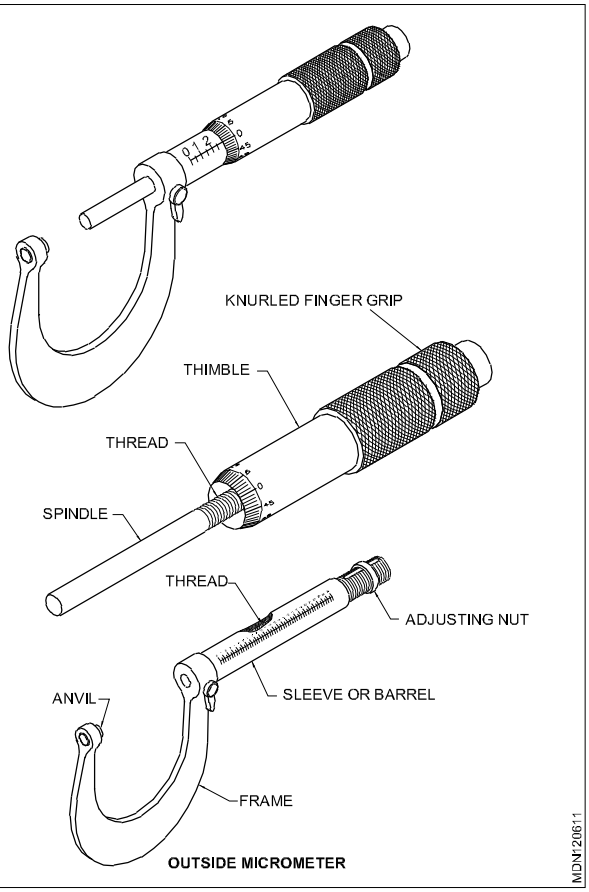
Least count calculation, care and use of micrometer

Objectives : At the end of this lesson you shall be able to
- **name the principal parts of an outside micrometer**
- **derive the least count of metric micrometer**
- **determine the reading by using a metric micrometer**
- **solve the reading and give the measurement**
- **state the features of a large micrometers.**

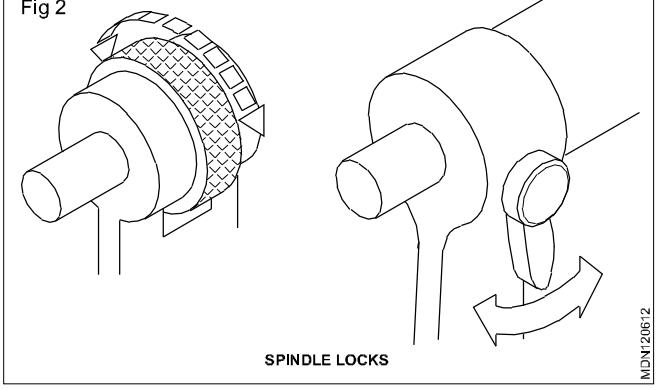
The purpose of a metric micrometer is to read an accuracy of 0.01 mm of an object. It is available in various sizes. However, the measuring range is limited to the length of the threaded spindle.(Fig 1)

Fig 1



OUTSIDE MICROMETER

Fig 2

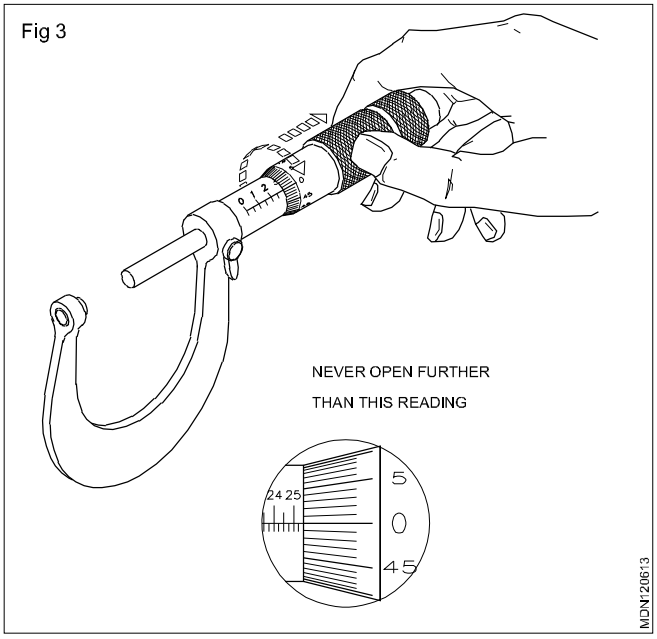


SPINDLE LOCKS

The principal parts of a micrometer are the frame, anvil, spindle and the thread, sleeve or barrel and the thimble, there is a knurled collar or small lever on the frame to lock the spindle in the barrel.(Fig 2) In addition to this, a ratchet stop is provided to the spindle in order to prevent a possible excess pressure on the screw treads.

The sleeve or barrel is marked (Fig 3) with the main scale in full mm and half mm. The thimble bevel end is graduated with the thimble scale. Fifty equal divisions are made on the circumference of the thimble bevel end. Every 5th division of the graduation is indicated with the number. Normally, the spindle face is fitted with a carbide tip to resist the wear. The spindle with the screw is attached to the thimble of the micrometer. The corresponding threaded nut is fitted to the barrel or sleeve of the micrometer. The other measuring face of the micrometer is the anvil, which is normally fitted with a carbide tip to resist the wear.

Fig 3



The range of micrometers are 0-5 mm, 25-50 mm, 50-75, 75-100 mm etc. The spindle can be easily screwed down in the barrel. In order to have the reference point for reading the micrometer, the datum or index line is marked on the sleeve.

When the face of the anvil and the face of the spindle are in contact, the O graduations of the index line and O graduation of the thimble coincide with each other.

The spindle may be withdrawn by rotating the thimble in an anticlockwise direction. The thimble portion is knurled to provide a good grip for holding as well as for rotating the spindle.

Deriving the least count of a metric micrometer

The main scale is graduated in ½ mm. Every 5th mm is shown with the reading. The pitch of the screw thread is accurately maintained to ½ mm.(Fig 4)

Fig 4

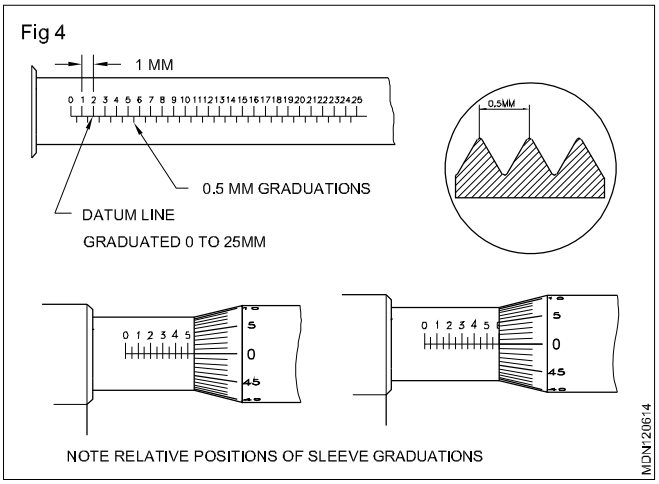
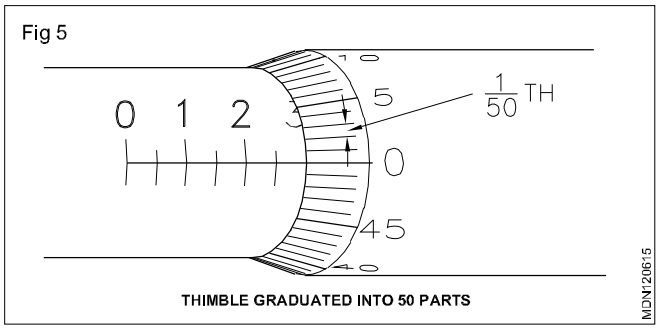


Fig 5



By turning one complete revolution of the thimble in a clockwise or an anticlockwise direction, the spindle moves exactly ½ mm in the forward direction or the reverse direction. As the circumference of the thimble graduated into 50 equal divisions, the advancement of the spindle for each division of the thimble scale is ½ mm - 50 i.e. 1/100 mm or 0.01 mm. Therefore, the least count of a metric micrometer is 1/100 mm or 0.01 mm.(Fig 5)

Determining the reading of a metric micrometer

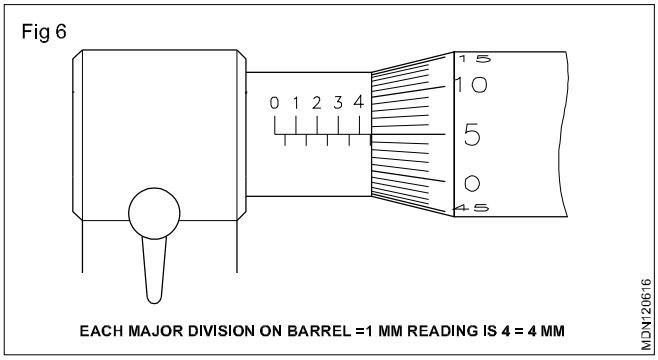
Before using the micrometer for measurement, it is necessary to ascertain that there is no error in the micrometer.

The faces of the anvil spindle must be free from dust.

While reading the micrometer, the spindle must be locked with the reading.

Method of reading

Fig 6



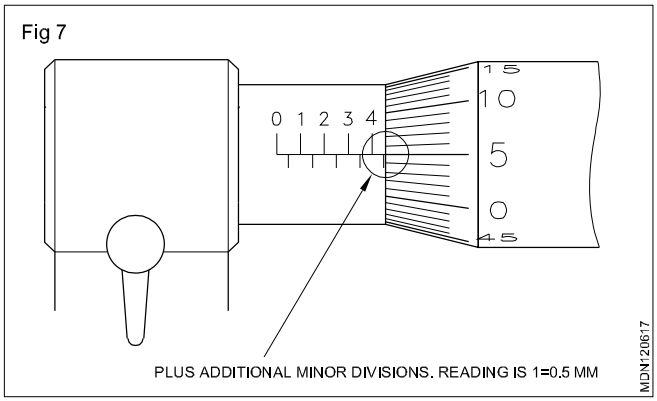
Read on the barrel scale the number of whole millimeters that are completely visible from the bevel edge of the thimble. It reads 4 mm. (Fig 6)

Add to this any half millimeters that are completely visible from the bevel edge of the thimble.

The figure reads ½ = 0.5 mm

Add the thimble reading to the two earlier readings.(Fig 7)

Fig 7

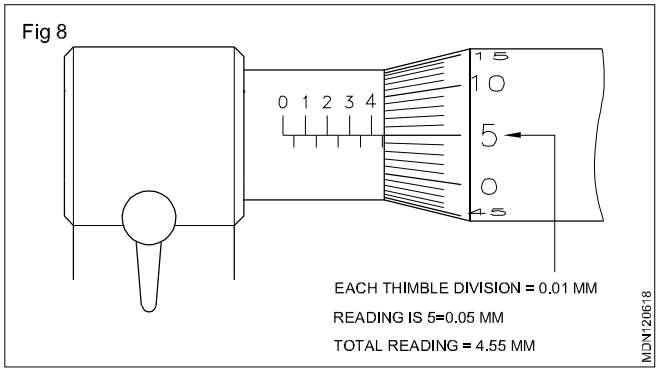


The figure shows the 5th division of the thimble is coinciding with the index line of the sleeve. Therefore the reading of the thimble is 5 8 0.01 mm = 0.05 mm. The total reading of the micrometer.(Fig 8)

a 4.00 mm

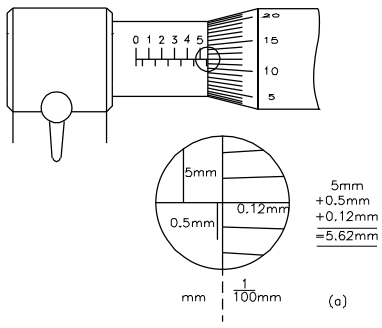
b 0.50 mm
c 0.05 mm
Total reading 4.55 mm

Fig 8

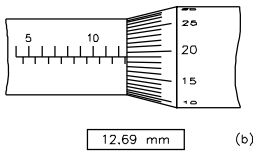


Some examples of metric micrometer readings and their solution.

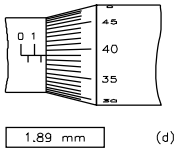
i) 5.00 mm
0.50 mm
0.12 mm
Total 5.62 mm



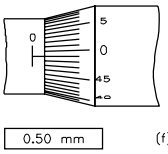
ii) 12.00 mm
0.50 mm
0.19 mm
Total 12.69 mm



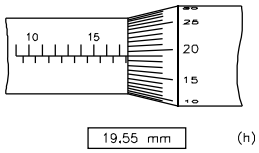
iii) 23.00 mm
0.50 mm
0.49 mm
Total 23.99 mm



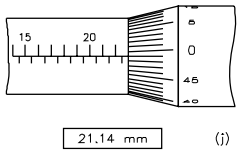
iv) 1.00 mm
0.50 mm
0.39 mm
Total 1.89 mm



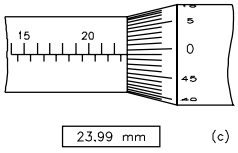
v) 5.00 mm
0.50 mm
0.00 mm
Total 5.50 mm



vi) 0.00 mm
0.50 mm
0.00 mm
Total 0.50 mm



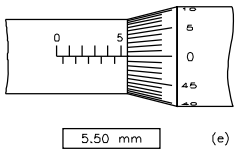
vii) 7.00 mm
0.00 mm
0.22 mm
Total 7.22 mm



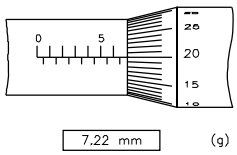
Outside micrometers have limited reading capacity as they are dependent upon the length of the spindle which itself is limited and fixed.

A 0-25 mm capacity outside micrometer can read a maximum dimension of 25 mm. For measuring sizes over and above this, we have to change to the next capacity micrometer 25-50 mm, then 50-75 mm and so on depending on the size of the job. As such, a good number of micrometers will have to be used for finishing jobs of various dimensions. In order to eliminate this problem, a large micrometer is used for measurements.

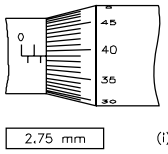
viii) 19.00 mm
0.50 mm
0.05 mm
Total 19.55 mm



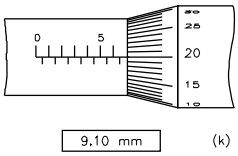
ix) 2.00 mm
0.50 mm
0.25 mm
Total 2.75 mm



x) 21.00 mm
0.00 mm
0.14 mm
Total 21.14 mm

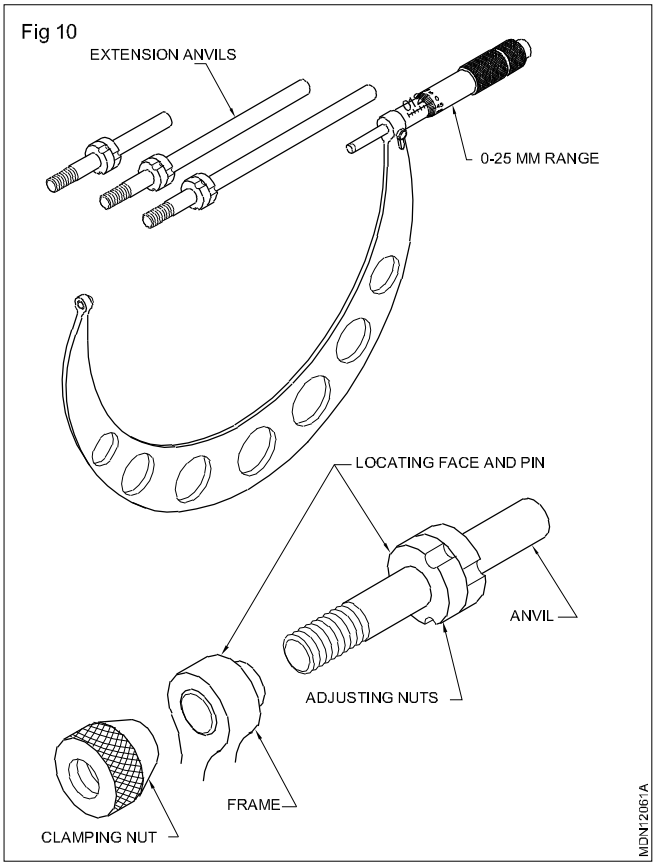


xi) 9.00 mm
0.00 mm
0.10 mm
Total 9.10 mm



Large micrometers (Fig 10)

Fig 10



Skill Information

Precision Measuring Instruments - Outside Metric Micrometer

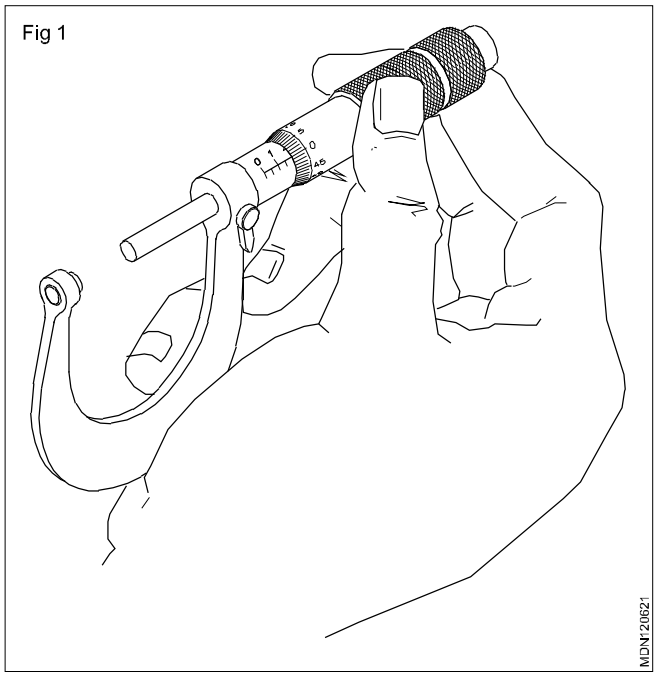
Objectives At the end of this lesson you shall be able to
- **hold the micrometer for measurement**
- **set the micrometer on work for measurement**
- **read the measurement.**

Holding the micrometer for measurement

The micrometer may be held either in one hand or both the hands.

Holding In one hand (Fig 1)

Fig 1



Hold the outside micrometer in your right hand, keeping the graduations on the main scale towards you.

Support the frame on the lower centre of your palm. Use your little or third finger to hold the frame in the palm.

Place the middle finger behind the frame to support it.

Keep the first finger and thumb free to adjust the knurled thimble.

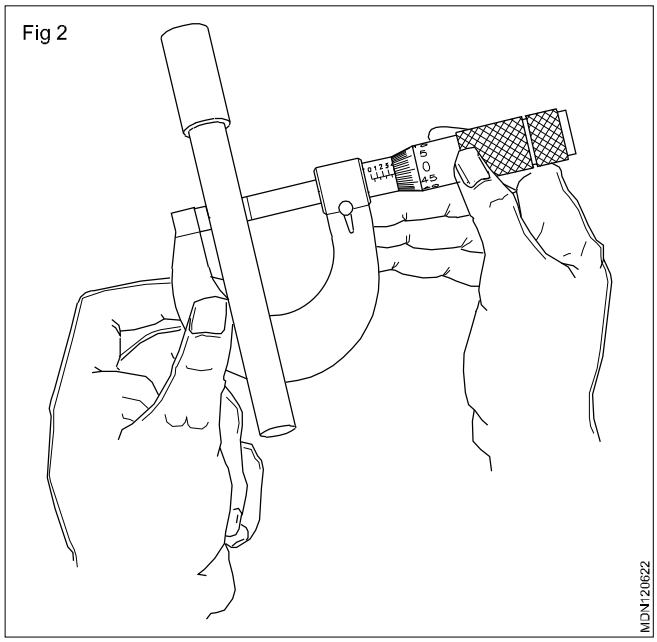
Holding by both the hands (Fig 2)

Sometimes, it may be more convenient to hold the micrometer with both the hands.

Support the frame between the fingers and the thumb of your left hand.

Use the thumb and finger of your right hand to adjust the thimble.

Fig 2



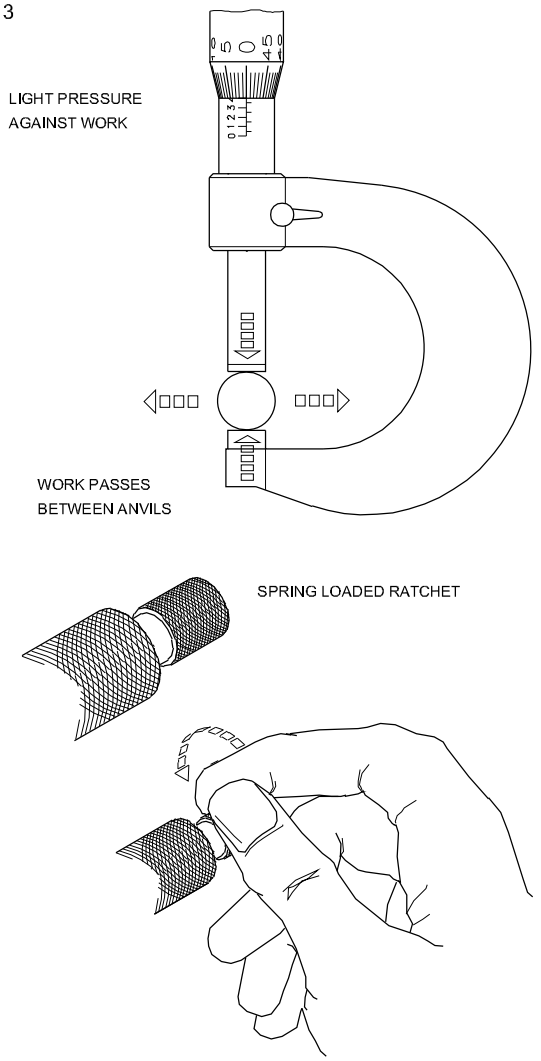
Setting the micrometer on the workplace for measurements (Fig 3**)**

High skills needed for obtaining accurate measurements with the outside micrometer. A wrong setting of the micrometer over the workplace may cause:

- inaccurate reading
- excessive strain on the screw thread
- distortion in the frame.

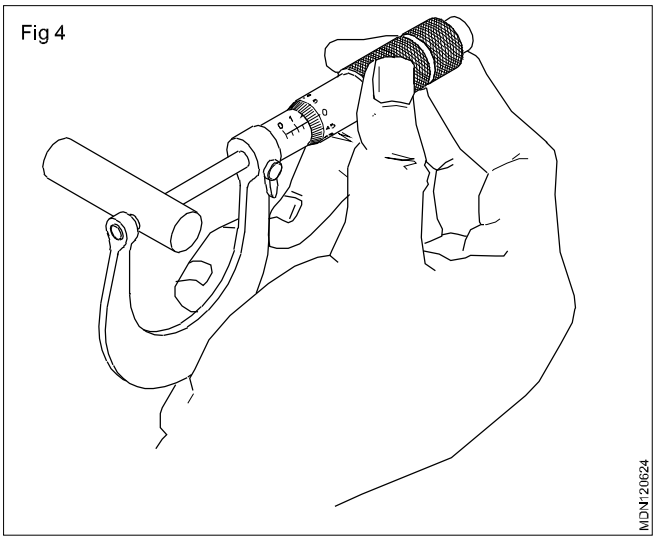
Figure shows the adjustment of the spindle and anvil over workplace. As you adjust the workplace between the spindle and the anvil, you should feel a light pressure or resistance against the workplace surface. Use the spring loaded ratchet stop to ascertain the feel.

Fig 3



While using only one hand: (Fig 4**)**

Fig 4



- Close the anvil and spindle until you feel them just touching the work
- Move the work slightly between the spindle and the anvil or pass the micrometer over the workplace by moving your wrist
- Make further adjustments of the thimble as required until you obtain the right 'feel'
- When satisfied with the feel, remove the fingers from the thimble
- Turn the micrometer towards you
- read the measurement

Method of reading the micrometer 0-25 range (Fig 5)

Look at the reading which has been taken from the workplace.

Read on the barrel scale the number of whole millimeters that are completely visible from the bevel edge of the thimble. Figure 'a' shows 4 divisions = 4 mm.

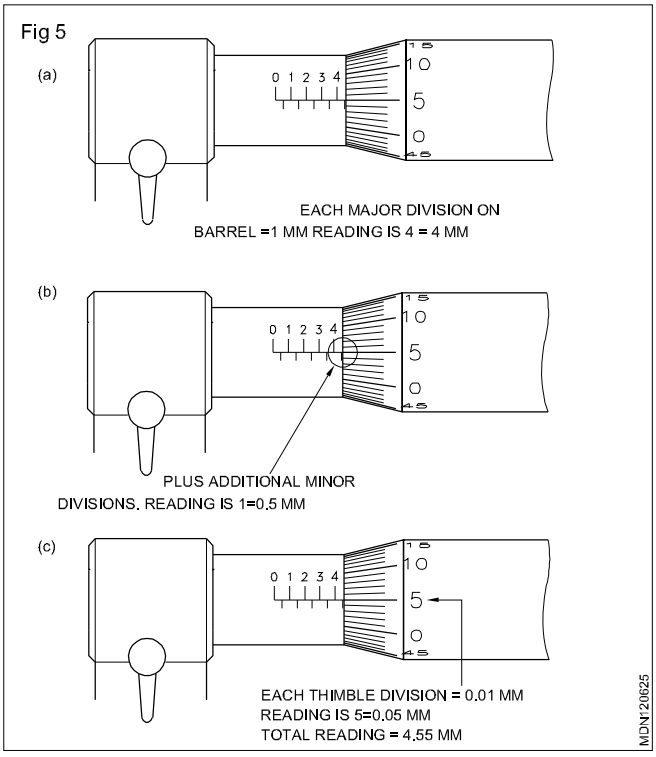
Add any half millimeters that are completely visible from the bevel edge of the thimble.

Figure 'b' shows 1 division = 0.5 mm.

Add the thimble reading to the main scale reading which has already been taken. Figure 'c' shows the 5th division of the thimble scale is coinciding with the index line. So thimble reading = 5 * 0.01 = 0.05 mm.

	4. 00 mm
	0.50 mm
	0.05 mm
Total reading	4.55 mm

Fig 5



Depth micrometer

Objectives: At the end of this lesson you shall be able to

- **name the parts of a depth micrometer**
- **state the constructional features of a depth micrometer**
- **read the depth micrometer measurement.**

Constructional features (Fig 1)

A depth micrometer consists of a stock on which a graduated sleeve is fitted.

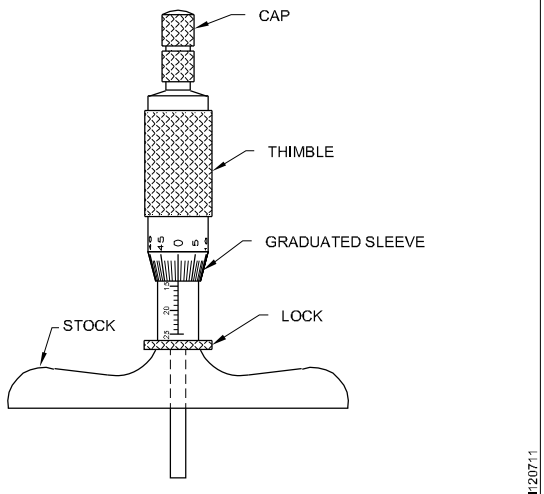
The other end of the sleeve is threaded with 0.5 mm pitch 'V' thread.

A thimble, which is internally threaded to the same pitch and form, mates with the threaded sleeve and slides over it.

The other end of the thimble has an external step machined and threaded to accommodate a thimble cap.

A set of extension rods are generally supplied. On each of them, the range of sizes that can be measured with that rod is engraved as 0-25 mm, 25-50 mm, 50-75 mm, 75-100 mm, 100-125 mm and 125-150 mm.

Fig 1



These extension rods can be inserted inside the thimble and the sleeve.

The extension rod has a collar head which helps the rod to be held firmly. (Fig 2)

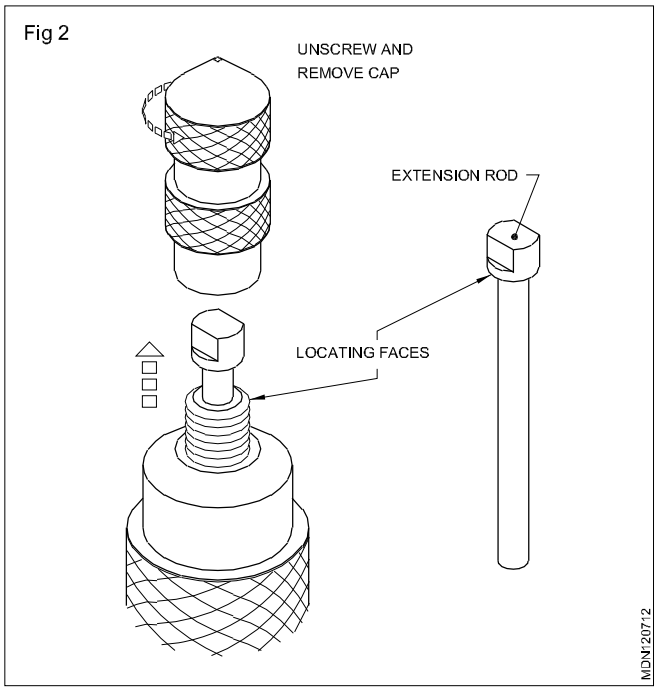
The measuring faces of the stock and the rods are hardened, tempered and ground. The measuring face of the stock is machined perfectly flat.

The extension rods may be removed and replaced according to the size to be measured.

Graduation and least count

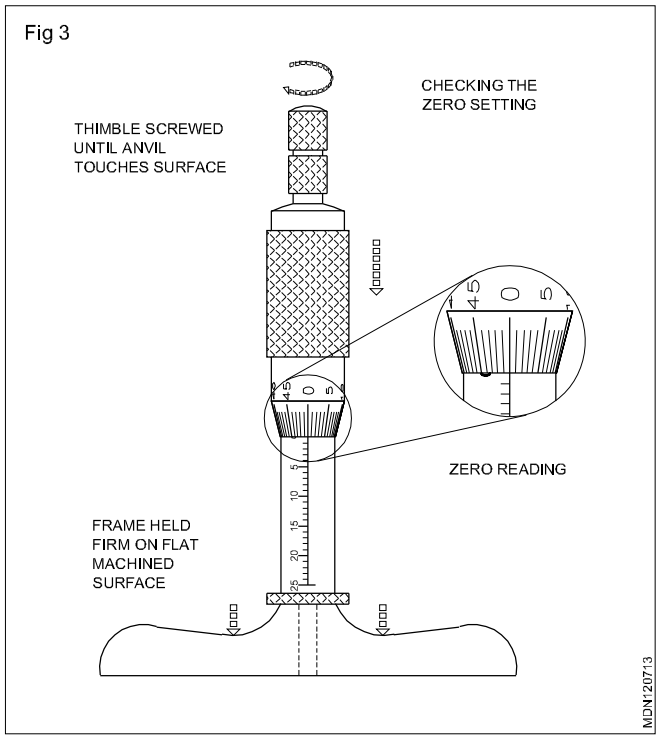
On the sleeve a datum line is marked for a length of 25 mm. This is divided into 25 equal parts graduated. Each

Fig 2



line represents one millimeter. Each fifth line is drawn little longer and numbered. Each line representing 1mm is further subdivided into two equal parts. Hence each subdivision represents 0.5 mm. (Fig 3)

Fig 3

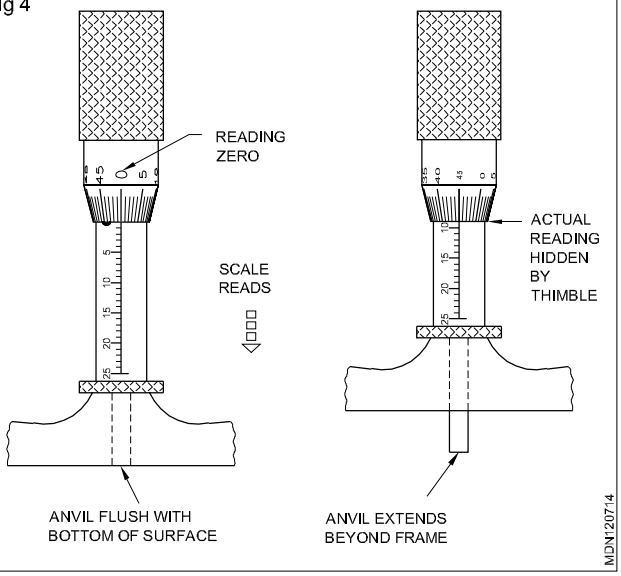


The graduations numbered are in the reverse direction to that marked on an outside micrometer.

The zero graduation of the sleeve is one the top and the 25 mm graduation is near the stock.

The bevel edge of the thimble is also graduated. The circumference is divided into 50 equal parts and every 5th division line is drawn longer and numbered. The numbering is in the reverse direction and increases from 0 to 5, 10, 15, 25, 30, 35, 40, 45 and 50 (0). (Fig 4)

Fig 4



The advancement of the extension rod for one full turn of the thimble is one pitch which is 0.5 mm.

Therefore the advancement of the extension rod for one division movement of the thimble will be equal to 0.5 / 50 = 0.01 mm.

This will be the smallest measurement that can be taken with this instrument, and so this is the accuracy of measurement of this instrument.

Uses of a depth micrometer

Depth micrometers are special micrometers used to measure:

- Depth of holes
- depth of grooves and recesses
- heights of shoulders and projections.

Description least count, calculation, care and use of vernier caliper

Objectives: At the end of this lesson you shall be able to
- **state the principle of vernier**
- **define least count**
- **derive the least count of vernier scales.**

The vernier principle

The basic principle of the vernier is that the smallest unit of size to which a vernier can be read is equal to the difference in the length between the divisions of the two scales.

The magnification on the vernier scale is given by two scales sliding over each other; the eye can detect which divisions on one of them are smaller than those on the other. The eye can detect which of these divisions are in line with each other, and it is this fact which enables us to read a vernier to 0.02 mm accuracy.

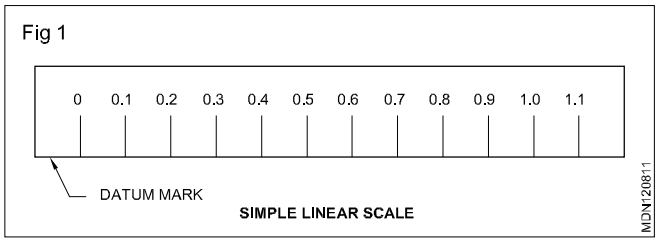


Figure 1 show the vernier principle being used to determine the reading. Figure 1 shows the main scale with the datum line marked.

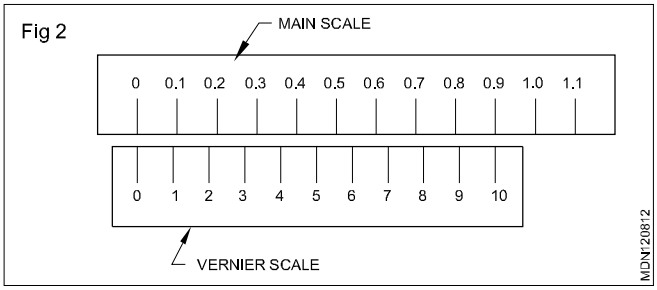


Figure 2 shows the main scale and vernier scale with graduations. The value of 1 main scale is 0.1 unit. In vernier scale 9 such units are taken and divided into 10 equal parts. Hence the value of 1 vernier scale is

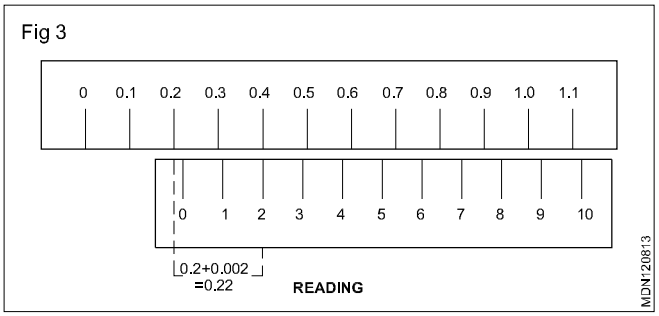
0.9/10=0.09 units

Now, by applying the vernier principle, the smallest unit of size is 1 M.S.D. - 1 V.S.D. (i.e.) 0.1 - 0.09=0.01 unit.

Definition of the least count

The least count is the smallest possible measurement that can be taken with the precision instrument.

Figure 3 shows the method of reading the vernier scale. The zero of the vernier scale is between 0.2 to 0.3 units



on the main scale and number 2 graduation of the vernier scale is coinciding with the 4th division of the main scale. Thus the reading is 0.2 + 2 * 0.01=0.22.

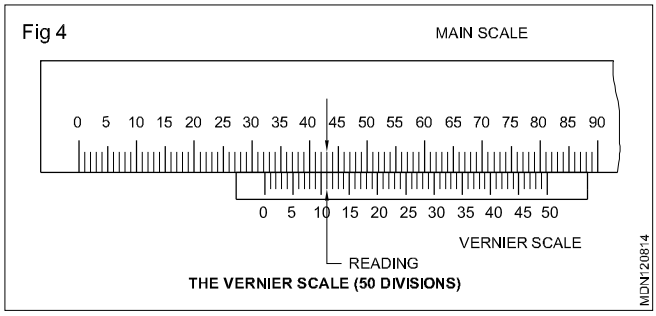
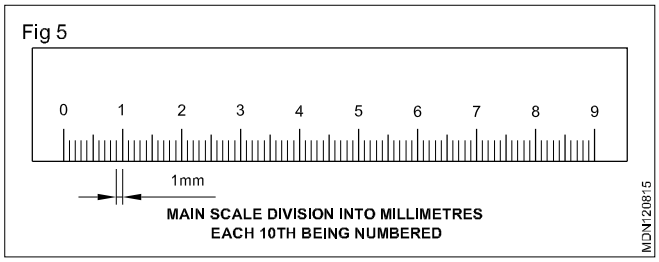
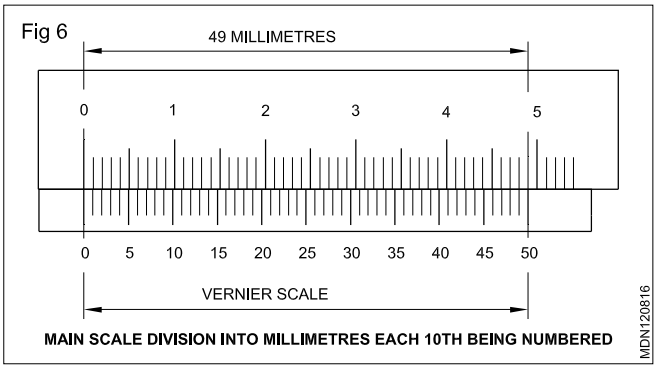


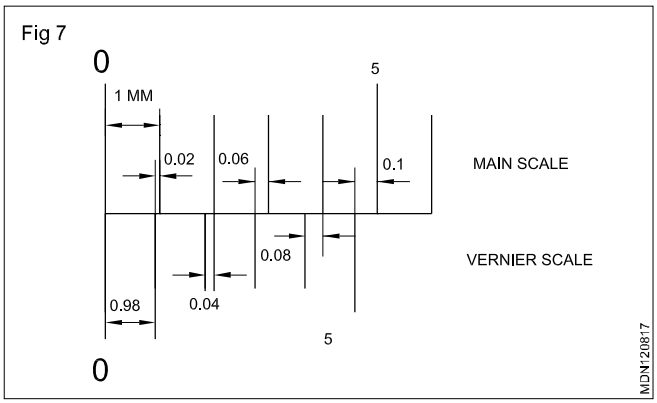
Figure 4 shows a typical 50 division vernier scale as used in modern metric measurements.



The main scale of this instrument is graduated in mm.

The purpose of a vernier 49 such divisions are … divided into 50 equal divisions. So the value of vernier scale division works out to 49/50 mm (Fig 6).





Least count is 1 main scale division - 1 vernier scale division (Fig 7).

which is $1\text{mm} - \frac{49}{50}\text{mm} = \frac{50 - 49}{50} = \frac{1}{50} = 0.02\,\text{mm}$

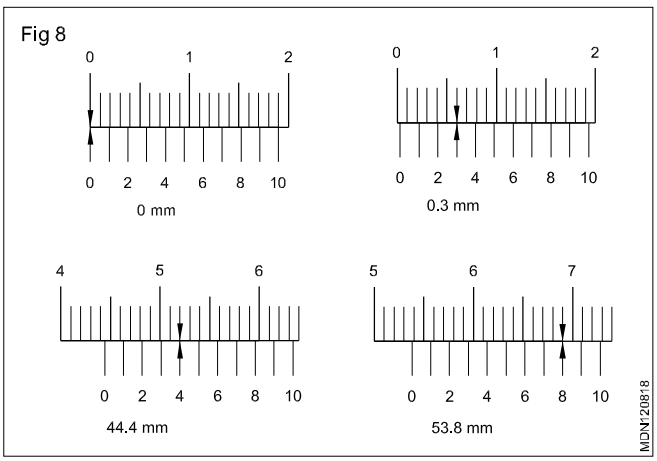
In that case of 150 mm capacity vernier calipers the main callers graduated in ½ mm instead of in 1 mm. For the purpose of the vernier scale 24 such divisions are taken and divided into 25 equal divisions. So the value of 1 vernier scale division is

$$\frac{1}{2} \times \frac{24}{25} = \frac{12}{25}\text{mm}$$

Least count = 1 M.S.D. - 1 V.S.D.

$$\frac{1}{2}\text{mm} - \frac{12}{25}\text{mm} = \frac{25 - 24}{50} = \frac{1}{50} = 0.02\text{mm}$$

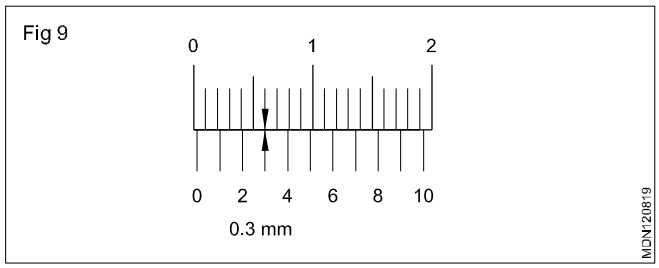
Measurement of reading (Fig 8)



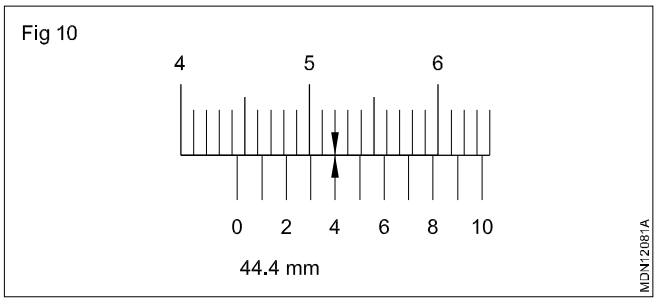
It is 0 mm as 'O' of vernier scale and 'O' of the main scale if that coincide.

Measurement of reading (Fig 9 & 10)

'O' of vernier is to the right of the main scale and lies between 'O' and 1st division of the main scale. The 3rd division of the vernier scale coincides with a division on the main scale.

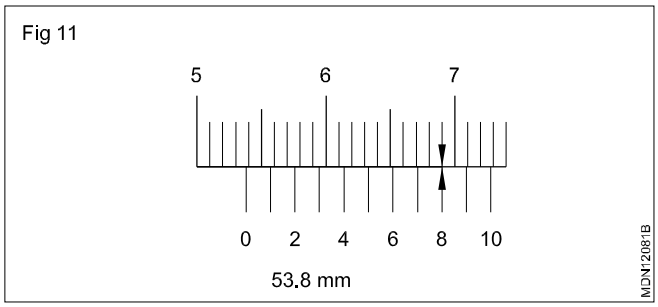


Hence measurement is 0 mm + 3 * 0.1 mm = 0.3 mm.



Measurement of reading (Fig 11)

'O' of the vernier scale lies between the 44th and 45th divisions of the main scale and the 4th division of the vernier scale coincides with a division of the main scale. Hence the measurement is 44 mm + 4 * 0.1 mm = 44.4



Measurement of reading

'O' of the vernier scale lies between the 53rd and 54th divisions on the main scale, and the 8th division of the vernier scale coincides with a division on the main scale. Hence measurement is 53 mm + 8 * 0.1 mm = 53.8 mm.

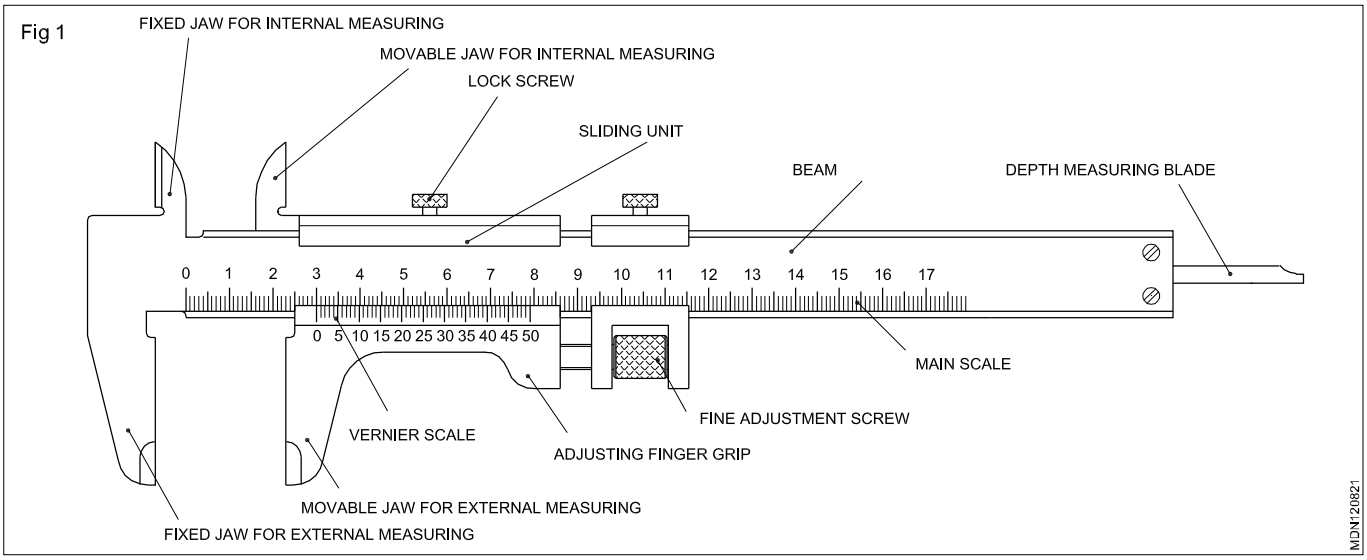
The least count of the vernier caliper used for the above readings is 0.1 mm.

The universal vernier caliper and its application

Objectives: At the end of this lesson you shall be able to
- **list out the parts of a universal caliper**
- **state the constructional features of the universal vernier caliper**
- **state its functional features**
- **list out the points for taking the measurements.**

One of the precision instruments having the principle of vernier applied to it is the universal vernier caliper. It is known as a universal vernier caliper because of its application to take outside, inside and depth measurements. Its accuracy is 0.02 mm.

Fig 1



A universal vernier caliper consists of a:

- Beam
- Fixed jaw for external measurements
- Movable jaw for external measurements
- Movable jaw for internal measurements
- Blade for depth measurement
- Main scale
- Vernier scale
- Fine adjustment screw
- Set of locking screws.

All parts are made out nickel-chromium steel, heat-treated and ground. They are machined to a high accuracy. They are stabilized to avoid distortion due to temperature variations.

Constructional features (Fig 1)

The beam is the main part and the main scale graduations are marked on it. The markings are in millimeters and every tenth line is drawn a little longer and brighter than the other graduations and numbered as 1,2,3 ….

To the left of the beam the fixed jaws for external and internal measurements are fixed as integral parts., The vernier unit slides over the beam.

At the bottom face of the beam a keyway-like groove is machined for its full length, permitting the blade to slide in the groove.

At the bottom right hand end, a unit is fixed serving as a support for the blade when it slides in the groove.

The vernier unit has got the vernier graduations marked on it. The movable jaws for both external and internal measurements are integral with this.

The fixed and movable jaws are knife-edged to have better accuracy during measurement. When the fixed and movable jaws are made to contact each other, the zero of the vernier scale coincides with the zero of the main scale.

At this position in the blade will be in line with the right hand edge of the beam.

When the vernier scale unit slides over the beam, the movable jaws of both the measurements as well as the blade advance to make the reading.

To slide the vernier unit, the thumb lever is pressed and pulled or pushed according to the direction of movement of the vernier unit.

Least count

In the vernier scale illustrated here, 19 mm are divided into 10 equal parts on the vernier scale. The value of 1 vernier scale division will then be

$$\frac{19}{10}=1.9\text{mm}$$

The difference of the two main scale divisions and 1 vernier scale division gives the least count and it is equal to 2*1m -1.9 mm = 0.1 mm.

For better accuracy, a 49 mm space is divided into 50 equal parts on the vernier scale so that one vernier scale division value will be

$$\frac{49}{50}=0.98\,\text{mm}$$

Here the least count will be 1 main scale division - 1 vernier scale divisions = 1 mm-0.98 mm= 0.02 mm.

The application of the universal vernier caliper is taking external, internal and depth measurements is shown in (Fig 2)

Advantages

No need to have separate precision instruments for taking external, internal and depth measurements.

Disadvantages

Accuracy of reading depends on the skill of the operator.

Loses its accuracy by constant usage as slackness in the sliding unit develops.

Cannot be used to measure components having deviations less than +/-0.02 mm.

Possibility of parallax error during noting down the coinciding line may cause the reading of the measurement to be wrong.

To read a measurement

Note the number of graduations on the main scale passed by the zero of the vernier. This gives the full mm.

Note which of the vernier scale division coincides with any one line on the main scale.

Multiply this number with the least count.

Add the multiplied value to the mainscale reading.

Fig 2