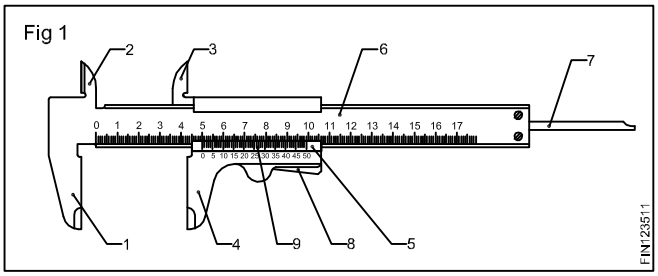
Vernier calipers

Objectives : At the end of this lesson you shall be able to
- **name the parts of a vernier caliper**
- **describe the parts of a vernier calipers**
- **state the uses of a vernier caliper.**

A vernier caliper is a precision measuring instrument. It is used to measure up to an accuracy of 0.02 mm. (Fig 1)

Fig 1



Parts of a vernier caliper

(Numbers as per Fig 1)

Fixed jaws (1 and 2): Fixed jaws are part of the beam scale. One jaw is used for taking external measurements, and the other for taking internal measurements.

Movable jaws (3 and 4): Movable jaws are part of the vernier slide. One jaw is used for external measurements, and the other for internal measurements. (Figs 2 and 3)

Fig 2

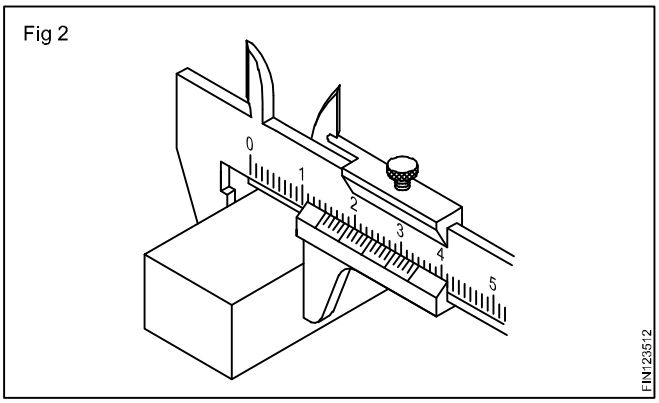
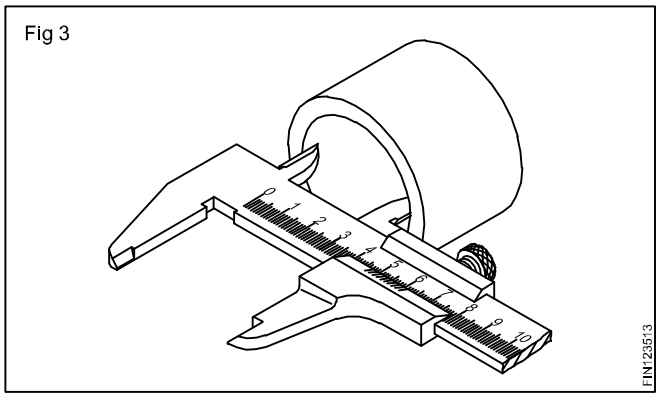


Fig 3

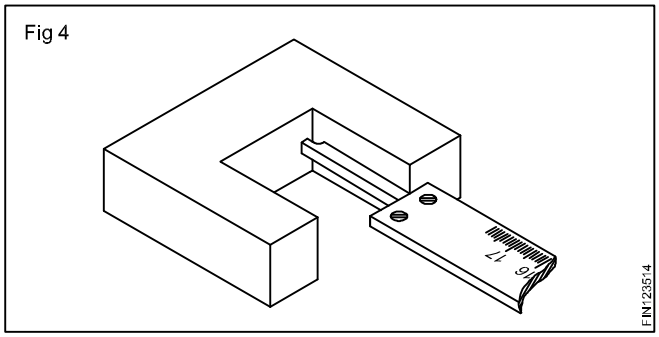


Vernier slide (5): A vernier slide moves over the beam and can be set in any position by means of a spring-loaded thumb lever.

Beam (6): The vernier slide and the depth bar attached to it, slide over the beam. The graduations on the beam are called the main scale divisions.

Depth bar (7) (Fig 4)**:**The depth bar is attached to the vernier slide and is used for measurement of depth.

Fig 4



Thumb lever (8): The thumb lever is spring-loaded which helps to set the vernier slide in any position on the beam scale.

Vernier scale (9): The vernier scale is the graduation marked on the vernier slide. The divisions of this scale are called vernier divisions.

Main scale: The main scale graduations or divisions are marked on the beam.

Sizes: Vernier calipers are available in sizes of 150 mm, 200, 250, 300 and 600 mm. The selection of the size depends on the measurements to be taken. Vernier calipers are precision instruments, and therefore, extreme care should be taken while handling them.

Never use a vernier caliper for any purpose other than measuring.

Vernier calipers should be used only to measure machined or filed surfaces.

They should never be mixed with any other tools.

Clean the instrument after use, and store it in a box.

Graduations and reading of vernier calipers

Objectives : At the end of this lesson you shall be able to
- **determine the least count of a vernier caliper**
- **state how graduations are made on a vernier caliper with 0.02 mm least count**
- **read vernier caliper measurements.**

Vernier calipers: Vernier calipers are available with different accuracies. The selection of the vernier caliper depends on the accuracy needed and the sizes of the job to be measured.

This accuracy/least count is determined by the graduations of the main scale and the vernier scale divisions.

Vernier Principle: The vernier principle states that two different scales are constructed on a single known length of line and the difference between them is taken for fine measurements.

Determining the least count of vernier calipers: In the vernier caliper shown in Fig 1 the main scale divisions (9 mm) are divided into 10 equal parts in the vernier scale.

i.e. One main scale division (MSD) = 1 mm

One vernier scale division (VSD) = 9/10 mm

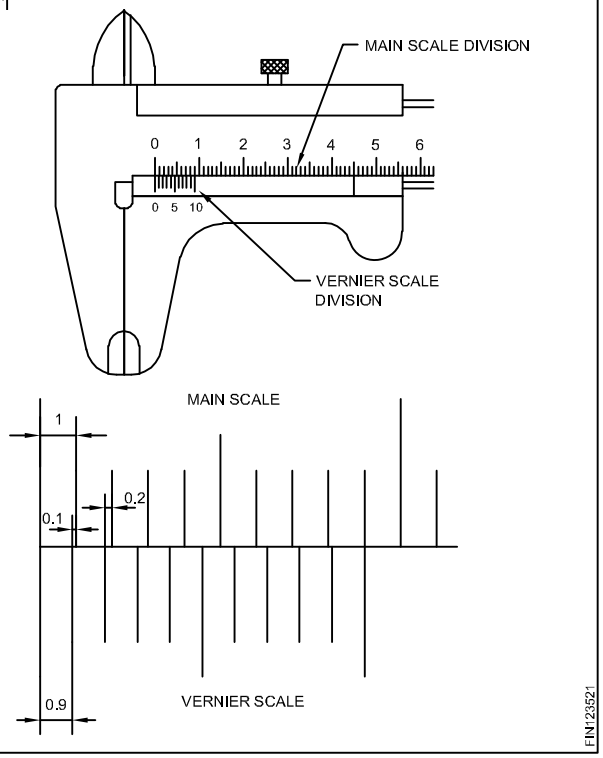
Least count = 1 MSD - 1 VSD

= 1 mm - 9/10 mm

= 0.1 mm

The difference between one MSD and one VSD = 0.1 mm

Fig 1



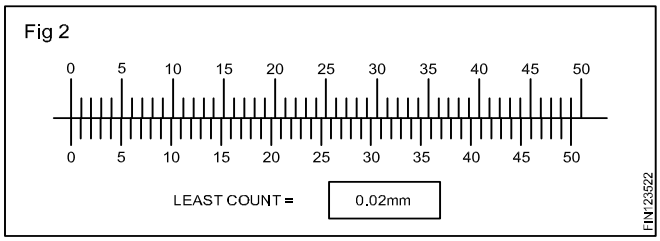
Reading vernier measurements: Vernier calipers are available with different graduations and least counts. For reading measurements with a vernier caliper, the least count should be determined first. (The least count of calipers is sometimes marked on the vernier slide)

Fig 2 shows the graduations of a common type of vernier caliper with a least count of 0.02 mm. In this, 50 divisions of the vernier scale occupy 49 divisions (49 mm) on the main scale.

Example

Calculate the least count of the vernier given in Fig 2.

Fig 2



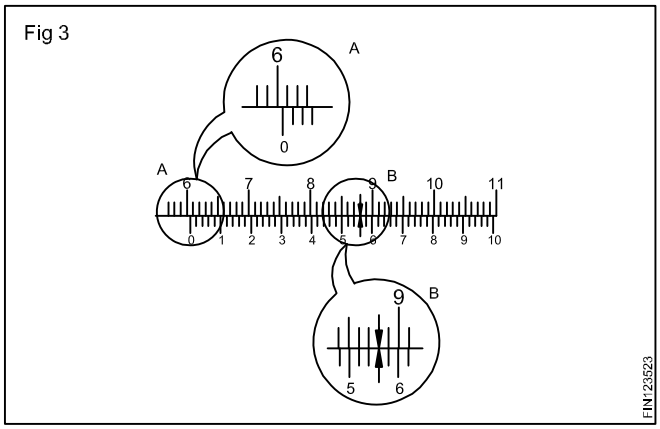
Least count = 1 mm - 49/50 mm

= 1/50 mm

= 0.02 mm.

Example for reading vernier caliper (Fig 3)

Fig 3



Main scale reading = 60 mm

The vernier division coinciding with the main scale is the 28th division, value = 28 x 0.02mm

= 0.56 mm

Reading = 60 + 0.56

Total Reading = 60.56 mm

The british system of measurement

Objectives : At the end of this lesson you shall be able to
- **name the different units and multiples of liner mesasurements in the Birtish System**
- **state the metric equivalent of the unit in the inch system**

The metric system for measurement is most widely used for industrial measurements. But in certain industries, the British system of measurement is still being used.

In this system of measurement, the inch, its multiples and sub-divisions are used to represent length measurements.

36 inches or 3 feet make 1 yard. 5280 feet or 1760 yards make 1 mile.

Coversions from inch to metric and vice versa	
CONVERSION FACTORS	
1"	= 25.4 mm or 2.54 cm
1 yard	= 36" or 0.9144 m
1 mm	= 0.03937"
1 metre	= 1000 mm or 39.37"

FRACTIONS/DECIMALS EQUIVALENT

1/64"	=	0.015625"
1/32"	=	0.03125"
1/16"	=	0.0625"
1/8"	=	0.125"
1/4"	=	0.25"
1/2"	=	0.5"

1.00 unit inch
0.1 one tenth
0.01 one hundredth
0.001 one thousandth
0.0001 one ten thousandth
0.00001 one hundred housands

0.000001 one millionth (one micro inch)

Example of conversion (Metric to inch)

1) .05mm = .00196 inch (.05x03937 = 0.0019685 inch)
2) 1.25m = 49.215 inch (1.25x39.37 = 49.215 inches)

Example of conversion (Inch to Metric)

1) 3/4" = .75" = 19.05 mm (.75x 25.4 = 19.05 mm)
2) 1/1000" = 0.001 = 0.0254 mm (.001x25.4 = 0.0254mm)

(One thousandth of an inch = 25 micrometre approx)

ASSIGNMENT

Convert the following.

1) 38.1mm =_____ inches
2) 300 mm =_____ inches
3) 8" =_____ mm
4) 40" =_____ mm.

5) Express the tolerance $\pm$.05" in metric terms to the nearest mm. _____

6) Express the tolerance $\pm$.02 mm in terms of inches to the nearest 1/10,000". _____

Reading vernier caliper and micrometer with inch graduations

Objectives : At the end of this lesson you shall be able to
- **state the graduations of vernier calipers in the inch system**
- **state the graduations of micrometers in the inch system**
- **read the measurement of vernier calipers and micrometers with inch graduations.**

Reading vernier caliper and micrometer

The universal vernier calipers generally used in machine shop will have graduations in both metric units and inches.

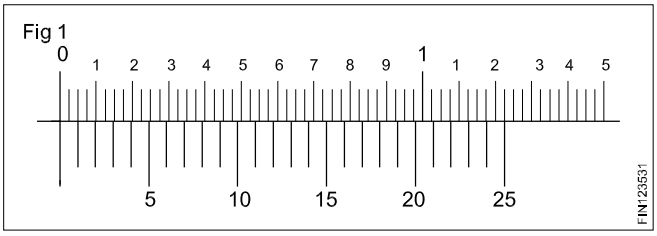
The vernier caliper with inch graduation will have a least count of 0.001".

The vernier scales for these calipers have graduation with 25 division or 50 divisions.

Vernier caliper with 25 divisions in vernier scale. (Fig.1)

One inch of the mainscale is divided into 10 major divisions, and each of these is further divided into 4 equal parts. The value of each sub-division is 0.025 inch. Such 49 divisions of the main scale are equal to 25 divisions of the vernier scale.

Fig 1



Least count

25 vernier scale divisions = 49 x 0.025 = 1.225"

Value of vernier scale division = 0.049"

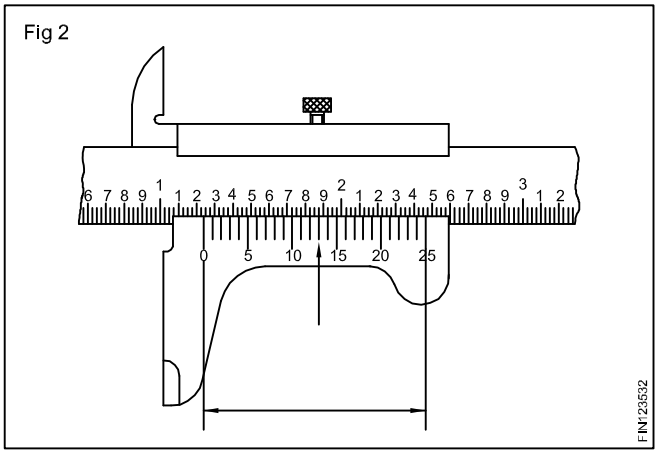
Value of 2 main scale divisions = 0.025 x 2 = 0.50"

Least count = Value of main scale divison - value of 1 vernier scale division

= 0.05" - 0.049" = 0.001" or 1/1000"

Example of reading (Fig 2)

Fig 2

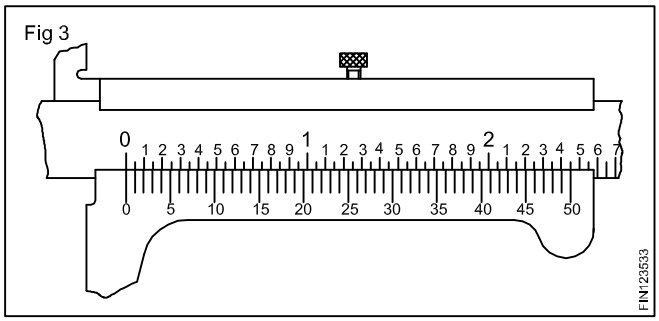


In Figure 2 the vernier '0' line is after 1" on the scale

Full inch		= 1.000"
2 main scale divisions		= .200"
Value of 1 subdivision		= .025"
coinciding	(13 x 001")	= .013"
	Reading	1.238"

In the vernier caliper given in fig 3 (50 divisions vernier scale), each inch of the main scale is divided into 10 major divisions, and they are further ssub - divided into two equal parts. The value of each subdivision is 0.05". 50 dividions of the vernier scale are equal to 49 sub divisions of the main scale.

Fig 3



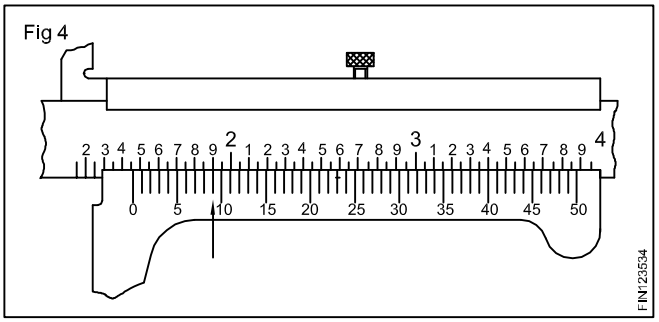
Least count

Value of 50 V.S.D.	= 49 x 0.05	= 2.45"
1.V.S.D.	= 2.45"/50	= 0.049"

Least count = Value of 1 MSD - Value of 1 VSD
= 0.05" - 0.049 = 0.001"

Example of reading (Fig 4)

Fig 4



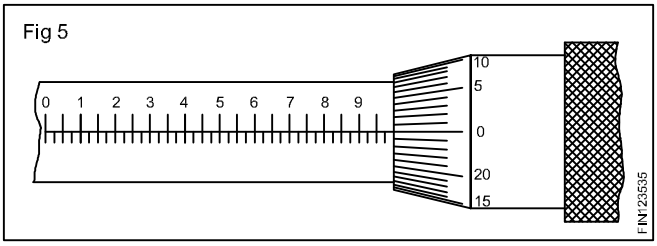
Vernier '0' line is after 1" on the main scale

Full inch		= 1.000"
The value of 4 major divisions	(4 x 0.1") =	.400"
The value of 1 subdivision	(1 x 0.05") =	.050"
The value of 9th vernier dividion coinciding	(9 x 0.001") =	.009"
	Reading	1.459"

Micrometer with graduations in inches

On micrometers with grduations in the inch system, the datum line on the barrel of the micrometer is graduated to a distance of 1 inch. This one inch is divided into 10 equal parts, and each of this is futher subdivided into 4 equal parts. (Fig 5)

Fig 5

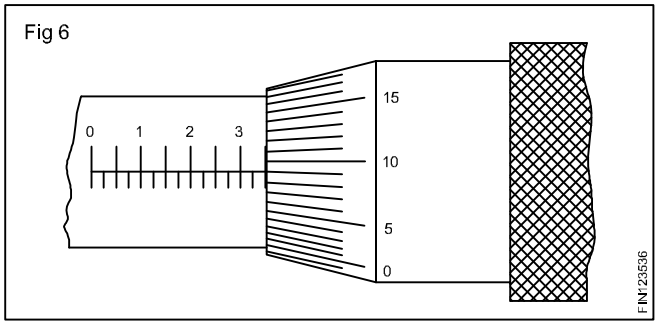


The value of each subdivision = 1/40" or 0.025". The thimble had 25 equal divisions marked on the circumference. The least counet is = 1/40"x1/25 = 1/1000" =.001'.

When the spindle of the micrometer advances by one division on the thimble, the actual value of the linear movement is = .001".

Example of reading (Fig 6)

Fig 6



Main divisions	3 x .1	= .300"
Subdivisions	2 x .025	= .05"
Thimble divisions	9 x .001	= .009"
Reading		= .359"

The barrel is graduated into 10 equal divisions each of which is further subdivided into 4 smaller divisions. The length of the sleeve graduations is 1". It is the distance the thimble travels in 40 complete revolutions.

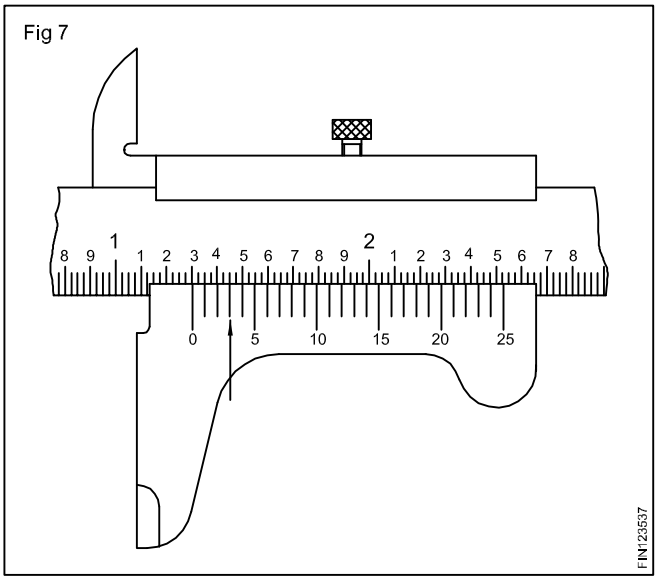
Barrel main divisions = 1/10 of an inch or 0.100" the distance the thimble moves in four complete revolutions. The thimble has 25 equal graduations on its circumference. Each graduation of the thimble is equal to 1/25 of 1/40 or 0.001".

Barrel subdivision 1/40 or 0.025 of an inch is equal to the distance the thimble moves in one complete revolution. The spindle screw has 40 TPI.

Assignment

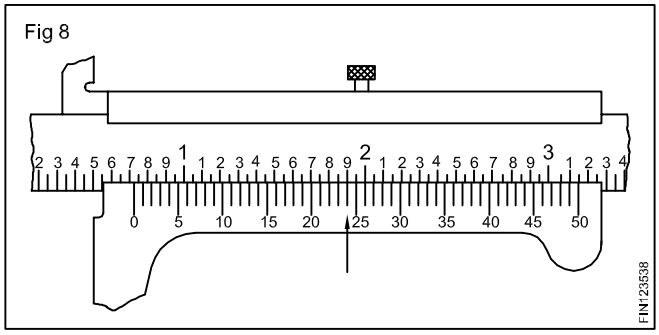
1 Read the vernier caliper measurement as shown in Figures 7 and 8.

Fig 7



Answer .....inch.

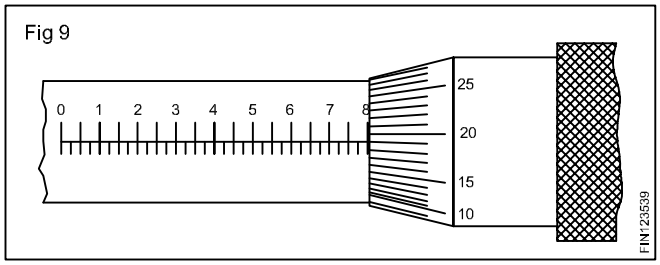
Fig 8



Answer .....inch.

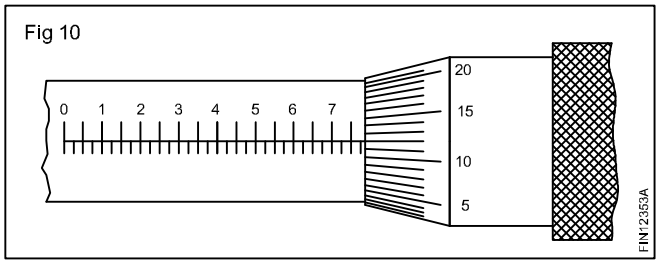
2 Read and record the measurements of an outside micrometer shown in the Figures 9 and 10.

Fig 9



Answer .....inch.

Fig 10



Answer .....inch.

Vernier height gauge

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

- **name the parts of a vernier height gauge**
- **state the constructional features of a vernier height gauge**
- **state the functional features of a vernier height gauge**
- **state the various applications of the vernier height gauge in engineering.**

Parts of a vernier height gauge (Fig 1)

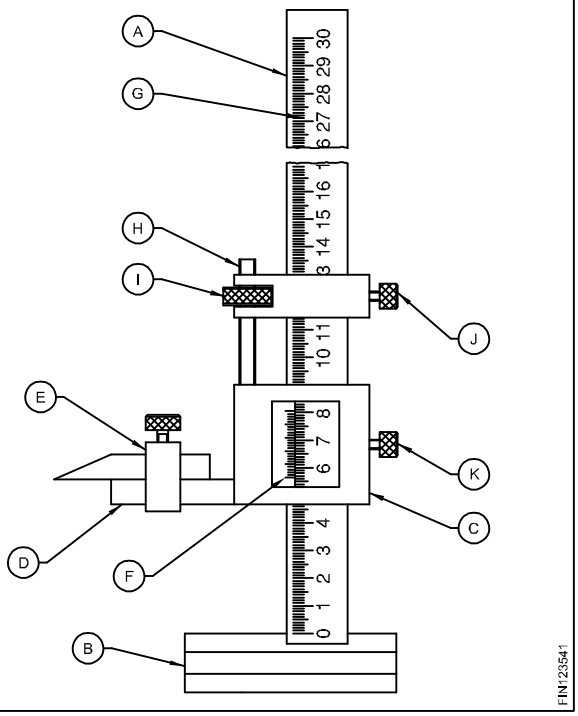
A	Beam
B	Base
C	Main slide
D	Jaw
E	Jaw clamp
F	Vernier scale
G	Main scale
H	Finer adjusting slide
I	Finer adjusting nut
J&K	Locking screws
L	Scriber blade

Constructional features of a vernier height gauge: The construction of a vernier height gauge is similar to that of the vernier caliper that it is vertical with a rigid base. It is graduated on the same vernier principle which is applied to the vernier caliper.

The beam is graduated with the main scale in mm as well as in inches. The main slide carries a jaw upon which various attachments may be clamped. The jaw is an integral part of the main slide.

The vernier scale is attached to the main slide which has been graduated, to read metric dimensions as well as the inch dimensions. The main slide is attached with the finer adjusting slide. The movable jaw is most widely used with

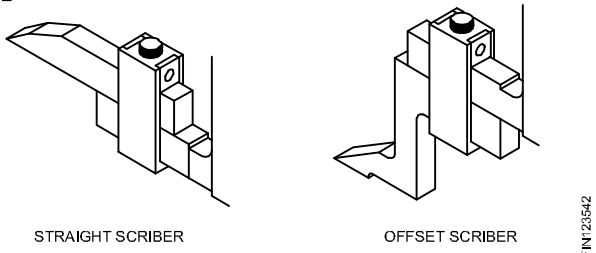
Fig 1



the chisel pointed scriber blade for accurate marking out as well as for checking the height, steps etc. Care should be taken to allow for the thickness of the jaw depending on whether the attachment is clamped on the top or under the jaw for this purpose.

The thickness of the jaw is marked on the instrument. As like in a vernier caliper, the least count of this instrument is also 0.02 mm. An offset scriber is also used on the movable jaw when it is required to take measurement from the lower planes. (Fig 2) The complete sliding attachment along with the jaw can be arrested on the beam to the desired height with the help of the locking screws. The vernier height gauges are available in ranges of capacities reading from zero to 1000 mm.

Fig 2



Functional features of the vernier height gauge: Vernier height gauges are used in conjunction with the surface plate. In order to move the main slide, both the locking screws of the slide and the finer adjusting slide have to be loosened. The main slide along with the chisel pointed scriber has to be set by hand, for an approximate height as required.

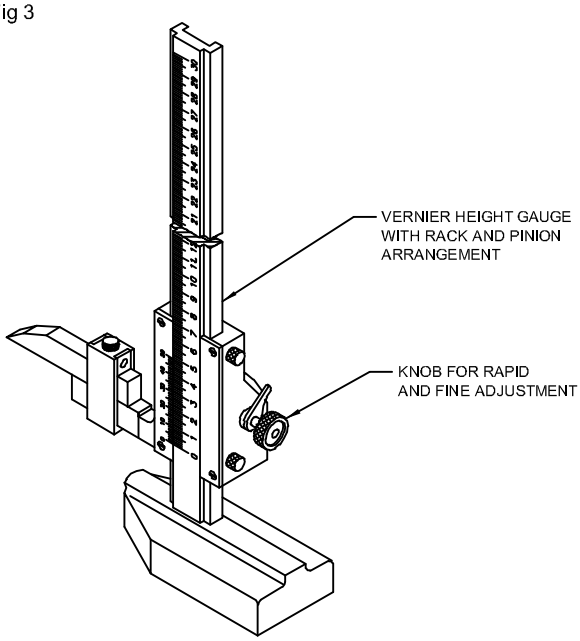
The finer adjusting slide has to be locked in position, for an approximate height as required. To get an exact markable height, the finer adjustments have to be carried on the slider with the help of the adjusting nut. After obtaining the exact markable dimension, the main slide is also to be locked in position.

Modern vernier height gauges are designed on the screw rod principle. In these height gauges, the screw rod may be operated with the help of the thumb screw at the base. In order to have a quick setting of the main slide, it is designed with a quick releasing manual mechanism. With the help of this, it is possible to bring the slide to a desired approximate height without wastage of time. For all other purposes, these height gauges work as ordinary height gauges. In order to set the 'zero' graduation of the main scale for the initial reading.

Some vernier height gauges are equipped with a sliding main scale which may be set immediately for the initial reading. This minimises the possible errors in reading the various sizes in the same setting.

Another kind of modern vernier height gauge has a rack and pinion set up for operating the sliding unit. This is shown in Fig 3.

Fig 3



Various applications of a vernier height gauge: The vernier height gauge is mainly used for layout work. (Fig 4)

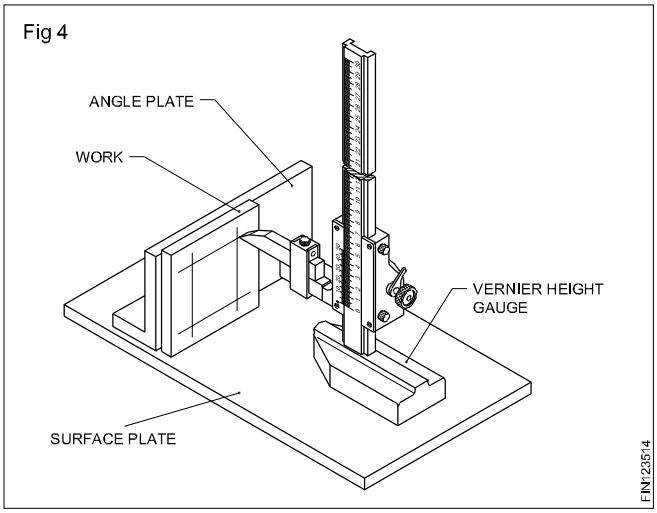
It is used for measuring the width of the slot and external dimension.

The vernier height gauge is used with the dial indicator to check hole location, pitch dimensions, concentricity and eccentricity.

It is also used for measuring depth, with a depth attachment.

It is used to measure sizes from the lower plane with the help of an offset scriber.

Fig 4



Vernier bevel protractor

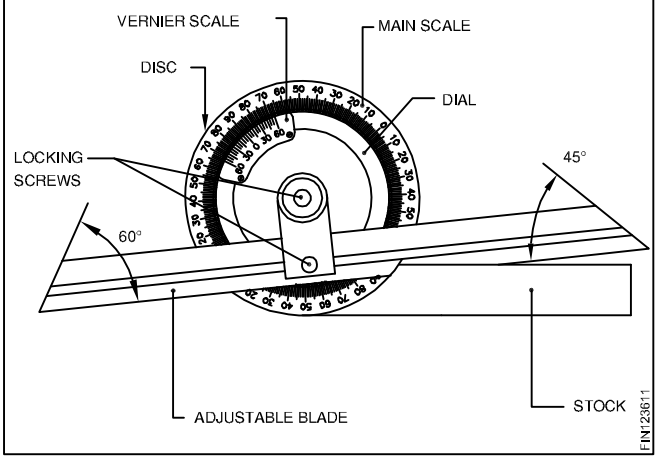
Objectives : At the end of this lesson you shall be able to
- **name the parts of a vernier bevel protractor**
- **state the functions of each part**
- **list out the uses of a vernier bevel protractor.**

The vernier bevel protractor is a precision instrument meant for measuring angles to an accuracy of 5 minutes. (5')

Parts of a vernier bevel protractor

The following are the parts of a vernier bevel protractor. (Fig 1)

Fig 1



Stock: This is one of the contacting surfaces during the measurement of an angle. Preferably it should be kept in contact with the datum surface from which the angle is measured.

Dial: The dial is an integrated part of the stock. It is circular in shape, and the edge is graduated in degrees.

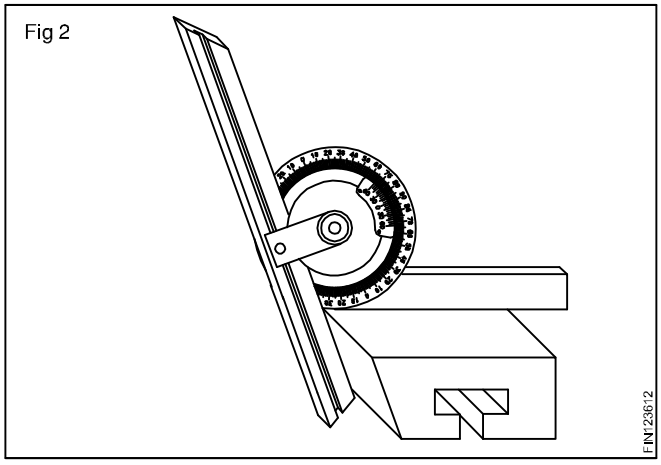
Blade: This is the other surface of the instrument that contacts the work during measurement. It is fixed to the dial with the help of the clamping lever. A parallel groove is provided in the centre of the blade to enable it to be longitudinally positioned whenever necessary.

Locking screws: Two knurled locking screws are provided, one to lock the dial to the disc, and the other to lock the blade to the dial..

All parts are made of good quality steel, properly heat-treated and highly finished. A magnifying glass is sometimes fitted for clear reading of the graduations.

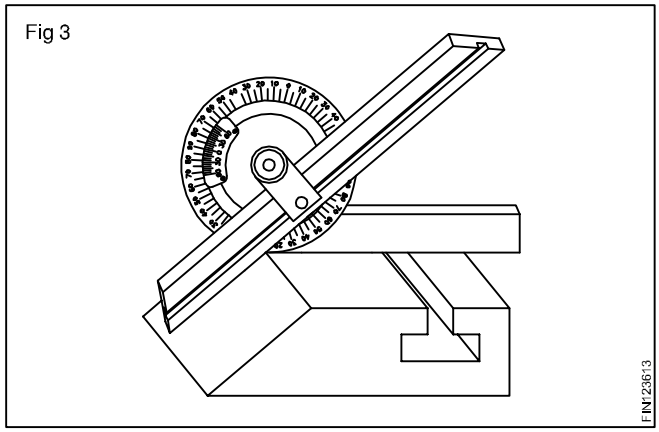
U**ses of a vernier bevel protractor:** Apart from being used for measuring angles a vernier bevel protractor is also used for setting work-holding devices on machine tools, work-tables etc.

Fig 2



The vernier bevel protractor is used to measure acute angles than 90° (Fig.2) obtuse angles more than 90° (Fig.3).

Fig 3



For setting work-holding devices to angles on machine tools, work tables etc., (Fig 4 & Fig 5)

Fig 4

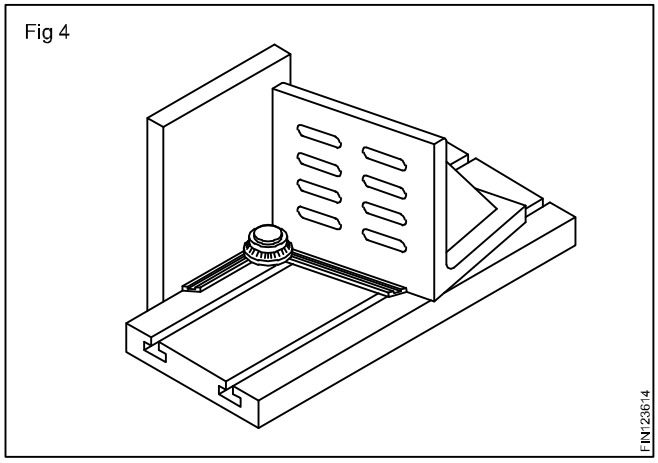
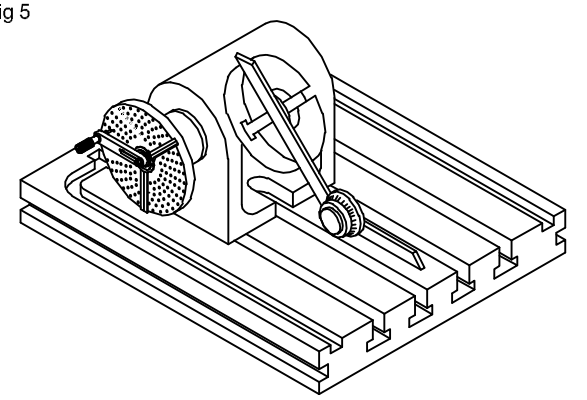


Fig 5



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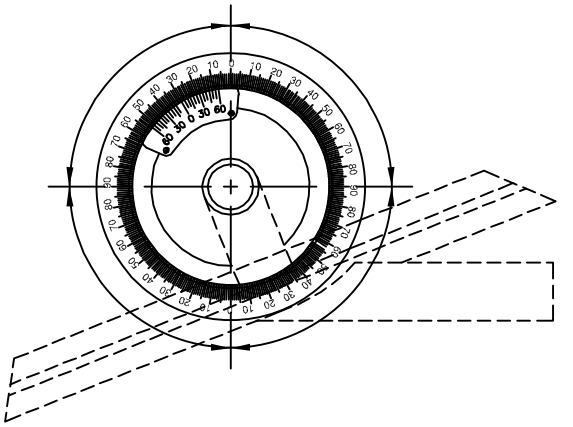
Graduations on universal bevel protractor

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

- **state the main scale graduations on the disc**
- **state the vernier scale graduations on the dial**
- **determine the least count of the vernier bevel protractor.**

The main scale graduations (Fig 1 & 2): For purposes of taking angular measurements, the full circumference of the dial is graduated in degrees. The 360° are equally divided and marked in four quadrants, from '0' degree to 90 degrees, 90 degrees to '0' degree. Every tenth division is marked longer and numbered. Each division represents 1 degree. The graduations on the dial are known as the main scale divisions. On the disc, 23 divisions spacing of the main scale is equally divided into 12 equal parts on the vernier. Each 3rd line is marked longer and numbered as 0, 15, 30, 45, 60. This constitutes the vernier scale. Similar graduations are marked to the left of '0' also. (Fig 1)

Fig 1



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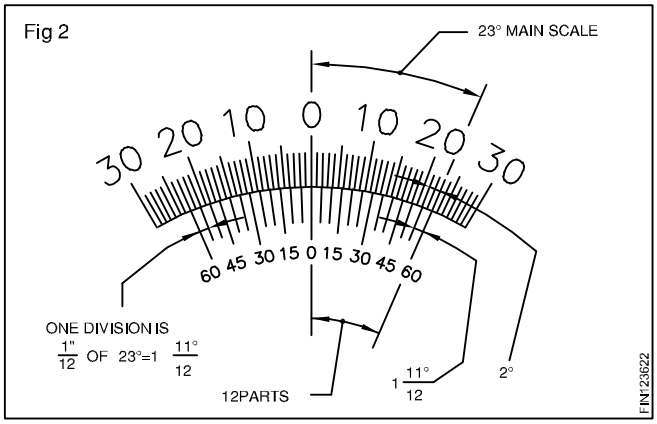
One vernier scale division VSD (Fig 2)

The least count of the vernier bevel protractor: When the zero of the vernier scale coincides with the zero of the main scale, the first division of the vernier scale will be very close to the 2nd main scale division. (Fig 2)

Fig 2



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Hence the least count is

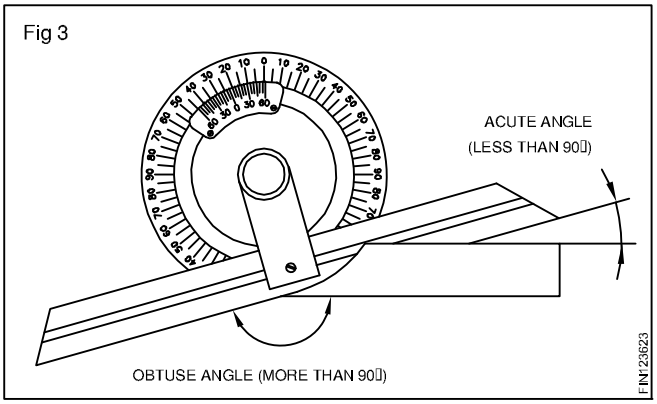
2 MSD - 1 VSD

i.e the least count = 2°

$$= \frac{24}{12} - \frac{23^0}{12} = \frac{1^0}{12} \text{ or } 5'$$

For any setting of the blade and stock, the reading of the acute angle and the supplementary obtuse angle is possible, and the two sets of the vernier scale graduations on the disc assist to achieve this. (Fig 3)

Fig 3



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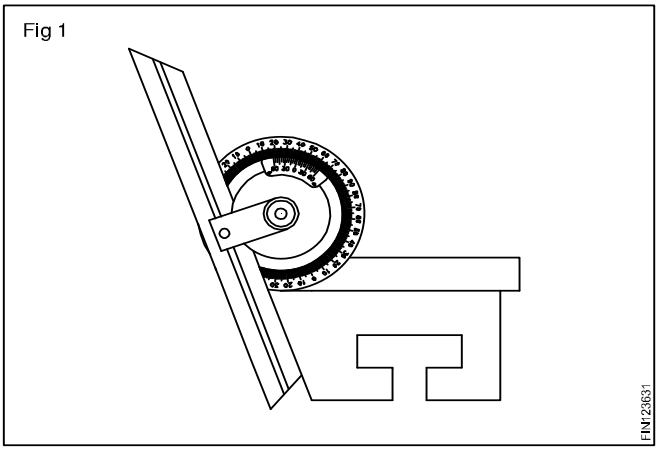
Reading of universal bevel protractor

Objectives: At the end of this lesson you will be able to
- **read a vernier bevel protractor for acute angle setting**
- **read a vernier bevel protractor for obtuse angle setting.**

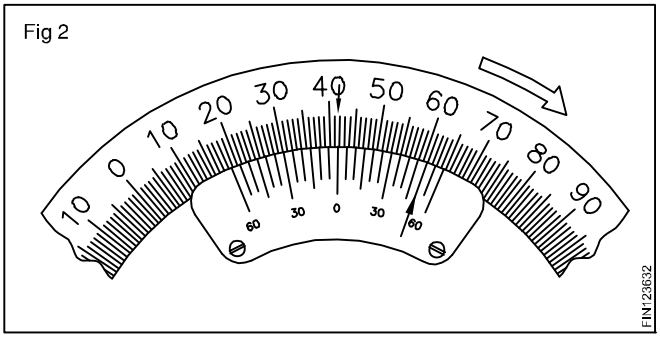
For reading acute angle set up (Fig 1)**:** First read the number of whole degrees between zero of the main scale and zero of the vernier scale.

Fig 1



Note the line on the vernier scale that exactly coincides with any one of the main scale divisions and determine its value in minutes. (Fig 2)

Fig 2



To take the vernier scale reading, multiply the coinciding divisions with the least count.

Example

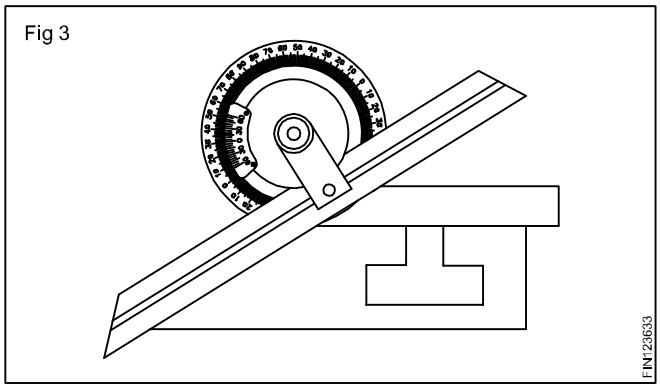
10 x 5' = 50'

Total up both the readings to get the measurements=41°50'.

If you read the main scale in an anticlockwise direction, read the vernier scale also in an anticlockwise direction from zero.

For obtuse angle set up (Fig 3**)**

Fig 3

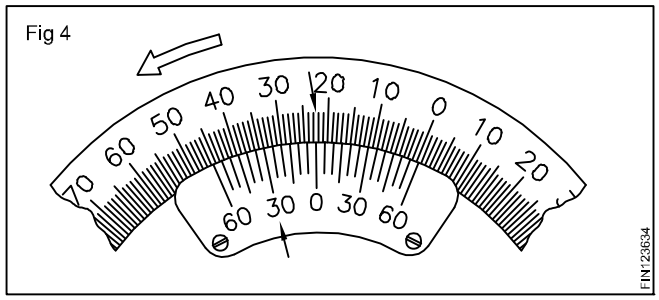


The vernier scale reading up is taken on the left side as indicated by the arrow (Fig 4). The reading value is subtracted from 180° to get the obtuse angle value.

Reading 22°30'

Measurement 180°-22°30'=157"30'

Fig 4



Care and maintenance of vernier bevel protractor

1 Clean the vernier bevel protractor before use.

2 Loosen the locking screw of dial to move the blade according to the angle measurment.

3 While taking a measurment apply light pressure on vernier bevel protractor

4 Heavy pressure will force the two scales out of parallel and show the false reading.

5 After using vernier bevel protractor wipe it clean and apply a thin coating of oil and keep it in safe place.

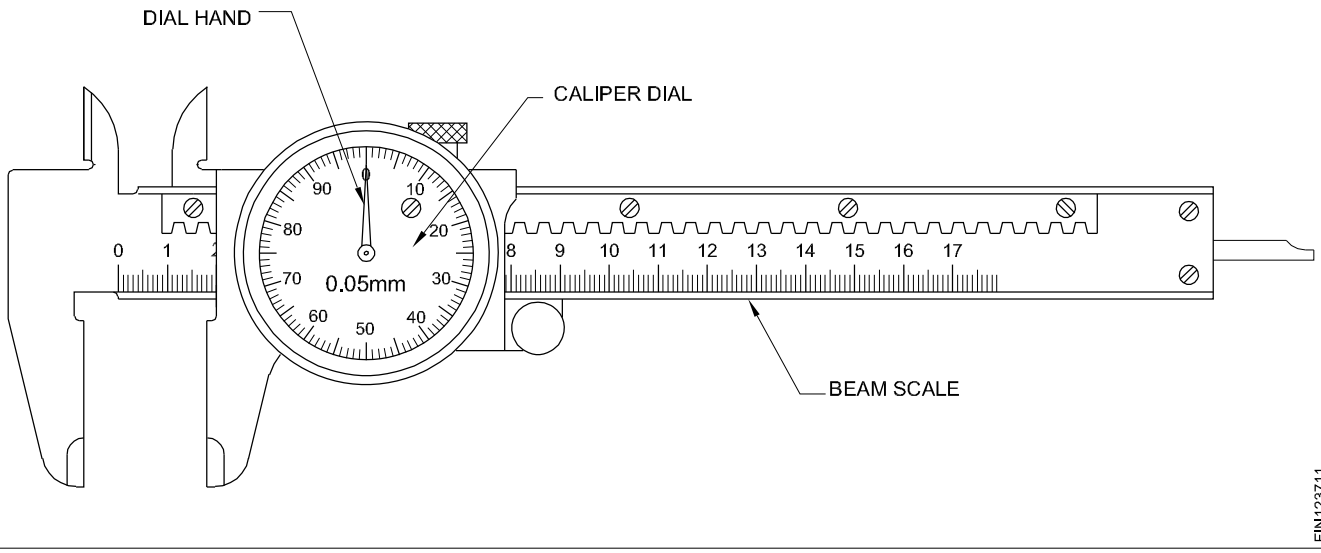
Dial Caliper

Objectives: At the end of this lesson you shall be able to
- **state the advantages of a dial caliper over a vernier caliper**
- **state the constructional features of a dial caliper**
- **read the dial caliper.**

A dial caliper is a direct reading instrument which resembles the vernier caliper. It is faster and easier to read a dial caliper than to read the traditional vernier caliper. (Fig 1)

The beam scale is graduated into 5mm increments on 0.05 mm accuracy caliper

Fig 1



Constructional features of dial caliper

The resemblance of a dial caliper is similar to normal Vernier caliper, but with additional construction of a rack mounted over the beam scale which is engaged to a pinion of the dial. The dial pointer is actuated by the movable action of vernier slide unit fixed with dial gauge.

The caliper dial on the movable jaw is graduated into 100 equal divisions. The hand of the dial makes one complete revolution for each 5 mm. Therefore, each dial graudation represents 1/100th of 5mm or 0.05 mm.

The dial hand is operated by a pinion that engages a rack on the beam.

Dial calipers are available in various sizes like vernier calipers. A dial caliper with 0.02 mm accuracy is also avaliable.

For reading a measurement (Fig 2)

Read the beam scale reading (25 mm) and add the reading shown by the hand of the dial. 24 x 0.05 = 1.2mm

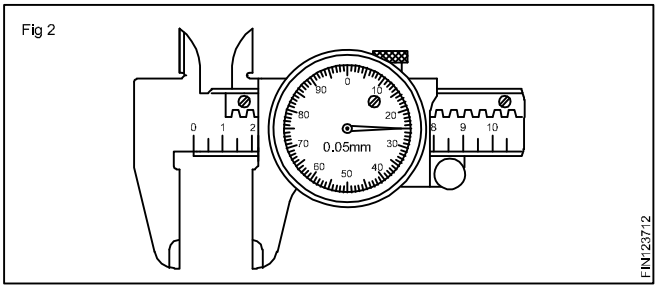
Reading = 25+1.2 mm = 26.2 mm.

Care and maintenance of dial caliper

1 Clean the dial caliper with a soft cloth before use.

2 Apply a small drop of oil to the beam, rack and pinion of the dial caliper to slide freely.

Fig 2



3 Check calibration of dial caliper, make sure that it is working correctly.

4 After using dial caliper, wipe it with a clean dry cloth, apply a thin coating of oil on sliding parts and keep it in safe place.

The digital caliper

Objectives : At the end of this lesson you shall be able to
- **state the uses of digital caliper**
- **name the parts of a digital caliper**
- **brief the zero setting of a digital caliper**

The digital Caliper (sometime incorrectly called the digital vernier caliper) is a precision instrument thant can be used to measure internal and external distance accurately to 0.01 mm, The digital vernier caliper is shown in fig 1, The distance or the measurements are read from LCD/LED display. The parts of digital calipers are similar to the ordinary vernier caliper except the digital display and few other parts.

Part of Digital Caliper (Fig 1)

1.Internal jaws

2.External jaws

3.Power On / Off button

4.Zero Setting button

5.Depth measuring blade

6.Beam scale

7.LED/ LCD Display

8.Locking screw

9.Metric/Inch button.

The digital caliper requires a small battery whereas the manual version does not need any power source. The digital calipers are easier to use as the measurement is clearly displayed and also, by pressing inch/mm button the distance can be read as metric or inch.

Zero setting of Digital Caliper

The display is turned on with the ON/OFF button. Before measuring, the zero setting to be done, by bringing the external jaws together untill they touch each other and then press the zero button. Now the digital caliper is ready to use.

> **Caution**
>
> **Always set zero position when turning on the display for the first time.**

Fig 1