METROLOGY

Metrology is a science of measurement. Metrology may be divided depending upon the quantity under consideration into: metrology of length, metrology of time etc.
Depending upon the field of application it is divided into engineering metrology, medical metrology etc.
Engineering metrology is restricted to the measurement of length, angles and other quantities which are expressed in linear or angular terms.
The **methods of measurement** can be classified as:
1. Direct method
2. Indirect method
3. Comparative method
4. Coincidence method
5. Deflection method
6. Complementary method
7. Contact method

Measuring system element
A measuring system is made of five basic elements. These are:
1. Standard
2. Work piece
3. Instrument
4. Person
5. Environment

Error :-The difference between the true value and the measured value is known as error of measurement.
Accuracy:- It is the degree to which the measured value of the quality characteristic agrees with the true value.

Types of Error
During measurement several types of error may arise, these are
Error of Measurement
1. Instrumental error
2. Error of observation
3. Based on nature of errors
4. Based on control

Classification of Measuring Instruments :-

1. **Precision or non-precision measuring instruments** :- The precision instruments are those which have ability to measure parts with an accuracy of 0.001 mm or better.
   The non-precision instruments are limited to the measurements of parts to a visible line graduation on the instruments used , such as graduated rule or scale etc.

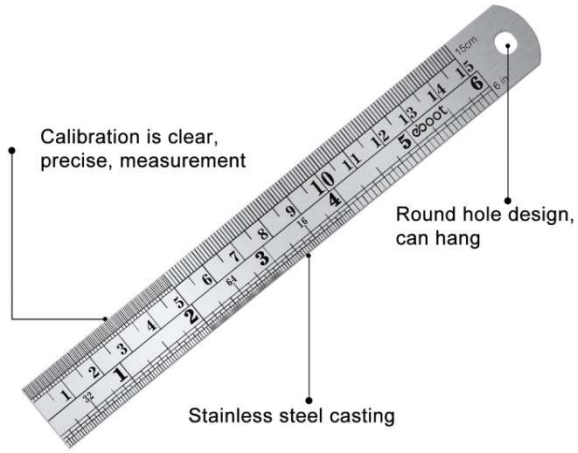
2. **Line measuring or end measuring instruments:-** In line measuring instruments, the ends of a dimension being measured are aligned with graduations of the scale from which the length is read directly such as steel rule. In end measuring instruments, the measurements are taken between the two ends as in micrometer, calipers, gauge block etc. These instruments are more useful and important for precision measuring work.

3. **Direct or Indirect type measuring instruments**:- The direct type measuring instrument are used to determine the actual size and dimension of a work piece. The indirect type measuring instruments are used to compare measurements of workpiece with the direct measuring instruments.

Description Of Some Measuring Instruments :-

1. **Steel Rule :-**

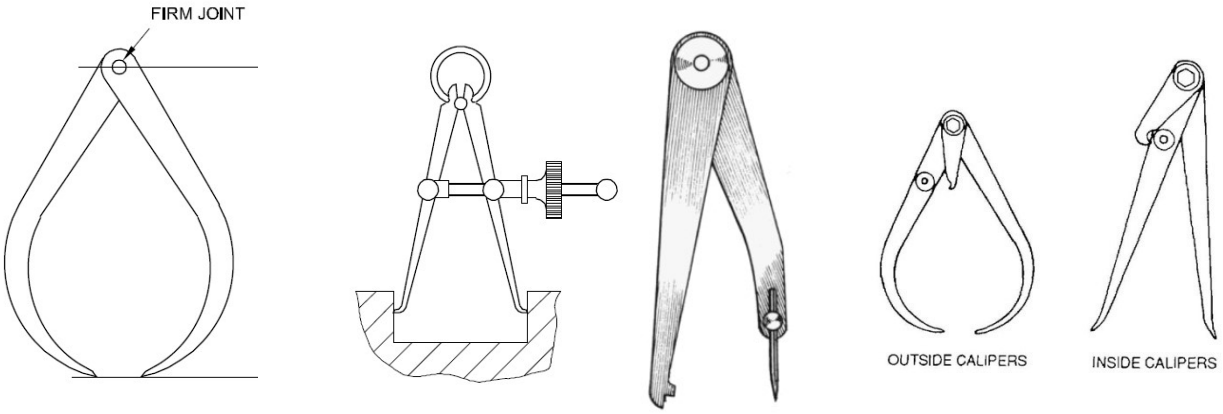
The Steel rule, also known as scale is the simplest and most common non-precision liner measuring instrument, and it is made of tempered steel. All the faces of a steel rule are machined true on one of the flat faces, the graduations are marked in inches and in centimeters.



2. **Calipers** :- These are non-precision linear measuring instrument used to transfer and compare a dimension from one object to another or from one part to a micrometer or to a scale

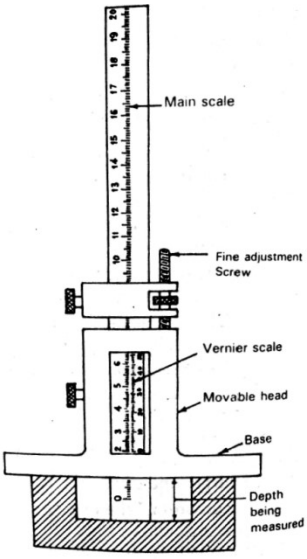
Type of calipers:-

i.Outside caliper , ii. Inside caliper , iii. Odd leg caliper & iv. Transfer caliper.



4. **Divider: -** The dividers may be firm joint type or spring type, but the spring type dividers are preferred for smaller and more accurate work. It is used for transfer ring dimension, making out curved and circles and for doing general layout work.

5. **Depth gauge** :- It is used for measuring the depth of blind holes, grooves, slots and heights of shoulders in holes etc.



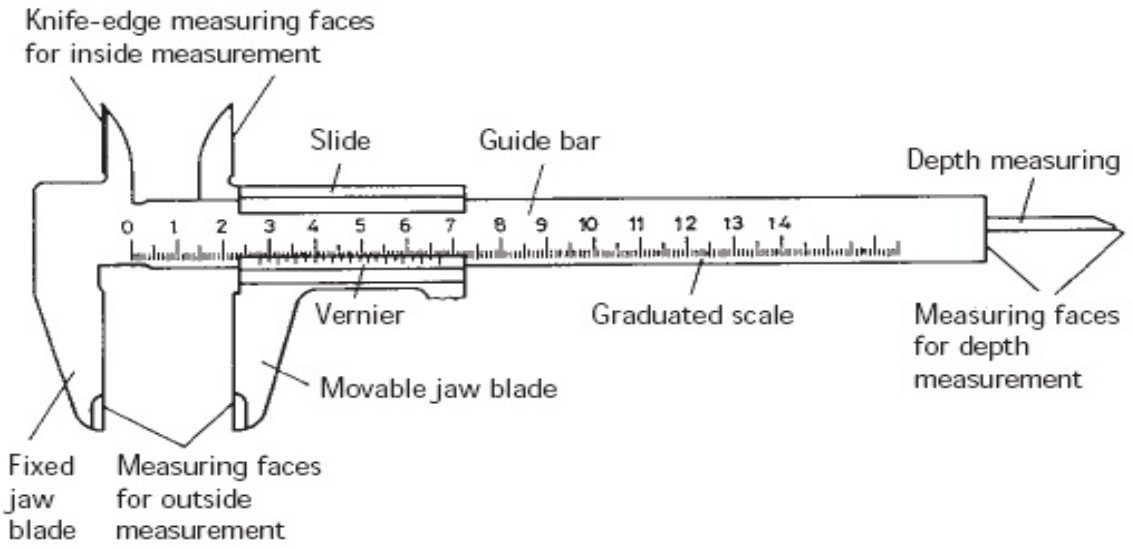
6. **Vernier Caliper**: -

It is a precision instrument which is used for measuring external as well as internal diameters of shafts, thickness of parts etc. to accuracy of 0.02mm.

The principle of vernier is that when two scales or divisions slightly different in size are used, the difference between them can be utilized to determine the accuracy of measurement.

$$\text{Least count of vernier caliper} = \frac{\text{Smallest division on main scale}}{\text{Number of division on vernier scale}}$$

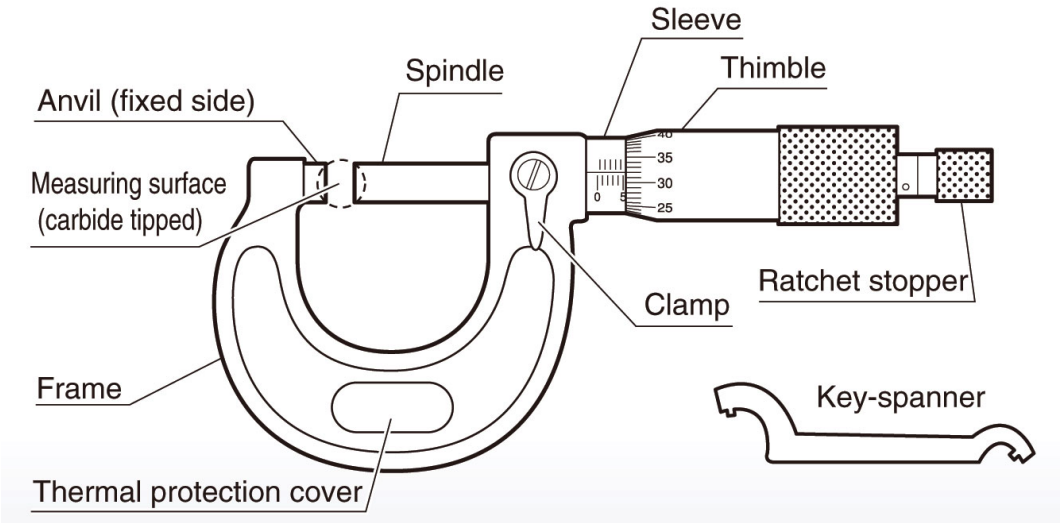
$$= \frac{0.5}{25} = 0.02 \text{ mm}$$



7. **Micrometers: -** It is mainly used to measure the outside diameter of a job or length of a small part. It can measure the dimension to an accuracy of 0.01 mm.

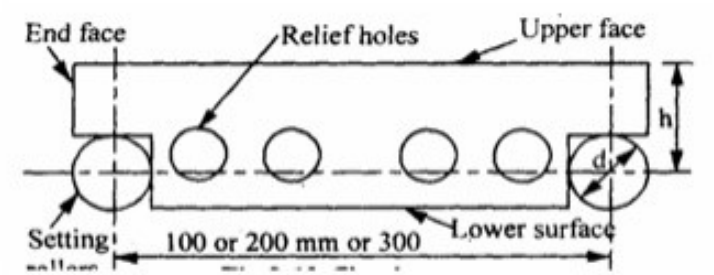
$$\text{Least count of micrometer} = \frac{\text{Pitch of the screw}}{\text{Number of division on the thimble}}$$

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



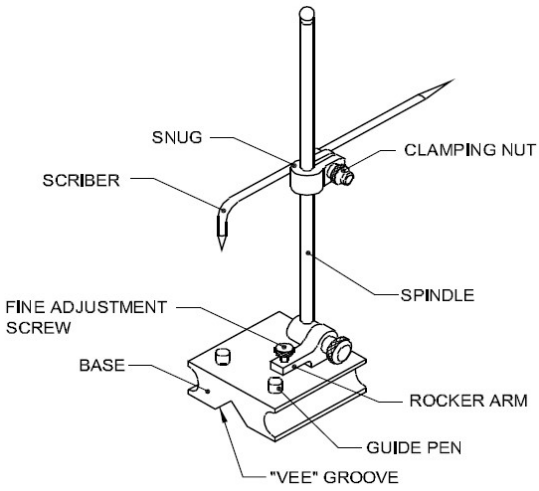
8. **Combination Set**:- It is extremely useful instrument and has all the essential features of try square bevel protractor, rule and scriber. This instrument is used for multipurpose measurements.

9. **Sine Bar**: It is issued either to measure angle more precisely than a bevel protractor or for locating any work to a given angle within very close limits. It is generally used in conjunction with clip gauges.



10. **Spirit Level**:- It is used for leveling the machinery and other equipment. It is based on precision angle measuring principle.

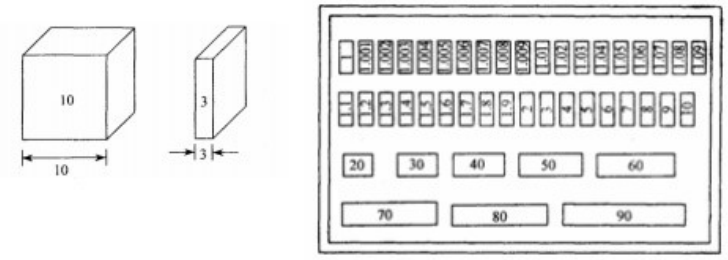
11. **Surface Gauge** :- In Metrology, the Surface gauge is a non-precision instrument.
It is used for checking parallelism of work, for scribing lines at specified heights and for making out parts that have to be fitted or machined.



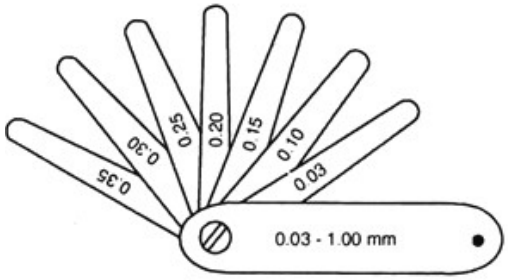
GAUGES

The gauges are fixed dimension instruments. These are generally used to check the particular dimension of a work piece within their tolerance. The gauges should be made so that a minimum of time and skill is required in their use. The instruments differ from measuring instruments because they have no graduation to measure the various length and angles and normally no adjustment can be made in their use. The gauges are specially made for some particular job which is to be produced in their quantities.

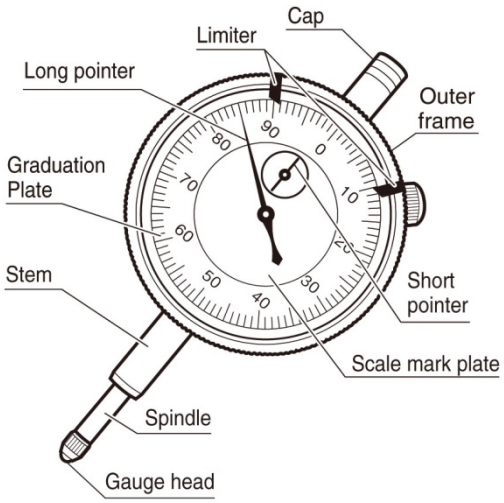
A. **Slip Gauges**:- The slip gauges are used for checking the accuracy of measuring instruments such as micrometers, calipers, snap gauges dial indicator etc. The slip gauges consist of steel blocks of section about 30 mm by 10 mm.



B. **Feeler Gauge**;- The feeler gauge is use to check the clearance between mating surfaces. It consists of a series of thin steel sheet strips hardened and ground to various thicknesses.



C. **Dial Gauge**: - The dial gauges are used for checking parallelism and concentricity of rods, holes and flatness of surface to an accuracy of 0.01 mm. These gauges are widely used to lathe.



D. **Bore Gauge:** A bore gauge is a special tool, which is used to accurately measure the inside diameter of a hole, cylinder or pipe.

FITS

The degree of tightness or looseness between the two mating parts is known as a fit of the parts. The nature of fit is characterized by the presence and size of clearance and interference.

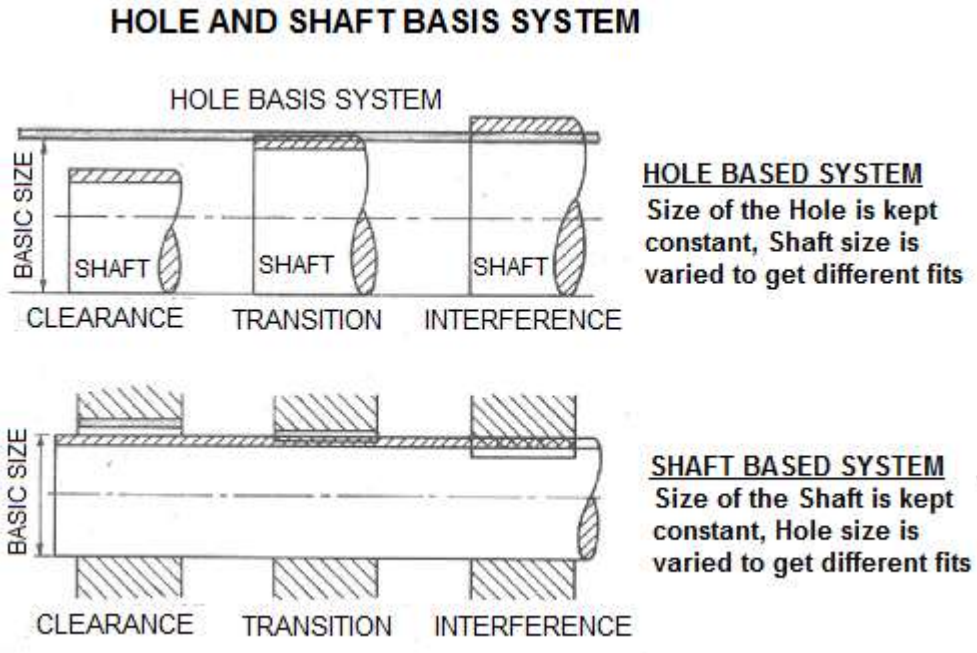
Types of Fits:-

1. **Clearance fits**:- In this type of fit, the size limit for mating parts are so selected that clearance between them always occur. The clearance fit may be slide fit, easy sliding fit, running fit, slack running fit and loose running fit.

2. **Interference fits**:- In this type of fit, the size limit for the mating parts are so selected that interference between them always occur. The interference fits may be shrink fit, heave drive fit and light drive fit.

3. **Transition fits**:- In this type of fits, the size limits for the mating parts are so selected that either a clearance or interference may occur depending upon the actual size of the mating parts. The transition fits may be force fit, tight fit and push fit.

   Basis of Limit system:-
   The following are two types of limit system.
   1. **Hole Basis**:- When the hole is kept as a constant member and different fits are obtained by varying the shaft size, then the limit system is said to be on a hole basis.
   2. **Shaft basis**:- When the shaft is kept as a constant member and different fits are obtained by varying the hole size, then the limit system is said to be on a shaft basis.



Electrical measuring instrument

Electrical instruments are instruments that use the mechanical movement of electromagnetic meter to measure voltage, power, and current. By using these instruments we can measure electrical parameters such as voltage, frequency, current, power factor, and resistance.

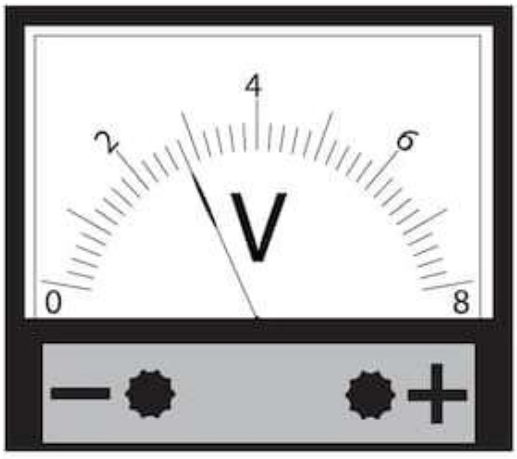
Classification of electrical instruments:

Electrical instruments are classified according to the electrical quantity or the measured characteristics. It is also classified according to the type of test function, according to the current that can be measured by them.

1. **Ammeter:-**An ammeter is an instrument which is used to measure the electric current in amperes in a branch of an electric circuit. In order to measure the current it must flow through the ammeter, so the ammeter must be placed in series with the measured branch and it must have very low resistance.

   Galvanometer was the first type of ammeter, it is used to detect and measure electric current. It is an analog electromechanical transducer which makes a rotary deflection in response to the electric current flowing through the coil.
   A galvanometer can read direct current flow, the magnetic field created as current flows through a coil acts on a spring, which will move the needle indicator.

2. **Voltmeter**
   The voltmeter used to measure the voltage potential of an electrical circuit or the potential difference between two points. A voltmeter can also be considered as an ammeter they also measure the current, voltage is only measured when the current is transmitted in a circuit through resistance. Voltmeters are capable to measure the current, voltage and resistance. Voltmeters are also termed as high resistance ammeters they can also measure DC and AC. A voltmeter can measure the change in voltage by two points in an electrical circuit and they are connected in parallel with the portion of the circuit on which the measurement is made.



3. **Ohmmeter**

An ohmmeter is an instrument that is used to measure the resistance and they can measure the value of resistance accurately. According to their measurement and construction, these instruments are classified into the series type and shunt type ohmmeter. It can be used to check the continuity of the electrical circuits and components. Series type ohmmeters are used to measure the high resistance values while the shunt type is used to measure low resistance values.

4. **Potentiometer**

Potentiometers are instruments that can be used to measure the unknown voltage. The known voltage will be supplied from a standard cell or any other known voltage reference source.

Potentiometer measurement has high accuracy because the measurement is done by the comparison method and the obtained result is not by the deflection of the pointer. Potentiometers can be used to compare the E.M.F of the two cells, it can be used to determine the E.M.F of a cell.

5. **Wattmeter**

Watt-meters are used to measure power, these instruments are similar in design and construction of an ammeter. It can be used to measure the average electric power in watts. Wattmeter has two coils they are current and pressure coil. Wattmeter can be used to measure the gain in amplifiers, bandwidth in filters.

6. **Multi-meter**

Multi-meters can be used to make various electrical measurements; they can be used to measure AC and DC voltage, AC and DC current, and resistance. It is known as multi-meter because it can do the functions of various meters such as voltmeter, ammeter, and ohm-meter. Multi-meters can also be used to check the continuity.

Multi-meters are of two types they are **analog** and **digital** multi-meter.