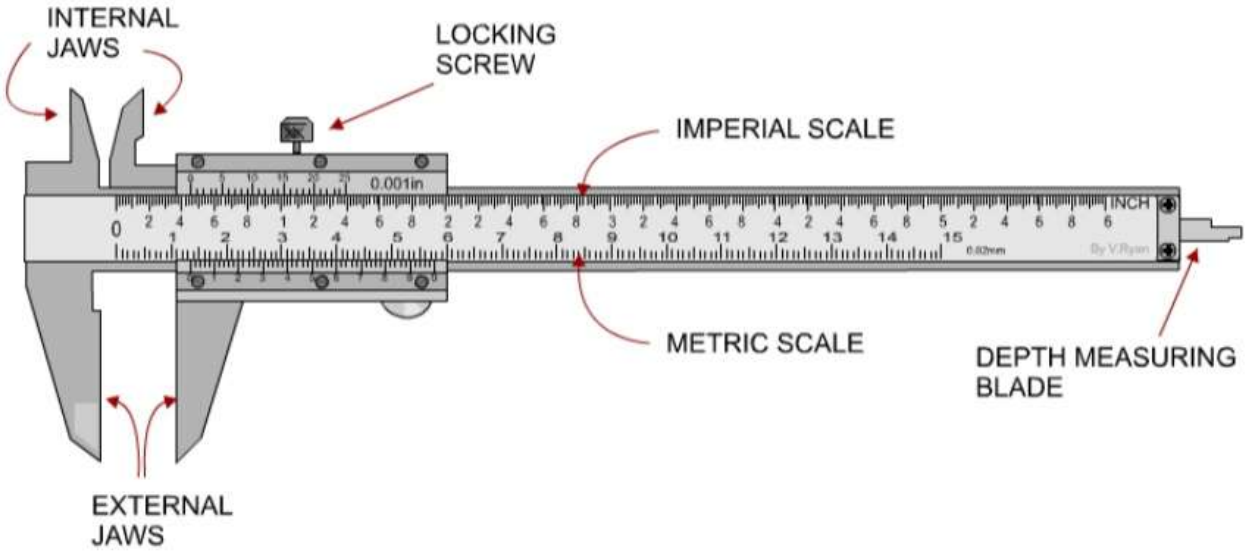
EXPERIMENT-1
LINEAR MEASUREMENT

AIM: Determine the dimensions of objects by using Vernier calipers.
OBJECTIVE: (1) to understand, operate and read the Vernier.
(2) Assess errors in Vernier caliper and to take the measurement.
EQUIPMENTS/ INSTRUMENT / MATERIAL:
Vernier caliper, Hollow cylinder, Cube, etc.

THEORY: The measurement of length, breadth, diameter, area, volume and depth of an object is taken by meter scale. The smallest measurement can be taken by meter scale 1 mm. To
Measure the fraction of mm, the Vernier calipers and micrometer screw is used.
LEAST COUNT: The smallest measurements that can be observed by the instruments is defined as least count.

DIAGRAM:



CONSTRUCTION & WORKING:
Vernier caliper consists of two scales. One scale called the main scale is fixed and is generally graduated in mm. The other scale called the Vernier scale slides along the main

scale. Graduation on the main scale and the Vernier scale are so designed that the length of n divisions of the Vernier scale is equal to the (n-1) divisions of the main scale.
The Vernier caliper is shown in the figure. It consists of long thin steel strip provided with a jaw J_1 at one end. The strip is graduated in mm. This is the main scale. Another small steel strip provided with the jaw J_2 at its end can slide over the main scale strip. This strip has 10/20/25 or 250 divisions marked on it and are called Vernier scale. The Vernier scale can be fixed at any position on the main scale with the help of screw S. Both the jaws are parallel and are projected on upper and lower sides of the main scale as shown in the figure.

The formula for the least count of Vernier caliper is:

On Vernier, 'n' equal divisions are marked in such a way that its total length becomes equal to the (n-1) divisions of main scale.

$$\therefore \mathbf{nV = (n-1)M}$$ where V= length of Vernier scale divisions &
M = Length of main scale divisions

$$\therefore \mathbf{V = \frac{(n-1)\,M}{n}}$$

$$\mathbf{i.e.\ L.C. = \frac{\text{Value of smallest division of main scale}}{\text{No. of divisions on Vernier scale}}}$$

ZERO ERROR: If the two jaws of both the scale (J_1 & J_2) are in contact, the zero of both the scales should coincide with each other, then the instrument is said to be free from zero error. But if the zero of both the scale does not coincide with each other, then the instrument is said to have zero error, equal to the distance between the two zero called as positive or negative zero error.

POSITIVE ZERO ERROR : If the zero of Vernier scale stands to the right of the zero mark of the main scale then the zero error is said to be positive. This difference of zero mark is multiplied with the least count of the Vernier scale and then deducted from the observed reading to get the corrected reading.

NEGATIVE ZERO ERROR: If the zero of the Vernier scale stands to the left of the zero mark of the main scale then the zero error is said to be negative. This difference of zero mark is multiplied with the least count of the Vernier scale and the added to the observed reading to get the corrected value (because the value for the negative zero error is taken with negative sign).

Correction for the zero error is done by the formula
Corrected reading = (Observed reading) – (Zero error with sign)
(i.e. '+' for positive error and '-' for negative error)

PROCEDURE:

1. Find the least count and the zero error of the Vernier caliper.
2. Placed the object between the two jaws and move the jaw till it touches the object.
3. Note the main scale reading (M) by finding which division of main scale coincides with the zero of the Vernier scale.
4. Note the Vernier scale reading (n) by finding which division of Vernier scale coincides with any division of the main scale.
5. Calculate the length or the diameter of the object using the formula
   Length or diameter = M + (n * L.C.)
   Find the corrected reading if there exist zero error in the instrument.

OBSERVATION TABLE:

1. Value of smallest division of the main scale = _____mm
2. No. of divisions on Vernier scale = _____ div.
3. least count of Vernier Caliper = _____mm _____cm
4. Zero error of the instrument = _____cm

Sr. No.	Object	Main Scale reading A cm	Vernier scale reading		Value of dimension (D) =A + B cm	Average value 'D' cm	Corrected value (D) cm
			Coinciding Mark 'n' div.	Total V.S. reading B = n(L.C.) cm			
A	Outer diameter of cylinder	1.					
		2.					
		3.					
B	Inner Diameter of cylinder	1.					
		2.					
		3.					

C	Length of cube	1.					
		2.					
		3.					
D	Breadth of cube	1.					
		2.					
		3.					

RESULT:

(1) Outer Diameter of the cylinder(D_0) = _____cm = _____mm

(2) Inner Diameter of the cylinder(D_i) = _____cm = _____mm

(3) Outer radius of the cylinder (R_0)= _____cm = _____mm

(4) Inner radius of the cylinder (R_i) = _____cm = _____mm

(5) Length of the cube (l) = _____cm = _____mm

(6) Breadth of the cube (b) = _____cm = _____mm

(7) Area of the cube (A) = l× b = _____cm^2 = _____mm^2

- **Viva Questions:**
  1. What is meant by least count?
  2. What is the formula for least count of Vernier calipers?
  3. The main scale normally provided in millimeter, 60 VSD coincide with 59 MSD .Find the least count of the Vernier caliper?
  4. Write down uses of the venire caliper?
  5. How will you find out the outer diameter of cylinder with the help of Vernier caliper?
  6. Define zero , positive and negative error of venire caliper:

EXPERIMENT - 2
PRECISION MEASUREMENT

AIM: To determine dimensions of objects by using micrometer screw gauge.
OBJECTIVE: (1) to understand micrometer screw and errors in micrometer.
(2) To take measurement using micrometer and compare Measurement by Vernier and micrometer.

EQUIPMENTS/ INSTRUMENT / MATERIAL:

Micrometer screw gauge25x1mm, Metal rod, a wire, etc.

THEORY: By the use of Vernier caliper, measurement can be taken correctly up to 1/10 mm or so. But by using micrometer screw gauge, we will be able to measure very accurately even up to 1/100 mm or so. When the length is to be measure very precisely, micrometer screw is used. Micrometer screw gauge works on the principle of screw. This instrument can measure thousand part of a cm and 10^{6th} part of meter and hence it is known as micrometer.

PRINCIPLE: The micrometer screw gauge works on the principle of a perfect screw fixed in a nut. Its translational motion is directly proportional to the amount of rotation that is given to it.

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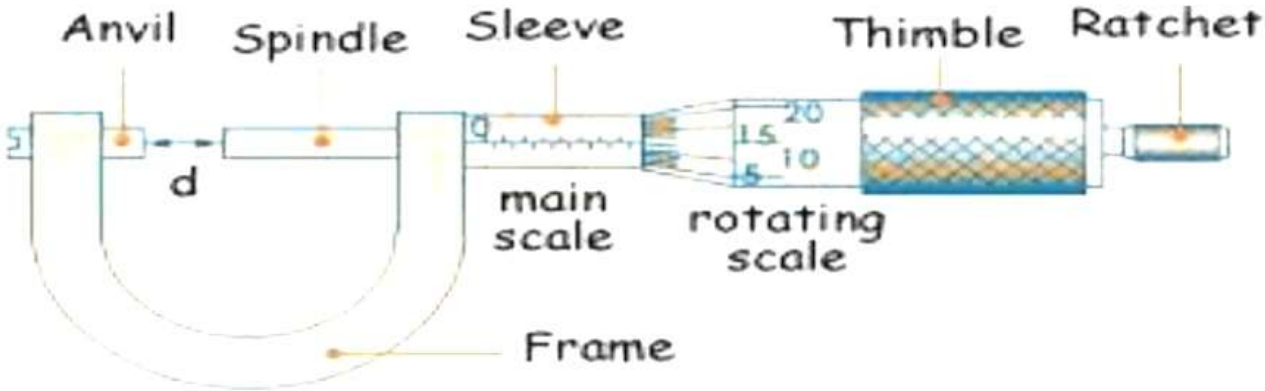
PITCH: The screw is the distance between two consecutive thread of the screw it called the pitch.

DIAGRAM:



CONSTRUCTION AND WORKING: There are two main parts of the micrometer screw. It's one part is semicircle steel plate(frame) whose both the ends are in the form of a

hollow cylinder, the screw is inserted in the left side of the hollow cylinder. A hollow tube N is attached to the right side of the hollow cylinder. On this hollow cylinder a straight line XY, called the base line is drawn. A scale in mm is marked on this line. It is called the main scale. Second part of the micrometer screw is S_1, whose left end B is flat and its right end is fixed with the hollow tube. This is anvil. The circular edge of the hollow tube is divided into the 50 or 100 division or equal parts. This scale is called circular scale.

***LEAST* COUNT**: Pitch of the micrometer screw gauge is defined as the linear distance moved by the screw in one complete rotation of its head. OR the distance between the two consecutive thread of the screw.

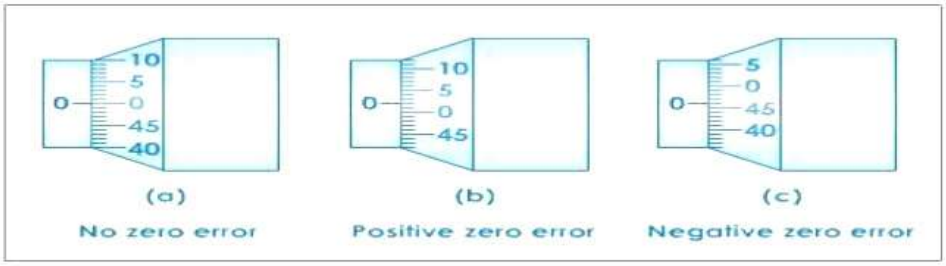
$$\textbf{L. C.} = \frac{\textbf{Pitch}}{\textbf{No. of divisions on C. S.}}$$

ZERO ERROR: If the two both the ends (A& B) are in contact, the zero of Circular scales should coincide the base line XY, then the instrument is said to be free from zero error. But if it is not so, then the instrument is said to have zero error.

POSITIVE ZERO ERROR : If the zero of Circular scale stands below the base line XY, then the zero error is said to be positive. This difference of zero mark is multiplied with the least count of the Micrometer screw and then deducted from the observed reading to get the corrected reading.

NEGATIVE ZERO ERROR: If the zero of the Circular scale stands above the base line XY, then the zero error is said to be negative. This difference of zero mark is multiplied with the least count of the Micrometer screw and the added to the observed reading to get the corrected value (because the value for the negative zero error is taken with negative sign).

Correction for the zero error is done by the formula
Corrected reading = (Observed reading) – (Zero error with sign)
(i.e. '+' for positive error and '-' for negative error)



PROCEDURE:

1. Determine the pitch of the micrometer screw
2. Fined the least count and the zero error of the micrometer screw
3. Place the object between ends A and B of the screw by turning the ratchet clockwise so that the object is gently fixed between the ends.
4. Note the main scale reading, by finding which division of the main scale (base line XY) coincides with the edge of the circular scale.
5. Note the circular scale reading (n) by finding which division of the circular scale coincides with the base line of the main scale.
6. Calculate the length or the diameter of the wire by using the formula

   Length or diameter = M + n (L.C.)

Find the corrected reading if there exist any zero error in the instrument

OBSERVATIONS:

1. Pitch of micrometer screw = _____mm
2. Number of divisions on circular scale (n) = _____div.
3. Least count of micrometer screw = P/n = _____mm = _____cm
4. Zero error = _____mm

OBSERVATION TABLE:

Object	No. of obs.	Main scale reading 'A' mm	Circular scale reading		Value of the dimension D=(A + B) mm	Average value(D) mm	Corrected value
			Division coinciding the base line 'n' div.	Total circular scale reading B= n(L.C.) mm			
Diameter of wire	1.						
	2.						
	3.						

Thickness of plate	1.						
	2.						
	3.						

RESULT:

(1) Diameter of the wire(d) = _____mm = _____cm
(2) Radius of the wire(r) = _____mm = _____cm
(3) Thickness of the plate= = _____mm = _____cm

- **Viva Question:**

1. Write down the principle of micrometer screw gauge.
2. What is the formula for least count of micrometer screw gauge?
3. Define zero, positive and negative error of the micrometer screw gauge:
4. Write the uses of micrometer screw
5. What do you mean by pitch?
6. Pitch of a micrometer screw is 0.5 mm. If its circular scale is divided in equal 50 divisions, calculate least count of micrometer screw gauge?
7. A micrometer screw has a least count 5×10^{-6} meter and total divisions on the circular scale is 100, It undergoes 5 complete rotations than determine the distance travelled by the edge of the circular scale on the main scale.