + \frac{L}{T^2} \times T^2$$

$$\Rightarrow L + L = L$$

$$[M^0 L^1 T^0] = [M^0 L^1 T^0]$$

$$T = \sqrt{\frac{L}{g}}$$

$$T \cdot T$$

$$L \cdot H.S = R \cdot H.S$$

Ques Convert 1 N to dyne by dimensional analysis

Solⁿ

$$1 \text{ N} \\ \text{kg m/s}^2$$

$$\times \text{ dyne} \\ \text{g cm/s}^2$$

$$PQ = n \times u$$

$$n_1 u_1 = n_2 u_2$$

$$\text{e.g. } 1 \text{ m} = 100 \text{ cm}$$

$$n_1 = 1$$

$$n_2 = ?$$

$$u_1 \left[\begin{array}{l} M_1 = \text{kg} \\ L_1 = \text{m} \\ T_1 = \text{s} \end{array} \right] u_2 \left[\begin{array}{l} M_2 = \text{g} \\ L_2 = \text{cm} \\ T_2 = \text{s} \end{array} \right]$$

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

$$n_1 u_1 = n_2 u_2$$

$$= \frac{10^3 \text{ g} \times 10^2 \text{ cm}}{1 \text{ g} \times 1 \text{ cm}}$$

$$M_1 L_1 T_1^{-2} \times 1 = M_2 L_2 T_2^{-2} \times n_2$$

$$= \frac{10^3 \times 10^2}{1 \times 1}$$

$$\frac{M_1 L_1 T_1^{-2}}{M_2 L_2 T_2^{-2}} = n_2$$

$$n_2 = 10^5$$

$$1 \text{ N} = 10^5 \text{ dyne}$$

$$1 \text{ N} = 10^5 \text{ dyne}$$

Que. Centripetal force 'F' acting on a particle of mass 'm' moving in a circle of radius 'r' with velocity 'v' depends upon m, v and r. Find expression for 'F'.

Solⁿ

$$F \propto m^x$$

$$F \propto v^y$$

$$F \propto r^z$$

$$= k m^x v^y r^z$$

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

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

$M' = M^x$	$L' = L^{y+z}$	$T^{-y} = T^{-2}$
$x = 1$	$z = -1$	$y = 2$

$$F = k m^1 v^2 r^{-1}$$

$$F = \frac{k m v^2}{r}$$

Limitations of Dimensional Analysis

1. It cannot find the value of proportionality constant.
2. Cannot be applied in expressions involving trigonometric ratios and exponential terms.

3. Cannot be applied in expressions involving proportionality constant which has dimensions.
4. Cannot be applied in expression involving Two or more terms separated by (+) or (-).

Significant figures

- It gives information of the no. of digits in a measured value to which we are confident of.

More significant figure $\rightarrow$ more accurate measurement

Rules for Calculating Significant figures

1. All non-zero digits are significant.
e.g. 284, 954, 1.926.
2. Trapped zeros (zeros b/w two non-zero digits) are significant.
e.g. 4.009, 2.04, 400.7.
3. Initial zeroes/leading zeroes are never significant.
eg 0.00238 $\rightarrow$ 3 s.f.
0.008 $\rightarrow$ 1 s.f.

4. Ending zeros (terminal or trailing) are significant if they appear after decimal.

e.g. $2.00 \rightarrow 3 \text{ s.f.}$

$2.00 \rightarrow 1 \text{ s.f.}$

$3.500 \rightarrow 4 \text{ s.f.}$

5. While changing units, no. of significant figures remain same (unchanged)

e.g. $1.5 \text{ m} \rightarrow 150 \text{ cm} (2 \text{ s.f.})$

$2.0 \text{ km} \rightarrow 2.0 \times 10^3 \text{ m} (2 \text{ s.f.})$

6. Order of magnitude is never significant

e.g. $2.1 \times 10^3 \rightarrow 2 \text{ s.f.}$

$4.009 \times 10^4 \rightarrow 4 \text{ s.f.}$

$2.010 \times 10^2 \rightarrow 4 \text{ s.f.}$

7. Pure number or constant have infinite significant Fig.

e.g.

perimeter of square = $4a$

inf. s.f.

Rounding off the Uncertain Digits

1. Preceding digits is raised by 1, if insignificant digit is more than 5.

e.g - $3.76 \rightarrow 3.8$

$3.78 \rightarrow 3.8$

2. Preceding digits left unchanged if the latter is less than 5.

e.g - $3.72 \rightarrow 3.7$.

3. If the significant figure is 5, then if the preceding digit is even the insignificant figure is simply dropped and if it is odd, the preceding digit is raised by 1.

e.g - $2.745 \rightarrow 2.74$

$2.735 \rightarrow 2.74$.

Calculation in Significant Fig.

⇒ Addition and Subtraction

The result of addition & subtraction after rounding off have same number of decimal places as present in the value with least decimal place

e.g.
$$\begin{array}{r} 436.32 \\ 227.2 \leftarrow \text{least decimal place is 1,} \\ 663.821 \end{array}$$
 So, the final answer is 663.8

Multiplication and division

The result is rounded off to same numbers of Significant figure as present in the value of with least s.f

e.g.
$$\begin{array}{r} 4.237 \\ 2.51 \end{array} = 1.69$$
 (Least s.f. 3)

$$2.42 \times 2.1 = 5.082 = \underline{\underline{5.0}}$$

Error Analysis

There is Always some difference between the measured value and the true value of a quantity, which is known as error.

⇒ Absolute Error

The magnitude of the difference between the individual measurement and the true value of quantity is called absolute error.

- Denoted by $|\Delta a|$, always positive

Let the quantity is measured 'n' times.
The measurements are $a_1, a_2, a_3, \dots, a_n$

$$\text{True Value / Mean value} = \frac{a_1 + a_2 + a_3 + \dots + a_n}{n} \text{ (or } a)$$

$$\text{Absolute Error } \Delta a_1 = a_n - a_1$$

$$\Delta a_2 = a_n - a_2$$

$$\text{Mean Absolute Error} = \frac{|\Delta a_1| + |\Delta a_2| + |\Delta a_3| + \dots + |\Delta a_n|}{n}$$

⇒ Relative Error / Fractional error

It is the ratio of the mean absolute error Δa_{mean} to the mean value a_{mean} of the quantity measured.

$$\text{Relative error} = \frac{\Delta a_{\text{mean}}}{a_{\text{mean}}} \quad (\text{Mean Absolute error})$$

⇒ Percentage error

When relative error is expressed in percent, it is called the percentage error (δa).

$$\text{Percentage error } (\delta a) = \frac{\Delta a_{\text{mean}}}{a_{\text{mean}}} \times 100$$

Error of a sum or a difference

- Errors of are always added in case of addition and subtraction

$$x = A + B$$

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

$$\Rightarrow \boxed{x \pm \Delta x} \rightarrow \text{Result,}$$

$$x = A - B$$

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

Result,

$$\Rightarrow \boxed{x \pm \Delta x}$$

Error of a product or a quotient

- When two quantities are multiplied or divided, the relative error in the result is the sum of the relative errors.

$$x = ab \text{ or } \frac{a}{b}$$

$$\boxed{\frac{\Delta x}{x} = \frac{\Delta a}{a} + \frac{\Delta b}{b}}$$

Errors in case of a measured quantity raised to a power.

- The relative error in a physical quantity raised to the power k is the k times the relative errors in the individual quantity.

$$x = \frac{a^p b^q}{c^r}$$

$$\boxed{\frac{\Delta x}{x} = \frac{p \Delta a}{a} + \frac{q \Delta b}{b} + \frac{r \Delta c}{c}}$$

(Fractional error)

Percentage error $\rightarrow$ Relative error $\times 100$

$$\frac{\Delta x}{x} \times 100 = p(\Delta a \times 100) + q(\Delta b \times 100) + r(\Delta c \times 100)$$

$$\% \text{ error of } x = p(\% \text{ error of } a) + q(\% \text{ error of } b) + r(\% \text{ error of } c)$$

Ques In an expression the % error occurred in the measurement of a physical quantity A, B, C and D are 1%, 2%, 3% and 4% respectively, then the max % error in the measurement x, where $x = \frac{A^2 B^4}{C^3 D^3}$, will be?

Sol $x = \frac{A^2 B^4}{C^3 D^3}$

$$\frac{\Delta x}{x} \times 100 = 2(\Delta A \times 100) + \frac{1}{2}(\Delta B \times 100) + \frac{1}{3}(\Delta C \times 100) + 3(\Delta D \times 100)$$

$$\text{max \% error} = 2(\% \text{ error of } A) + \frac{1}{2}(\% \text{ error of } B) + \frac{1}{3}(\% \text{ error of } C) + 3(\% \text{ error of } D)$$

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

$$= 2 + 1 + 1 + 12$$

$$\boxed{\text{max \% error} = 16\%}$$

Ques The density of a material in the shape of a cube is determined measuring three side of the cube and its mass. If the relative error in measuring the mass and length are respectively 1.5% and 1%, the max. error in determining the density is?

Solⁿ Relative % error of m ($\frac{\Delta m}{m} \times 100$) = 1.5%.
density = $\frac{\text{mass}}{\text{vol.}}$

Relative % error of l ($\frac{\Delta l}{l} \times 100$) = 1%.

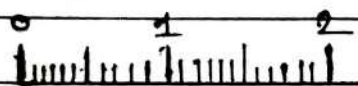
$$\text{max \% error in density } \left(\frac{\Delta d}{d} \times 100 \right) = \frac{\Delta m}{m} \times 100 + 3 \left(\frac{\Delta l}{l} \times 100 \right)$$

$$= 1.5 + 3$$

$$= 4.5\%$$

Vernier Callipers

To measure length of an object we use normal scale in which is marked in cm.



$$1 \text{ cm} = 10 \text{ Division}$$

$$LC = \frac{1}{10} = 0.1 \text{ cm.}$$

Least Count - Smallest measurement which can be made by an instrument.

⇒ But it cannot give precision upto second decimal place.

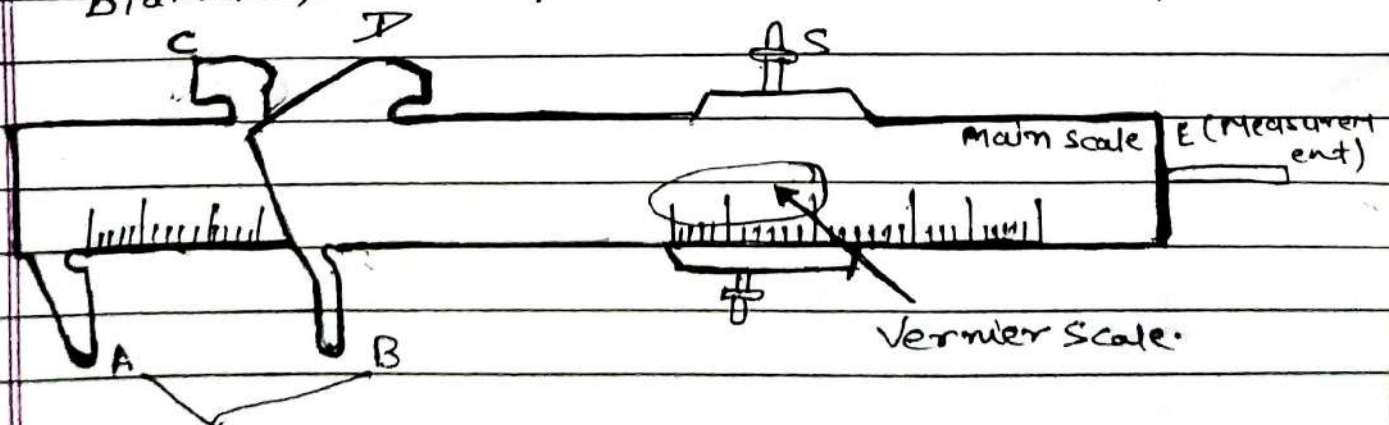
In 1631, Pierre Vernier divided

Vernier Callipers

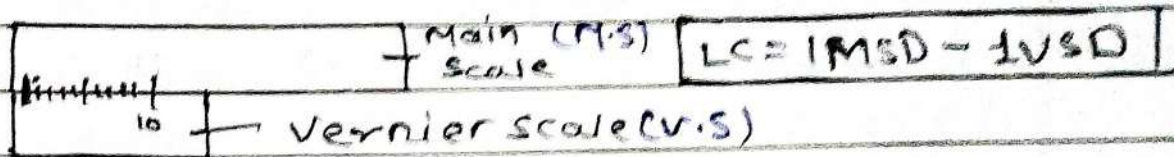


can give accurate measurement upto second decimal place.

(Measure internal diameter)



Jaws (measure diameter of small cylindrical body,



Generally, each division on V.S. is smaller than each division of M.S.

Let 'n' VSD are equal to 'm' MSD

$$n \text{ V.S.D} = m \text{ M.S.D}$$

$$1 \text{ V.S.D} = \frac{m}{n} \text{ M.S.D}$$

$$\begin{aligned} LC &= 1 \text{ MSD} - 1 \text{ VSD} \\ &= 1 \text{ MSD} - \frac{m}{n} \text{ MSD} \end{aligned}$$

$$LC = \text{MSD} \left(1 - \frac{m}{n} \right)$$

no. of MSD which is equal to
no. of VSD

⇒ In ordinary vernier calliper :-

$$10 \text{ VSD} = 9 \text{ MSD}$$

$$\text{MSD} = \frac{1 \text{ cm}}{10} = 0.1 \text{ cm.}$$

$$LC = \text{MSD} \left[1 - \frac{m}{n} \right]$$

$$= 0.1 \left(1 - \frac{9}{10} \right)$$

$$= \frac{0.1}{10}$$

$$LC = 0.01 \text{ cm}$$

Que In a vernier calliper, the M.S is marked in mm & 20 vernier scale division are equal to 16 M.S.D
Calculate L.C.

Solⁿ

$$\begin{aligned} LC &= MSD \left[1 - \frac{m}{n} \right] \\ &= 1\text{mm} \left[1 - \frac{16}{20} \right] \\ &= 1\text{mm} \times \frac{1}{5} = 0.2\text{mm}. \end{aligned}$$

Ques 'N' divisions of MS are equal to 'N+1' division of vernier scale. If each division on m.s measure 'a' units. Find L.C.

Sol

$$1 \text{ MSD} = a$$

$$LC = 1 \text{ MSD} \left[\frac{1-m}{n} \right]$$

$$= a \left[\frac{1-N}{N+1} \right]$$

$$= a \left[\frac{N+1-N}{N+1} \right]$$

$$LC = \frac{a}{N+1}$$

Reading of Vernier Calipers

$$\text{Total Reading} = \text{MSR} + \text{VSR}$$

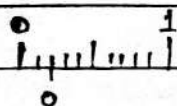
(L.C. $\times$ coinciding division V.S.)

Applicable only when $VSD < MSD$ and there is zero error

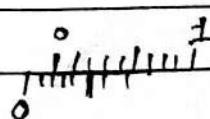
* Zero Error

When zero of V.S & zero of m.s do not coincide, then the instrument is said to have a zero error

+ve zero error
(When zero of V.S
is on right of MS)



-ve zero error
(Zero of V.S is on left
of MS)



$$\text{correct Reading} = \text{Total Reading} - \text{Zero error} \\ (\text{MSR} + \text{VSR})$$

$$\text{+ve zero error} = \text{L.C} \times \text{coin. div. of V.S}$$

$$\text{-ve zero error} = -\text{L.C} \times \text{coin. div of V.S}$$

Que In a vernier callipers $10 \text{ VSD} = 9 \text{ MSD}$ and 1 cm on MS is divided into 10 parts while measuring the length of a wire, the zero of V.S is just ahead of 1.8 cm mark and 4th division of V.S coincides with main scale division. The length of line is

Solr $10 \text{ VSD} = 9 \text{ MSD}$

$$1 \text{ MSD} = 0.1 \text{ cm.}$$

$$\text{LC} = \text{MSD} \left(1 - \frac{m}{n}\right)$$

$$= 0.1 \left(1 - \frac{9}{10}\right) = 0.01 \text{ cm.}$$

$$\begin{aligned} \text{Total Reading (Length)} &= \text{V.S.R} + \text{M.S.R} \\ &= \text{L.C} \times \text{coin. div of V.S} + \text{M.S.R} \\ &= 0.01 \times 4 + 1.8 \\ &= 0.04 + 1.8 \\ &= \underline{\underline{1.804 \text{ cm}}} \end{aligned}$$

Ques

JEE
ADVANCE
NCE
2013)

The diameter of a cylinder is measured using a V.C with non-zero error. It is found that the zero of V.C line b/w 5.10 cm and 5.15 cm of M.S. The V.C have 50 division equivalent to 2.45 cm. The 24th division of V.C exactly coincides with one of the M.S.D. The dia- of cylinder is?

5.10 5.15 M.S.
V.C

$$50 \text{ division (VSD)} = 2.45 \text{ cm.}$$

$$1 \text{ division (VSD)} = 0.049 \text{ cm.}$$

$$1 \text{ MSD} = 0.05 \text{ cm}$$

$$L.C = 1 \text{ MSD} - 1 \text{ VSD}$$

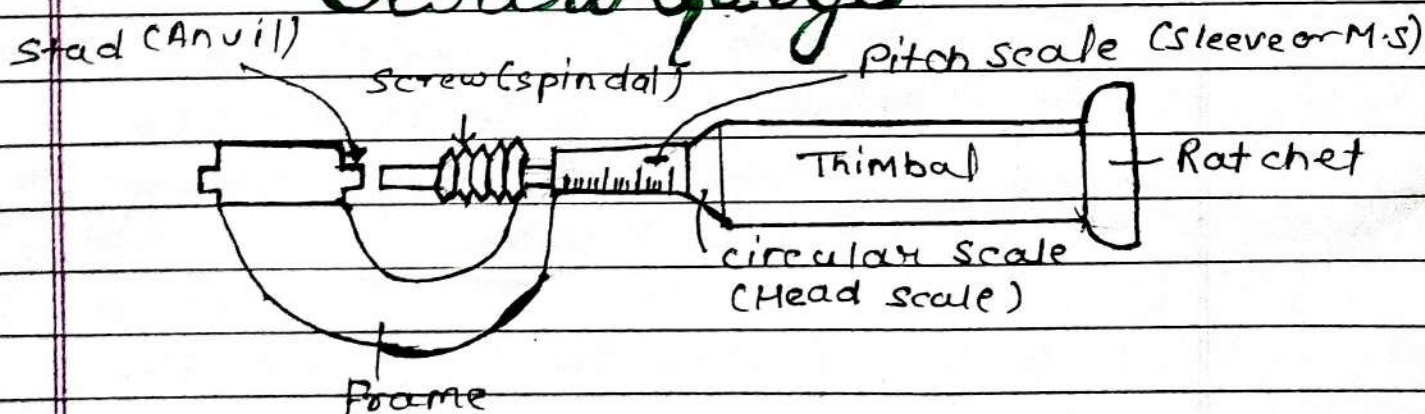
$$= 0.05 - 0.049 = 0.001 \text{ cm.}$$

$$\text{Total Reading (diameter)} = \text{MSR} + L.C \times \text{coin of div}$$

$$= 5.10 + 0.001 \times 24$$

$$= 5.124 \text{ cm.}$$

Screw Gauge



Pitch $\Rightarrow$ The distance covered by screw in one complete rotation of the circular scale is called pitch,

- Distance b/w two consecutive thread.

$$LC = \frac{\text{Pitch}}{\text{No. of circular scale divisions}}$$

Ques Two Full turns of circular scale of a gauge cover a distance of 1mm on scale. Total no. of division on circular scale is 50. Find LC.

$$2 \text{ Pitch} = 1 \text{ mm}$$

$$1 \text{ Pitch} = \frac{1}{2} \text{ mm}$$

Soln $LC = \frac{1/2 \text{ mm}}{50}$

$$= 0.01 \text{ mm}$$

Ques The LC of MS of a screw gauge is 1mm. The min. no of divisions on its circular scale required to measure 5 μm diameter of a wire is p

(JEE
Mains
2019)

$$1 \mu\text{m} = 10^{-6} \text{ m}$$

$$1 \text{ mm} = 10^{-3} \text{ m}$$

Soln Pitch = 1mm $\Rightarrow 10^{-3}$
LC = 5 μm 5×10^{-6}

$$\text{No of CSD} = \frac{\text{Pitch}}{\text{L.C}} \Rightarrow \frac{10^{-3}}{5} = 200$$

Finding Reading

$$\text{Reading} = \text{MSR} + \text{CSR}$$

LC $\times$ coin div. on CS with base line.

Ques Circular scale 100 division. calculate diameter of the wire-

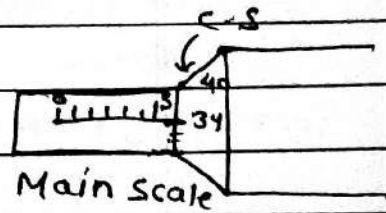
Solve Reading (Diameter) = MSR + CSR

$$= \text{MSR} + \text{LC} \times \text{coin div}$$

$$= 5 + 0.01 \times 34$$

$$= 5 + 0.34$$

$$= 5.34 \text{ mm or } 0.534 \text{ cm.}$$



$$\text{LC} = \frac{1}{100} = 0.01$$

Ques The thimble of screw has 50 division and spindle advance 1 mm when the screw is turned through two rotation when the screw is used to measure the diameter of wire the reading on the sleeve is found to be 0.5 mm and reading on thimble is found 27 divisions. what is the d. of wire in cm.

Solve 2 rotation = 1 mm

$$1 \text{ rotation} = \frac{1}{2} \text{ mm (Pitch)}$$

$$\text{L.C} = \frac{\text{Pitch}}{\text{No. of div. on CS}} = \frac{\frac{1}{2}}{50} = 0.01 \text{ mm}$$

$$\text{Reading} = \text{MSR} + \text{VSR}$$

$$= \text{m.s.r} + \text{LC} \times \text{coin of div. on VS}$$

$$= 0.5 \text{ mm} + 0.01 \text{ mm} \times 27.$$

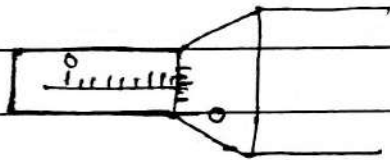
$$= 0.5 \text{ mm} + 0.27 \text{ mm.}$$

$$= 0.77 \text{ mm or } 0.077 \text{ cm.}$$

Zero Error & Correct Reading

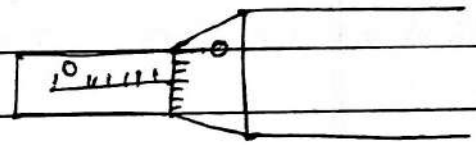
Zero of C.S does not coincide with base line (at initial) then it is said that there is a zero error in screw gauge.

1. +ve zero error



Zero of C.S is below the base line

2. -ve zero error



Zero of C.S is above base line
 $\Rightarrow$ zero hides.

$$\text{Correct Reading} = \text{Reading} - \text{Zero error}$$

+ve zero error = $+LC \times \text{Coin. div. of C.S with base line.}$

-ve zero error = $-LC \times \text{Coin. div. of C.S with base line.}$

Ques The pitch and the no. of division, on the C.S for a given screw gauge are 0.5mm and 100, respectively, when the screw gauge is fully tightened without any object, the zero of its C.S. lies 3 division below the main line. The reading of the M.S and C.S for a thin sheet are 5.5mm and 48 respectively, thickness of sheet is?

Sol

$$\text{Pitch} = 0.5\text{mm}$$

$$\text{No. of div} = 100$$

$$\text{LC} = \frac{0.5}{100} = 0.005\text{mm.}$$

$$\begin{aligned}\text{+ Zero error} &= \text{LC} \times \text{Coin. div} \\ &= 0.005 \times 3 \\ &= +0.015\text{mm.}\end{aligned}$$

$$\begin{aligned}\text{Reading} &= \text{MSR} + \text{LC} \times \text{Coin div} \\ &= 5.5 + 0.05 \times 48 \\ &= 5.740\text{mm.}\end{aligned}$$

$$\begin{aligned}\text{Correct Reading} &= \text{Reading} - \text{Zero error} \\ &= 5.740 - 0.015 \\ &= 5.725\text{mm.}\end{aligned}$$

Que A screw gauge with a pitch of 0.5 mm and a CS with 50 division is used to measure thickness of a thin sheet of aluminium. Before starting the measurement, it is found that when two jaws of the screw gauge are brought in contact, the 45th division coincides with M.S Line and that the zero of MS is barely visible. What is the thickness of the sheet if the MS reading is 0.5 mm and the 25th division coincides with MS line?

Sol

$$\text{Pitch} = 0.5 \text{ mm}$$

$$\text{No. of div.} = 50$$

$$LC = \frac{0.5}{50} = 0.01 \text{ mm}$$

$$\begin{aligned} \text{-ve zero error} &= -LC \times \text{coin. div} \\ &= -(-0.01) \times 5 \\ &= -0.05 \text{ mm.} \end{aligned}$$

$$\text{MSR} = 0.5 \text{ mm.}$$

$$\begin{aligned} \text{Reading} &= \text{MSR} + LC \times \text{coin div} \\ &= 0.5 + 0.01 \times 25 \\ &= 0.75 \text{ mm} \end{aligned}$$

$$\begin{aligned} \text{Correct Reading} &= \text{Reading} - \text{zero error} \\ &= 0.75 - (-0.05) \\ &= 0.75 + 0.05 \\ &= 0.80 \text{ mm.} \end{aligned}$$