UNITS

A unit is a standard chosen to measure a physical quantity

PHYSICAL QUANTITY

The quantities which can be measured by an instrument and by means of which we can describe the laws of physics are called physical quantities.

TYPES OF PHYSICAL QUANTITIES

FUNDAMENTAL

Certain physical quantities have been chosen arbitrarily and their units are used for expressing all the physical quantities, such quantities are known as Fundamental, Absolute or Base Quantities.

DERIVED

Physical quantities which can be expressed as a combination of base quantities are called derived quantities.

e.g: $\text{Velocity}\left[\frac{m}{s}\right] = \frac{\text{Length [m]}}{\text{Time [s]}}$

SUPPLEMENTRY

Besides the seven fundamental physical quantities, two supplementary quantities are also defined, they are:

- Plane angle
- Solid angle

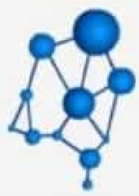
NOTE : The supplementary quantities have only units but no dimensions.

MAGNITUDE

Magnitude of physical quantity = (numerical value) x (unit)

Magnitude of a physical quantity is always constant. It is independent of the type of unit.

$$n_1 u_1 = n_2 u_2 = \text{constant}$$

FUNDAMENTAL UNITS							
QUANTITY	Length	Mass	Luminous intensity	Amount of substance	Time	Electric current	Temperature
UNITS	Metre	Kilogram	Candela	Mole	Second	Ampere	Kelvin

DIMENSIONS

Dimensions of a physical quantity are the power to which the fundamental quantities must be raised to represent the given physical quantity.

1 USE OF DIMENSIONS

CONVERSION OF UNITS

$$n_1 [u_1] = n_2 [u_2]$$

Suppose the dimensions of a physical quantity are 'a' in mass, 'b' in length and 'c' in time. If the fundamental units in one system are M_1, L_1 and T_1 and in the other system are M_2, L_2 and T_2 respectively. Then we can write.

$$n_1 [M_1^a L_1^b T_1^c] = n_2 [M_2^a L_2^b T_2^c]$$

ANALYZING DIMENSIONAL CORRECTNESS OF A PHYSICAL EQUATION

Every physical equation should be dimensionally balanced. This is called the **'Principle of Homogeneity'.** The dimensions of each term on both sides of an equation must be the same.

Note: A dimensionally correct equation may or may not be physically correct.

PRINCIPLE OF HOMOGENEITY OF DIMENSIONS

This principle states that the dimensions of all the terms in a physical expression should be same.

For e.g, in the physical expression $s = ut + \frac{1}{2}at^2$, the dimensions of **s, ut** and $\frac{1}{2}at^2$ all are same.

Note: Physical quantities separated by the symbols +, –, =, >, < etc., have the same dimensions.

2 LIMITATIONS OF DIMENSIONAL ANALYSIS

- By this method, the value of dimensionless constant can not be calculated.
- By this method, the equation containing trigonometrical, exponential and logarithmic terms cannot be analysed.
- If a physical quantity depends on more than three factors, then relation among them cannot be established because we can have only three equations by equating the powers of **M, L** and **T.**

ERROR

Difference between the result of the measurement and the true value of what you were measuring

Types of Error

RANDOM ERROR

Random errors appear randomly because of the operator, fluctuations in the external conditions and variability of the measuring instruments. The effect of random error can be some what reduced by taking the average of measured values. Random errors have no fixed sign or size.

Thus they are represented in the form **A ± a**

SYSTEMATIC ERROR

Systematic error occurs due to an error in the procedure or miscalibration of the instrument etc. Such errors have same size and sign for all measurements. Such errors can be determined.

The systematic error is removed before beginning calculations. Bench error and zero error are examples of systematic error.

ABSOLUTE ERROR

Error may be expressed as absolute measures, giving the size of the error in a quantity in the same units as the quantity itself.

Least Count Error :- If the instrument has known least count, the absolute error is taken to be **half** of the least count unless otherwise stated.

RELATIVE (OR FRACTIONAL) ERROR

Error may be expressed as relative measures, giving the ratio of the quantity's error to the quantity itself

$$\text{Relative Error} = \frac{\text{Absolute error in a measurement}}{\text{Size of the measurement}}$$

RULES OF ERROR MEASUREMENT

01 ADDITION & SUBTRACTION RULE

The absolute random errors **add**

If $R = A + B$, or $R = A - B$, then $r = a + b$

02 PRODUCT & QUOTIENT RULE

The relative random errors **add**

If $R = AB$, or $R = \frac{A}{B}$, then $\frac{r}{R} = \frac{a}{A} + \frac{b}{B}$

03 POWER RULE

When a quantity Q is raised to a power P, the relative error in the result is P times the relative error in Q. This also holds for negative powers.

IF $R = Q^P$, then $\frac{r}{R} = P \times \frac{q}{Q}$

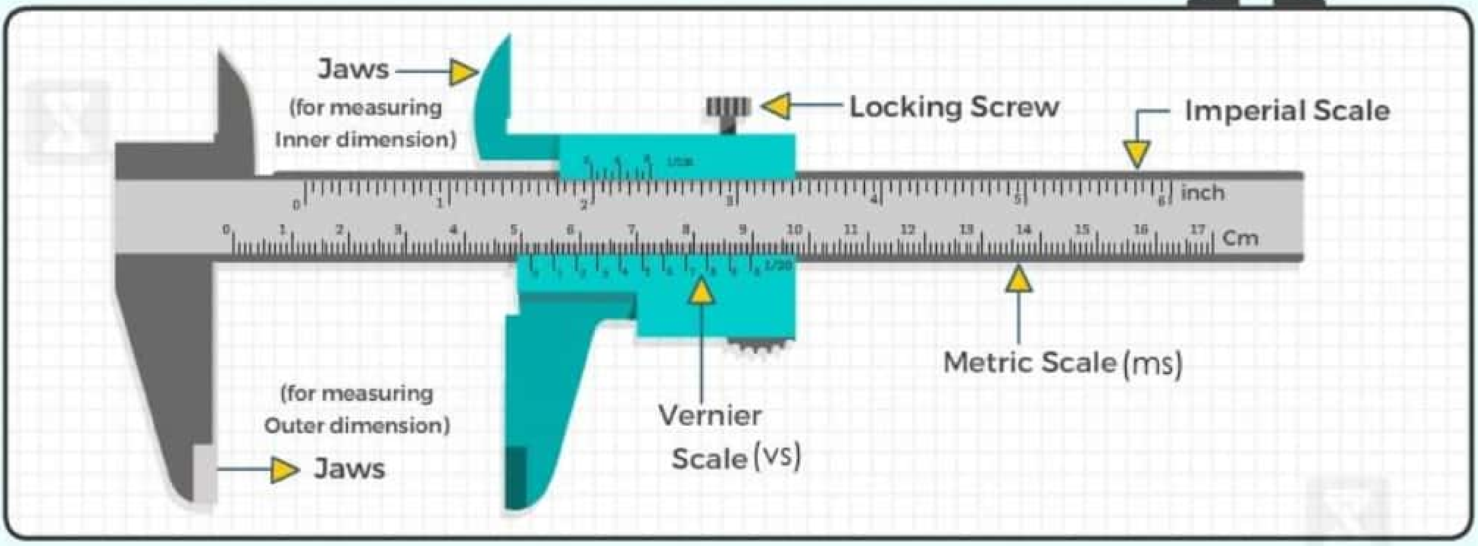
VERNIER CALLIPERS

Least count of Vernier Callipers

The least count of Vernier Callipers **(v.c)** is the minimum value of correct estimation of length without eye estimation. If N^{th} division of vernier calliper coincides with **(N–1)** division of main scale, then

$$N(vs) = (N-1)\ ms \Rightarrow 1\ vs = \frac{N-1}{N} ms$$

vs = Vernier Scale Reading : ms = Main Scale Reading

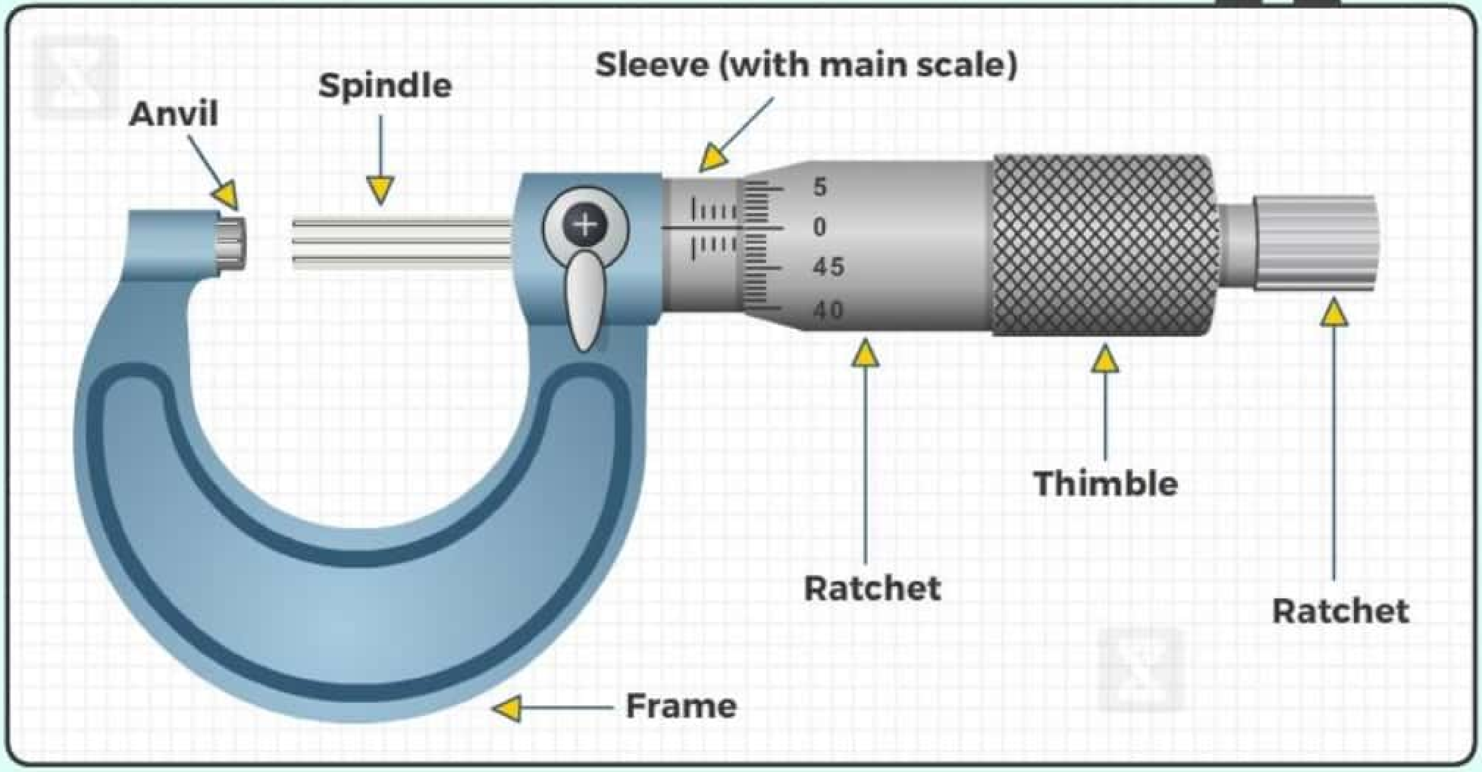


Vernier Constant $= 1\ ms - 1\ vs = \left(1 - \frac{N-1}{N}\right) ms = \frac{1}{N} ms$, which is equal to the value of the smallest division on the main scale divided by total number of divisions on the vernier scale.

SCREW GAUGE (OR MICROMETER SCREW)

The instrument is provided with two scales

- The main scale or pitch scale is (M) graduated along the axis of screw.
- The cap-scale or head scale (H) around the edge of the screw head.



Pitch :- The pitch of the instrument is distance between two consecutive threads of the screw which is equal to the distance moved by the screw due to one complete rotation of the cap. Thus for,

10 rotation of cap = 5 mm, then pitch = 0.5 mm.

Least count :- The minimum (or least) measurement (or count) of length is equal to one division on the head scale which is equal to pitch divided by the total cap divisions.

$$\text{Least count} = \frac{\text{Pitch}}{\text{Total cap divisions}}$$

Measurement of length by screw gauge

Length, L = n × pitch + f × least count,

where **n = main scale reading & f = caps scale reading**

Zero Error

In a perfect instrument the zero of the main scale coincides with the line of gradiation along the screw axis with no zero-error, otherwise the instrument is said to have zero-error which is equal to the cap reading with the gap closed. This error is positive when zero line of reference line of the cap lies **below** the line of graduation and vice-versa. The corresponding corrections will be just opposite.