1. Units and Measurements

☆ Physical Quantities:-

A quantity that can be measured and by which various physical happenings can be explained and expressed in the form of laws is called a physical quantity.

Ex. length, mass, time, force, acceleration, temperature, pressure, etc.

[1] Fundamental Physical Quantities:-

Out of a large number of physical quantities that exist in nature, there are seven quantities that are independent of all other quantities and do not require the help of any other physical quantity for their definition, therefore these are called absolute quantities.

- These quantities are also called fundamental or base quantities.

Fundamental quantity	Base unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Thermodynamic Temperature	kelvin	K
Luminous Intensity	candela	cd
Quantity of matter	mole	mol

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[2] Derived Physical Quantities:-

Apart from the seven fundamental quantities, all other physical quantities can be derived by fundamental quantities. Therefore, these are called derived physical quantities.

Ex. Velocity - m/s
Acceleration - m/s^2
Force - $kg\ m/s^2$
Area - m^2
Volume - m^3
Pressure - $kg/m\ s^2$

☆ Characteristics of Units:-

- The measure of a unit should be definite and unambiguous.
- The unit should be such that its measure does not change with time.
- Unit is defined with the help of some phenomenon, that phenomenon must be permanent.
- Unit should be easily reproducible.
- The replica of a unit should be easily available.

☆ Requirement of Unit:-

- To express any physical quantities from unit.

1. Fundamental Physical Quantities
2. Derived Physical Quantities

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Some important practical units:-

1 angstrom (Å) = 10^{-10} m
1 AU or 1 astronomical unit = 1.496×10^{11} m
1 light year = 9.46×10^{15} m
1 micron = 1 μ or 1 μm = 10^{-6} m
1 nanometre = 1 nm = 10^{-9} m
1 fermi or femtometer (F) = 10^{-15} m
a.m.u. = 1.66×10^{-27} kg

Supplimentary Units:-

(1) The radian (rad):

One radian is the angle subtended at the centre of a circle by an arc equal in length to the radius of the circle.

- If an arc of length ds subtends an angle $d\theta$ at the centre O of a circle of radius r.

$$d\theta = \frac{ds}{r} \text{ radian}$$

(2) The Steradian (sr):-

One steradian is the solid angle subtended at the centre of a sphere by that surface of the sphere, which is equal in area to the square of radius of the sphere.

- If an area dA of a special surface subtends a solid angle $d\Omega$ at the centre

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of the sphere of radius r.

$$d\Omega = \frac{dA}{r^2} \text{ steradian}$$

(3) Curie:

Disintegration of 3.70×10^{10} atoms of a radioactive elements per second is called 1 curie.

$\therefore$ 1 C = 3.70×10^{10} disintegration / second

1 μC = 3.70×10^{4} disintegration / second

Interconversion of units - MKS to CGS and vice versa:-

$1 m^2 = 10^4 cm^2$
$1 kg/m^3 = 10^{-3} g/cm^3$
$9.8 m/s^2 = 980 cm/s^2$
$1 N = 10^5$ dyne
$36 km/h = 10 m/s$

Vernier Calipers:-

French mathematician Pierre Vernier invented the Vernier Calipers.

→ Principle:-

It works on least count.

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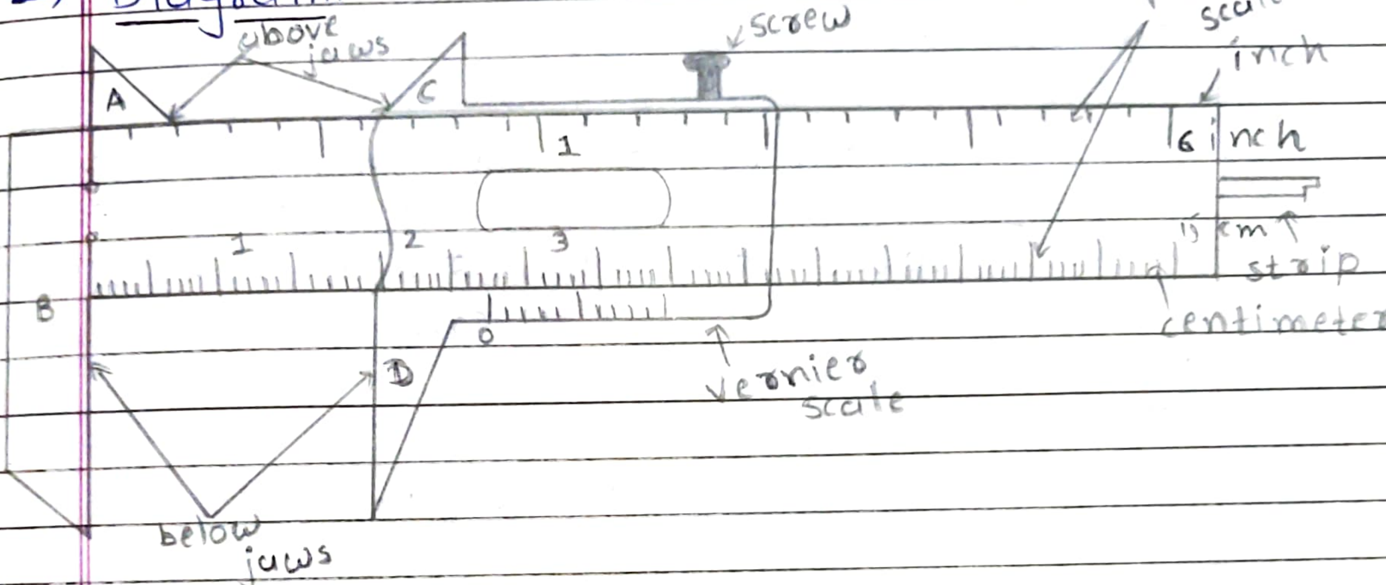
Least count:

The smallest fraction of a unit length which can be measured by vernier Calipers is known as least count of vernier Calipers.

→ Diagram:-



→ Construction:-

1. Main Scale: The upper scale on the main scale is in inches ~~and the lower scale is in inches~~ and the lower scale is in centimeters. This scale is called the main scale.

2. Vernier Scale: A small sliding scale arranged on the main scale is called the vernier scale.

3. Jaws: There are two jaws namely A and C on the left side of the main scale. The edge of both jaws A and C are in the same line.

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There are two jaws namely B and D at the left side of the vernier scale. The edge of both jaws A and C are in the same line.

The jaws A, B, C and D are used to hold the object which is to be measured.

→ **Formula of Least Count:-**

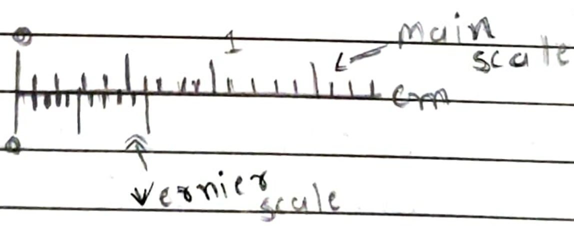
$$\text{Least count} = \frac{\text{the value of the smallest division on main scale}}{\text{total divisions on vernier scale}}$$

$$= \frac{0.1\ cm}{10} = 0.01\ cm$$

→ **Error:-**

Error = ± matching divisions × Least count

1. **Zero Error:-**



There is no gap between the jaws of vernier calipers AC or BD, then zero of vernier scale coincindes with zero of main scale.

- This equipment causes zero error.

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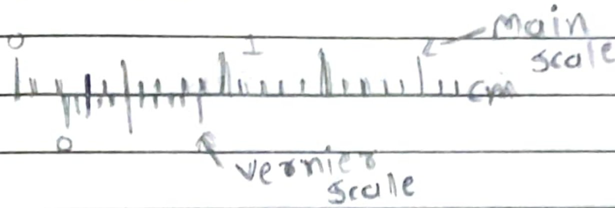
2. Positive Error:-



There is no gap between the jaws of vernier calipers AC or BD, then zero of vernier scale stands right side of zero of main scale.

- This equipment causes positive error.

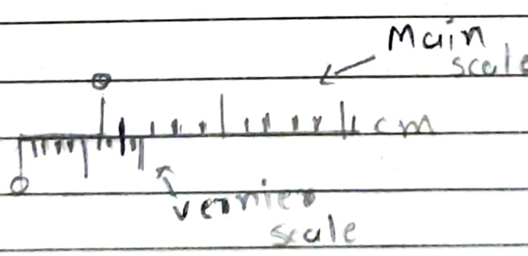
- Positive Error = + matching division x Least Count

$= +2 \times 0.01$ cm

$= +0.02$ cm

- Correction for positive error = -0.02 cm

3. Negative Error:-



There is no gap between the jaws of vernier calipers AC or BD, then zero of vernier scale stands left side of main scale.

- This equipment causes negative error.

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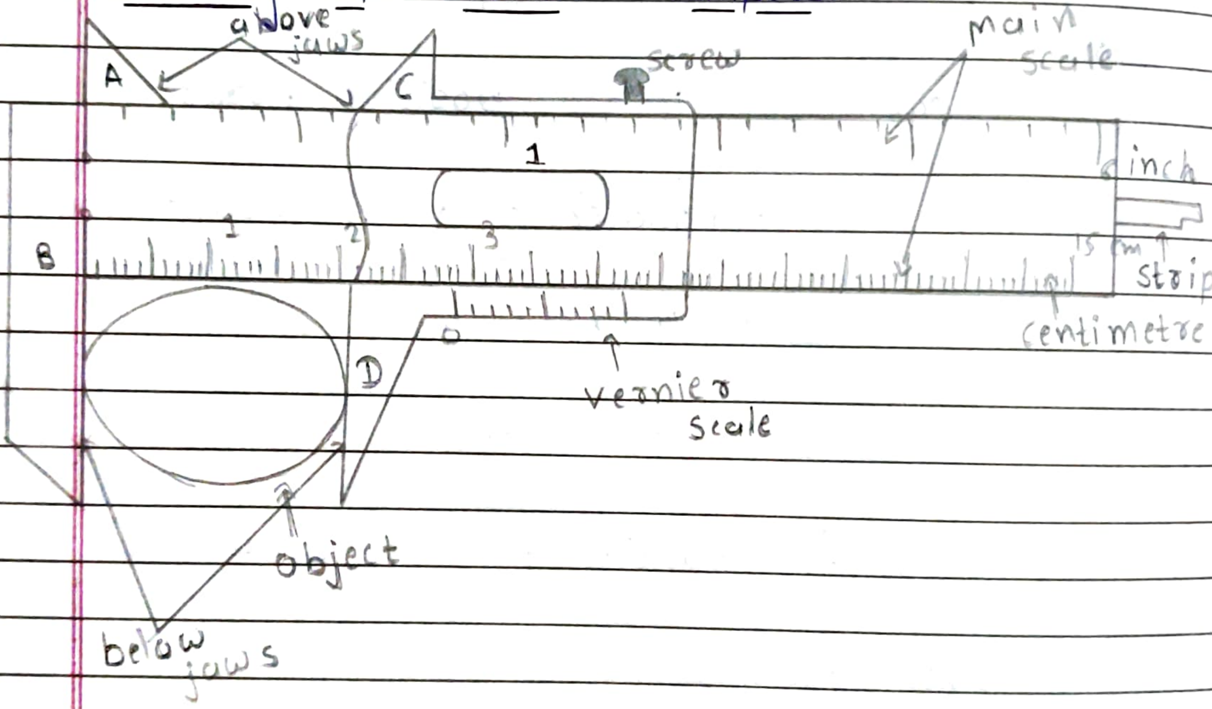
- Negative Error = - matching division × Least count

$= -2 \times 0.01$ cm

$= -0.02$ cm

- Correction for negative error = +0.02 cm

→ Working of Vernier Calipers:-



1. $$\text{Least count} = \frac{\text{The value of smallest division on main scale}}{\text{Total divisions on vernier scale}}$$

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

$= 0.01$ cm

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2. Check out error of given vernier calipers

∴ Error (C') = zero error.

3. To find out diameter of object placed betwe below jaws of vernier calipers and note down the readings of ~~vernier~~ main scale.

4. Main scale reading = 5.6 cm

5. To find out vernier scale reading coincide mark multiply into least count.

∴ Vernier Scale reading = coinciding mark × least count

= 9 × 0.01

= 0.09 cm

6. Outer diameter of given object

∴ D = M.S.R + V.S.R + C'

= 5.6 + 0.09 + 0

= 5.69 cm

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→ Applications of Vernier Calipers:-

- It is used to measure inner diameter of hollow object.
- It is used to find outer diameter of solid object.
- It is used to measure volume of block.
- It is used to measure depth or height of liquid filled in the vessels which have small diameter.

☆ Micrometer Screw Gauge:-

→ Principle:-

It works on least count.

Least count:

The smallest fraction of a unit length which can be measure by micrometer screw gauge is known as least count.

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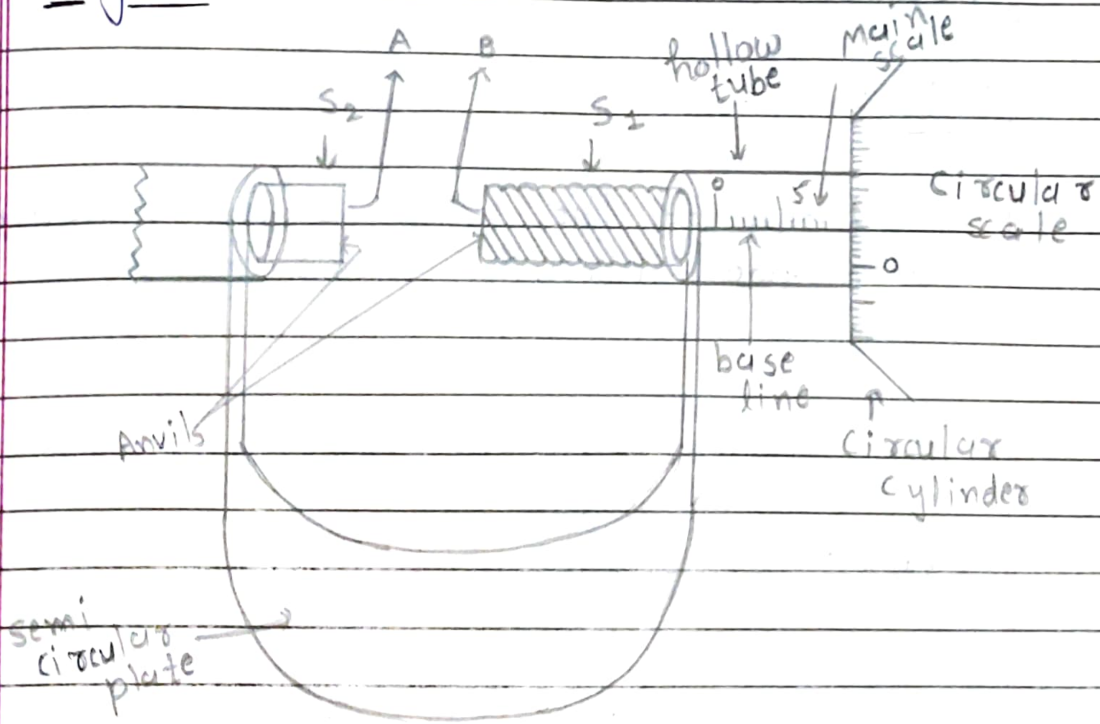
→ Diagram:-

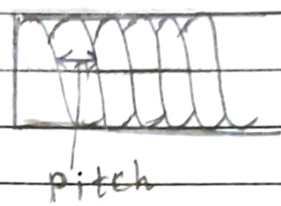


→ Construction:-

There are two main parts of the micrometer screw. It's one part is semicircular steel plate (frame) whose both ends are in the form of a hollow cylinder, the screw S_2 is inserted in the left side hollow cylinder. A hollow tube N is attached to the right side of hollow cylinder. On this hollow cylinder a straight line XY, called a base line, is drawn. A scale in mm is marked on this line. It is called main scale. Second part of the micrometer is a screw S_1, whose left ~~and~~ end B is flat and its right end is fixed with the hollow tube. The circular edge of the hollow tube is divided into 50 or 100 equal parts. This scale is called circular scale.

→ **Pitch:-**

Pitch of the screw is the distance between two consecutive thread of the screw.



→ **Formula:-**

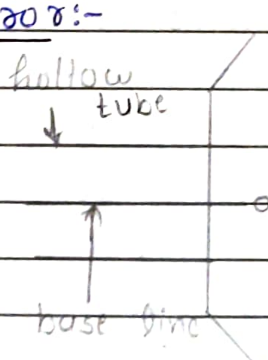
$$\text{Least count} = \frac{\text{pitch distance}}{\text{total divisions on circular scale}}$$

$$= \frac{1}{100}\,mm = 0.01\ mm$$

→ **Error:-**

Error = ± matching division × least count

1. **Zero error:-**



There is no gap between the anvils of the micrometer screw gauge, then the zero of the circular scale coincides with the base line.

- This equipment causes zero error.

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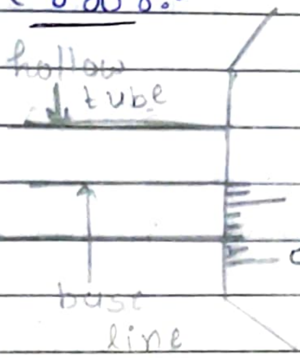
2. Positive error:-



There is no gap between the anvils of the micrometer screw gauge, then the zero of the circular scale lies/stands below the base line.

- This equipment causes positive error.

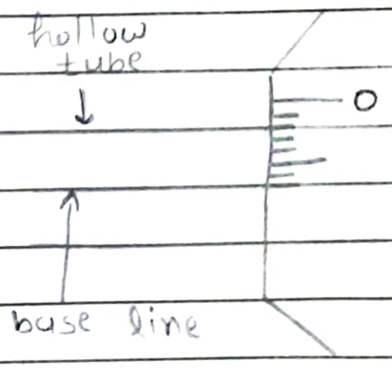
- Positive error = + matching division × least count

$= +7 \times 0.01$ mm

$= +0.07$ mm

- Correction For Positive Error
$c^{+} = -0.07$ mm

3. Negative Error:-



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There is no gap between the anvils of the micrometer screw gauge, then the zero of circular scale stands above the base line.

- This equipment causes negative error.

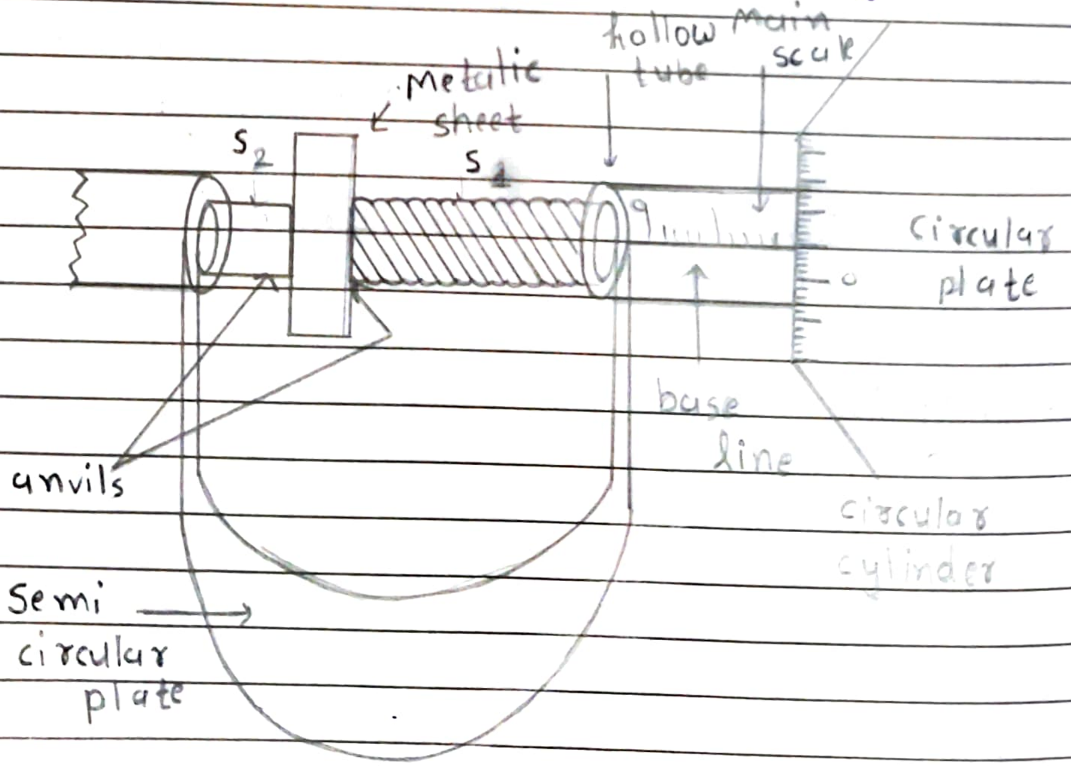
- Negative Error = - matching division x least count

$= -7 \times 0.01$ mm

$= -0.07$ mm

- Correction For Negative Error
$C^- = +0.07$ mm.

→ **Working Of Micrometer Screw Gauge:-**



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1. To find out the least count of given micrometer screw gauge.

$$\text{Least count} = \frac{\text{pitch distance}}{\text{total divisions on circular scale}}$$

$= \frac{1}{100}$ mm

$= 0.01$ mm

2. Check out the error of given micrometer screw gauge.

∴ Error (c') = zero Error

3. To find out thickness of metalic sheet placed between two anvils of micrometer screw gauge and note down the main scale reading.

4. Main scale = 6 mm.

5. To find out circular scale reading coinciding mark multiply with least count.

∴ Circular scale reading = coinciding mark × least count

$= 99 \times 0.01$ mm

$= 0.99$ mm

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6. Thickness of metalic sheet

$= M.S.R + C.S.R + C'$

$= 6 + 0.99 + 0$

$= 6.99$ mm

Types Of Error:-

1. Systemetic Error
2. Random Error
3. Gross Error

1. Systemetic Error:-

During experiments systematic error is either positive or negative. These errors can not be both positive and negative. Reasons for systematic error can be known. So these errors can be reduced.

a) Instrumental Error:

This error is due to defect in the instrument or defect in the calibration of scale e.g. One end of meter scale is broken, then systematic error is created.

b) Errors due to imperfaction in experimental technic or procedure:

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This type error is created due to procedure of experiment e.g. Temperature of body is taken by putting thermometer in armpit, which is less than true temperature of the body.

c) Personal Error:

This error is created due to procedure of taking reading by an individual, unproper arrangement of instruments carelessness.

D) Error due external reasons:

Temperature, pressure, moisture in air, velocity of air etc. can create error in taking reading in experiment.

2. Random Error:-

Even after using fault free, correctly calibrated instruments, taking every care while taking observations, some error occur in the measurements. These errors are called random errors. The random error can be estimated by taking large number of observation and using statistical methods.

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☆ Estimation of Errors:-

1. True Value:

Physical quantity be measured n times and the measured values be $a_1, a_2, a_3, \ldots a_n$. The arithmetic mean of these values is true value.

$$\bar{a} = \frac{a_1 + a_2 + \ldots a_n}{n}$$

2. Absolute Error:

The difference between the true value and the individual measured value of quantity is called absolute value.

$\Delta a_1 = \bar{a} - a_1$ $\Delta a_3 = \bar{a} - a_3$ $\Delta a_5 = \bar{a} - a_5$

$\Delta a_2 = \bar{a} - a_2$ $\Delta a_4 = \bar{a} - a_4$

3. Mean absolute error:

Mean absolute error is defined as mean of positive values (mode) of absolute errors of all the observations.

$$\Delta \bar{a} = \frac{|\Delta a_1| + |\Delta a_2| + \ldots |\Delta a_n|}{n}$$

4. Relative error or Fractional error:

The relative error or fractional error of measurement is defined as the mean absolute error to the mean value of the quantity measured.

$$\delta a = \frac{\Delta \bar{a}}{\bar{a}}$$

5. **Percentage error:-**

when the ~~rel~~ realtive/fractional error is expressed in percentage is called percentage error.

Percentage error $= \delta a \times 100\ \%$

☆ **Significant Figures:-**

The digits that are known reliably plus the first uncertain digit are known as significant digits or significant figures.

→ **Rules for counting / Identification of Significant Figures:**

→ Rule 1: All non-zero digits are significant.
example: 1, 2, 3, 4, 5, 6, 7, 8 and 9.

→ Rule 2: All zeros occuring between two non-zero digits are significant no matter where the decimal point is.

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example: 1007 has four significant figures.
1.0809 has five significant figures.

→ Rule 3: If the number is less than one, the zero(s) on the decimal point and to the left of the first non-zero digit are not significant.
example: 0.005704 has four significant figures.

→ Rule 4: In a number without a decimal point, the terminal or trailing zeros are not significant.
example: 3210 has three significant figures.

→ Rule 5: In a number with decimal point, the trailing zeros are significant.
example: 3.500 has four significant figures
0.0069000 has five significant figures

→ Rule 6: Change of units does not change the number of significant figures in a measurement.
example: 5.608 has four significant digits.

→ Rule 7(A): If the digit to be dropped is less than 5, then the preceding digit is left unchanged.
~~For example, rounded off to 7.8~~
example: 7.82 rounded off to 7.8.

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→ Rule 7(B): If the digit to be dropped is more than 5, then the preceding digit is raised by one.

example: 6.87 rounded off to 6.9.

☆ Definition:-

1. Physical Quantities:-

A quantity that can be measured and by which various physical happenings can be explained and expressed in the form of laws is called a physical quantity.

Ex. length, mass, time, force, etc.

2. Unit:-

A unit is a value, quantity or magnitude in terms of which other values, quantities or magnitudes are expressed. Generally, a unit is independent of physical and environment conditions and is fixed by definition.

3. Metre:-

It is defined in terms of the standard wavelength of light and is equal to 1650763.73 wavelengths in vacuum of radiation corresponding to transition between the energy levels $^2p_{10}$ and $^5d_5$ of krypton 86 atom.

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4. Kilogram:-

The mass of 1 litre pure water at 4°c is known as kilogram.

5. Second:-

It is defined as 9192631770 periods of radiation corresponding to the unperetuxbed transition between the hyper fine levels of the ground state of the atom of caesium (C^{133}) atom.

6. Ampere:-

Ampere is defined as the current which when of flowing through two parallel conductors of infinitely long and negligible cross section area placed in vaccume one meter part, conductor experiences a force of 2.0×10^{-7} newton per meter.

7. Kelvin:-

On thermodynamic scale $1/273.16^{th}$ part of temperature of triple point of water is defined to be 1°k.

8. Candela:-

The luminous flux radiated by 1/6,00,000 sq meter surface of a perfactly

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black body having 1.01325×10^5 N/m^2 pressure and temperature corresponding to melting point of platinum is known as candela.

9. Mole:-

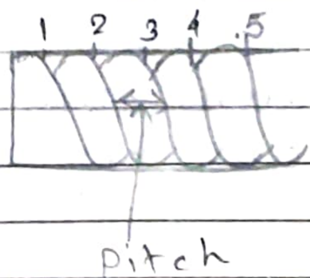
One mole contains exactly $6.02214076 \times 10^{23}$ elementary entities. This number is the fixed numerical value of the Avogadro constant N_A, when expressed in the unit mol^{-1} and is called the Avogadro number. An elementary entity may be an atom, a molecular, an ion, an electron, any other particle or specified group of particles.

10. Least Count:-

The smallest fraction of the unit of length which can be measured with vernier callipers is called it's least count.

11. Pitch:-

Pitch of the screw is the distance between two consecutive thread of the screw.



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12. Accuracy:-

The accuracy of a measurement is a measure of how ~~mu~~ close the measured value is to the true value of the quantity.

13. Precision:-

Precision means to what resolution or limit the quantity is measured by a measuring instrument.

14. Vector quantities:-

Those physical quantities which have magnitude and direction both are called vector quantities. Ex. velocity, acceleration, etc.

15. Scalar quantities:-

Those physical quantities which possess only magnitude and no direction in space is known as scalar quantities. Ex. temperature, mass, etc.

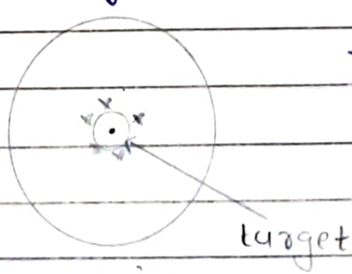
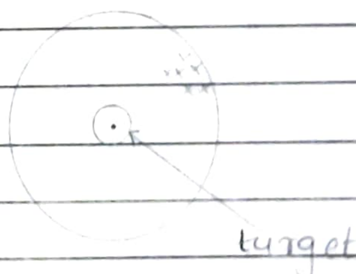
16. Error:-

Difference between true value and measured value of any physical quantity is known as error.

* Write the difference between MKS and CGS system.

MKS	CGS
- MKS stands for Meter kilogram second.	- CGS stands for Centimeter Gram second.
- In MKS, length's unit is meter.	- In CGS, length's unit is centimeter.
- In MKS, mass' unit is kilogram.	- In CGS, mass' unit is gram.

* Write the difference between accuracy and precision.

Accuracy	Precision
- The accuracy of a measurement is a measure of how close the measured value is to the true value of the quantity.	- Precision means to what resolution or limit the quantity is measured by a measuring instrument.
- 	- 
- When we shoot on a target with rifle all shoots nearer to target. so, here we can see accuracy.	- When we shoot on a target with rifle all shoots are far away from the target but are nearer to each other. So, here we can see precision

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☆ Conversion from MKS to CGS or vice versa:-

1. $0.046\ N/m^2 = 0.46\ dyne/cm^2$

$= \frac{0.046 \times 10^5}{10^4}\ dyne/cm^2$

$= 0.046 \times 10^{5-4}\ dyne/cm^2$

$= 0.046 \times 10\ dyne/cm^2$

$= 0.46\ dyne/cm^2$

2. $1\ gm/cm^3 = 1000\ kg/m^3$

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

$= \frac{1 \times 10^{-3}}{10^{-6}}$

$= 1 \times 10^{-3+6}$

$= 1 \times 10^3$

$= 1000\ kg/m^3.$