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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 x unit

$$\boxed{PQ = n \times u}$$

Types of Physical Quantity :-

1. **Fundamental Physical Quantity**

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

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	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 = $m \times m \times m = m^3$

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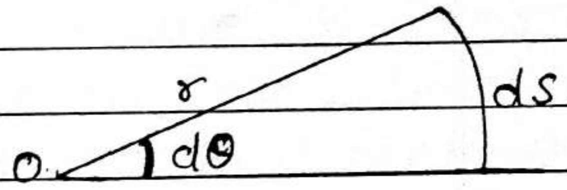
3. Supplementary Physical Quantity

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

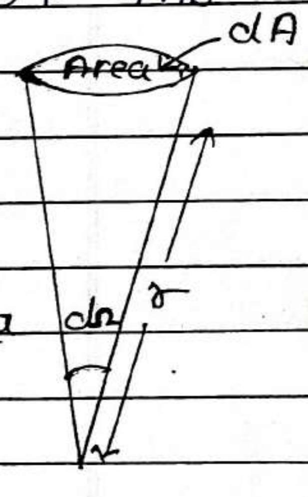
$$\boxed{d\theta = \frac{ds}{r}} = \frac{\text{arc}}{\text{radius}}$$



(ii) Solid angle $d\Omega$ as the ratio of the intercepted area dA of the Spherical surface.

3D angle.

$$\boxed{d\Omega = \frac{dA}{r^2}} = \frac{\text{Surface area}}{r^2}$$



Unit = Steridian (sd) or (sr)

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

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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]

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Example :-

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

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

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

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

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

5. Trignometric Ratios = $[L]/[L]$ = $[M^0 L^0 T^0]$

→ Trignometric ratios, angles, numbers are dimensionless.

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Dimensional formula and Dimesional Equations

Dimensional formula	Dimensional Equations
Expression which shows how & which of the base quantities represent the dimensions of PQ.	Equation obtained by equating a physical quality with its dimensional formula.

⇒ Principle of Homogenety of Dimension

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

A dimesionally correct equation need not be actually an exact eq^n, but a dimensionally wrong or inconsistent eq^n must be wrong.

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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

$$L/T = d.\ of\ a$$

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

$$d.\ of\ bt = d.\ of\ v$$

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

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

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

Sol.

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

d. of a = d. of t^2 (Principle of homogenety of dimension)

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

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

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

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

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

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

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

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

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

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

Solve Power is a pure number, So αt^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 ($kg m^2/s^2 K$).

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

⇒ Power is dimensionless

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

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

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

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

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

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

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

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

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

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

Sol^n. $Y = A\sin(\underbrace{\omega t - kx}_{\text{Angle (dimensionless)}})$

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

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

d. of y = d of A

d. of $A = [L]$

d. of $kx = M^0 L^0 T^0$

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

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 eq^n

① $S = ut + \frac{1}{2}at^2$

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

$\Rightarrow L + L = L$

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

② $T = 2\pi\sqrt{\frac{l}{g}}$

$T = \sqrt{\frac{\cancel{L}}{\frac{\cancel{L}}{T^2}}}$

$T \cdot T$

L.H.S = R.H.S

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Que Convert 1 N to dyne by dimesional analysis

Solⁿ

$1N$ | x dyne
$kg\,m/s^2$ | $g.cm/s^2$

$n_1 = 1$ | $n_2 = ?$

$$u_1\begin{bmatrix} M_1 = kg & M_2 = g \\ L_1 = m & L_2 = cm \\ T' = s & T_2 = s \end{bmatrix}u_2$$

$n_1 u_1 = n_2 u_2$

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

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

$PQ = n \times u$

$\boxed{n_1 u_1 = n_2 v_2}$

e.g $1m = 100m$.

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

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

$n_2 = 10^5$

$1N = 10^5$ dyne.

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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

$F \propto m^x$

$F \propto v^y$

$F \propto r^z$

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

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

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

$M^1 = M^x$	$L^1 = L^{y+z}$	$T^{-y} = T^{-2}$
$\boxed{x = 1}$	$\boxed{z = -1}$	$\boxed{y = 2}$

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

$$\boxed{F = \frac{kmv^2}{r}}$$

Limitations of Dimensional Analysis

1. It cannot Find the value of proportionality constant.

2. Cannot be applied in expressions involving trignometric ratios and exponential terms.

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3. Cannot be applied in expressions involving proportionality constant which has dimensions.

4. Cannot be applied in expression involvin-g 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 ⟶ more accurate measurement

Rules for Calculating Significant figures

1. All non-zero digits are significant.
   e.g 284, 954, 1.926.

2. Trapped zeros (zeroes 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 → 3 s.f
   0.008 → 1 s.f

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

e.g 2.00 $\longrightarrow$ 3 s.f
200 $\longrightarrow$ 1 s.f
3.500 $\longrightarrow$ 4 s.f

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

e.g. 1.5 m $\longrightarrow$ 150 cm (2 s.f)
2.0 km $\longrightarrow$ 2.0×10^3 m (2 s.f.)

6. order of magnitude is never significant

e.g $2.1 \times 10^3 \rightarrow$ 2 s.f.
$4.009 \times 10^4 \rightarrow$ 4 s.f
$2.010 \times 10^2 \rightarrow$ 4 s.f.

7. Pure number or constant have infinite significant Fig.

e.g

perimeter of square = $\underbrace{4}_{\text{inf. s.f.}}a$

Rounding off the Uncertain Digits

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

   e.g - 3.76 ⟶ 3.8
   3.78 ⟶ 3.8

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

   e.g - 3.72 ⟶ 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 ⟶ 2.74
   2.735 ⟶ 2.74.

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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.
$$\begin{array}{r} 436.32 \\ 227.2 \\ \hline 663.821 \end{array}$$

← least decimal place is 1, 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. $\frac{4.237}{2.51} = 1.69$ (Least s.f. 3)

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

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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 — — — — a_n

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

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

$$\Delta a_2 = a_n - a_2$$

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

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⇒ **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.

$$\boxed{\text{Relative error} = \frac{\Delta a \text{ (Mean Absolute error)}}{a \text{ (mean value)}}}$$

⇒ **Percentage error**

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

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

Error of a sum or a difference

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

$x = A + B$

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

⇒ $\boxed{x \pm \Delta x}$ → Result.

$x = A - B$

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

Result,

⇒ $\boxed{x \pm \Delta x}$

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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 quatity raised to a power.

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

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

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

(Fractional error)

Percentage error → Relative error × 100

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

% error of x = p(% error of a) + q(% error of b) + r(% error of c)

Ques [NEET 2019] In an expression the % error occured in the measurement of a physical quantity A, B, C and D and 1%, 2%, 3% and 4% respectively, then the max % error in the measurement x, where $x = \frac{A^2 B^{1/2}}{C^{1/3} D^3}$, will be?

Soln

$$x = \frac{A^2 B^{1/2}}{C^{1/3} D^3}$$

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

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

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

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

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

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Ques (main 2013) 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 $m \left(\frac{\Delta m}{m} \times 100\right) = 1.5\%$.

density = $\frac{\text{mass}}{\text{vol.}}$

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

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.

0 1 2

1cm = 10 Division

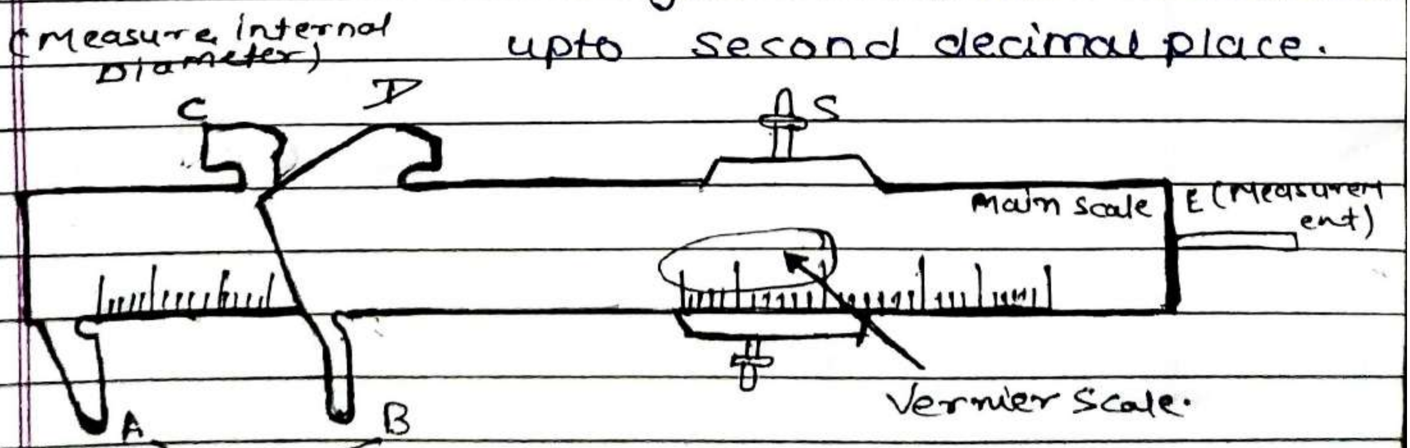
$LC = \frac{1}{10} = 0.1$ cm.

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

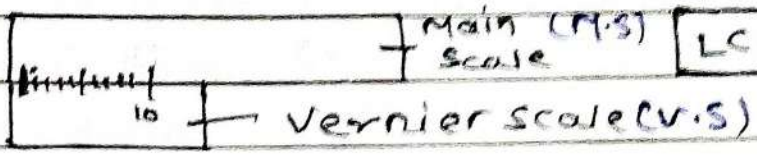
⇒ But it cannot give precision upto second decimal place.

In 1631, Pierre Vernier divided

Vernier callipers
⇓
can give accurate measurement upto second decimal place.



Jaws (Measure diameter of small cyledrical body.



$\boxed{LC = 1MSD - 1VSD}$

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

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

$$n\ V.S.D = m\ M.S.D$$

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

$$LC = 1MSD - 1VSD$$
$$= 1MSD - \frac{m}{n}\ MSD$$

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

m — no. of MSD which is equal to

n — no. of VSD

→ In ordinary vernier calliper:

$$10\ VSD = 9\ MSD \qquad MSD = \frac{1cm}{10} = 0.1cm.$$

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

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

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

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

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

Soln

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

$$= 1mm\left[1 - \frac{16}{20}\right]$$

$$= 1mm \times \frac{1}{5} = 0.2mm.$$

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Que (JEE 2003) '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

Soln

$1\ MSD = a$

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

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

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

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

Reading of Vernier Callipers

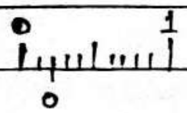
$$\boxed{\text{Total Reading} = MSR + \underbrace{VSR}_{(L.C \times \text{coinciding division V.S.})}}$$

Applicable only when VSD < MSD and there in zero error

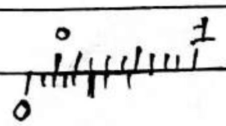
* Zero Error

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 VS is on right of ms)



-ve zero error (zero of VS is on left of MS)



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

+ve zero error = L.C × coin. div. of V.S
−ve zero error = −L.C × coin. div of V.S

Que In a vernier callipers 10 VSD = 9 MSD and 1 cm on MS is divided into 10 parts while measuring the length of a line, 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

Sol

$10\ VSD = 9\ MSD$

$1\ MSD = 0.1\ cm.$

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

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

Total Reading (Length) = V.S.R + M.S.R

= L.C × coin. div of V.S + M.S.R

$= 0.01 \times 4 + 1.8$

$= 0.04 + 1.8$

$= 1.804\ cm$

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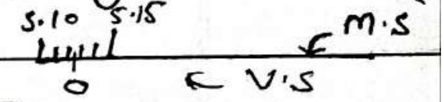
Ques [JEE ADVANCE 2013] The diameter of a cylinder is measured using a V.C with non-zero error. It is found that the zero of V.C line b/w 5.10cm and 5.15 cm of MS. The V.C have 50 division equivalent to 2.45 cm. The 24th division of V.C exactly coincides with one of the M.S.D. The dia. of cylinder is?



Solⁿ

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

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

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

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

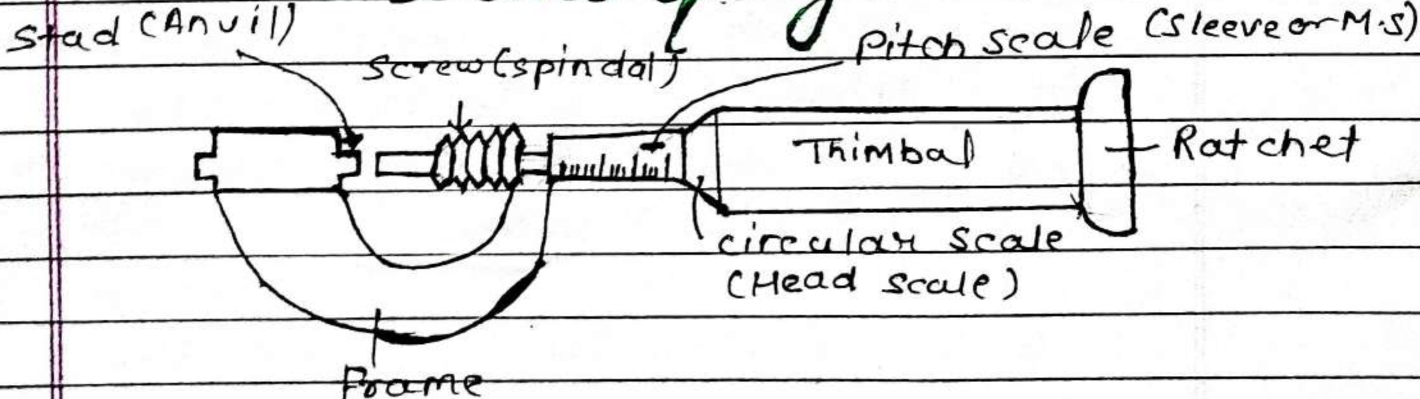
$= 0.05 - 0.049 = 0.001\text{cm}$.

Total Reading (diameter) = msR + LC x coin of div

$= 5.10 + 0.001 \times 24$

$= 5.124\text{ cm}$.

Screw Gauge



Pitch ⇒ The distance covered by screw in one complete rotation of the circular scale is called pitch.

- Distance b/w two consecutive thread.

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

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 (JEE mains 2019) 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

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

$1 mm = 10^{-3} m.$

Solve Pitch = 1mm

$LC = 5 \mu m$

$\text{No of CSD} = \frac{\text{Pitch}}{L.C}$

$\Rightarrow \frac{10^{-3}}{5 \times 10^{-6}}$

$\Rightarrow \frac{10^{3}}{5} = 200M$

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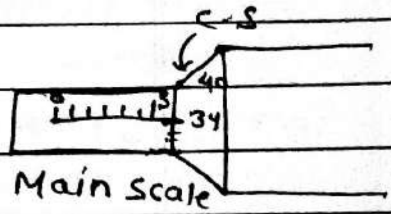
Finding Reading

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

CSR ⇓ LC × coin. div. on CS with base line.

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



Solve Reading (Diameter) = MSR + CSR
= MSR + LC × coin div
= 5 + 0.01 × 34
= 5 + 0.34
= 5.34 mm or 0.534 cm.

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

Q. 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.

Sol^n 2 rotation = 1 mm
1 rotation = ½ mm (Pitch)

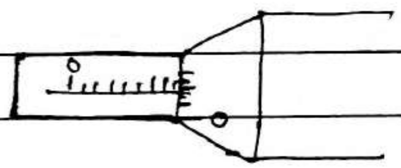
$L.C = \frac{\text{Pitch}}{\text{No. of div. on CS}} = \frac{1/2}{50} = 0.01\,mm$

Reading = MSR + VSR
= M.S.R + LC × coin of div. on VS
= 0.5 mm + 0.01 mm × 27.
= 0.5 mm + 0.27 mm.
= 0.77 mm or 0.077 cm.

Zero Error & Correct Reading

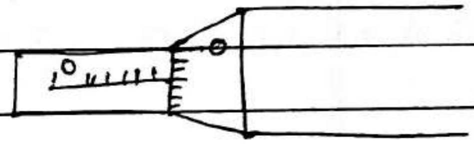
zero of c.s does not coincide with base line (at intial) then it is said that there is a zero error in screw gauge.

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
⇒ zero hides.

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

+ve zero error = +LC × coin. div of c.s with base line.

-ve zero error = -LC × coin. div. of c.s with base line.

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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 CS. lies 3 division below the main line. The reading of the MS and CS for a thin sheet are 5.5 mm and 48 respectively. thickness of sheet is?

Soln

Pitch = 0.5mm

No. of div = 100

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

+ zero error = LC X coin. div
= 0.005 x 3
= + 0.015 MM.

Reading = MSR + LC x coin div
= 5.5 + 0.05 x 48
= 5.740 mm.

Correct Reading = Reading − zero error
= 5.740 − 0.015
= 5.725 mm.

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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 faws 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. Pitch = 0.5 mm

No. of div. = 50

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

-ve zero error = -LC × coin. div

= -(-0.01) × 5

= -0.05 mm.

MSR = 0.5 mm.

Reading = MSR + LC × coin div

= 0.5 + 0.01 × 25

= 0.75 mm

Correct Reading = Reading - zero error

= 0.75 - (-0.05)

= 0.75 + 0.05

= 0.80 mm.