RADIANT 2026

Physics

Measurements and Experimentation

Lecture - 04

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Topics *to be covered*

1. Vernier Callipers
2. Principle of Vernier
3. Least Count
4. Zero Error Vernier Callipers
5. Question's

Recap *of previous lecture*

1. Need of Unit for Measurement
2. Unit
3. King of Unit
4. Properties of Unit
5. Units of Length, Mass and Time

Scale → 1 mm = 0.1 cm

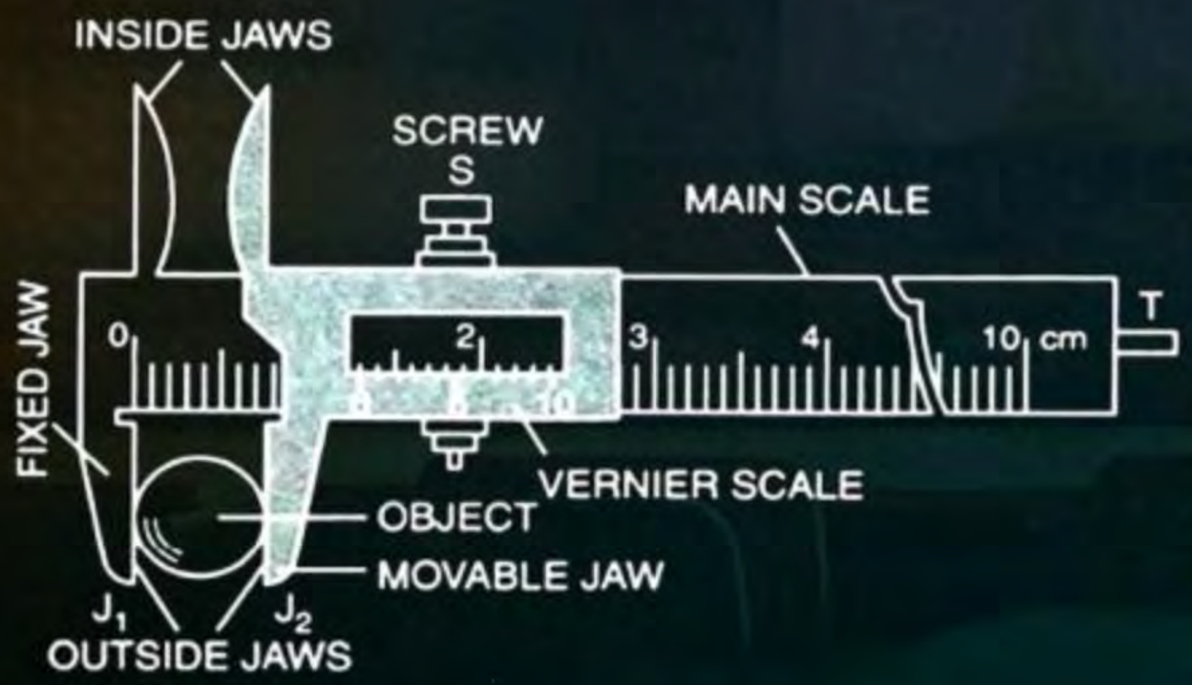
VC → 0.1 mm = 0.01 cm

SG → 0.01 mm = 0.001 cm

Least Count

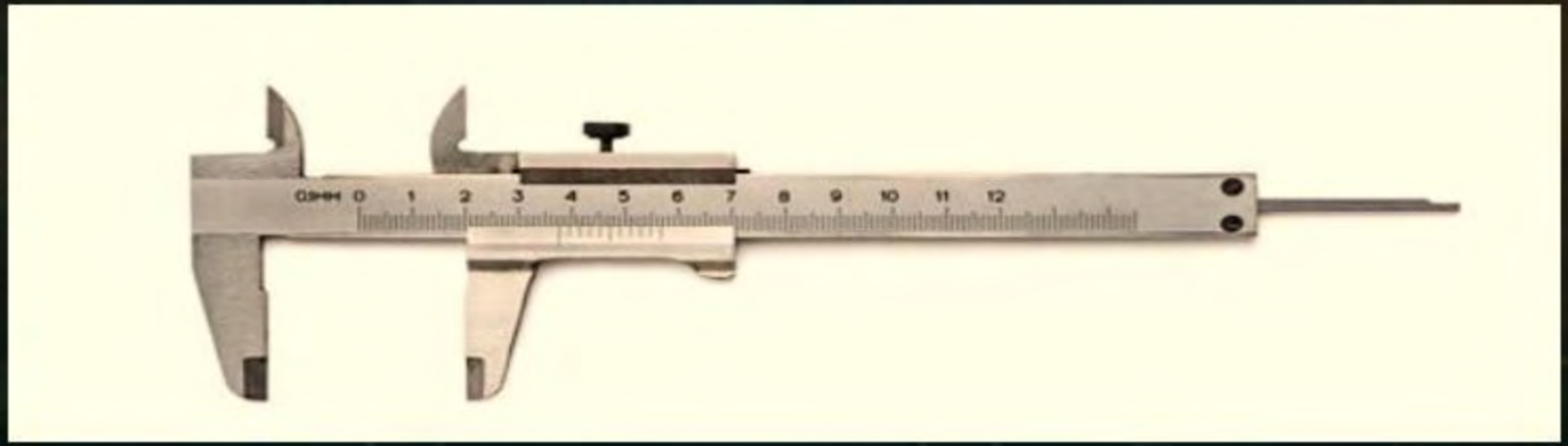
The least count of an instrument is the smallest measurement that can be taken accurately with it.

Vernier Callipers



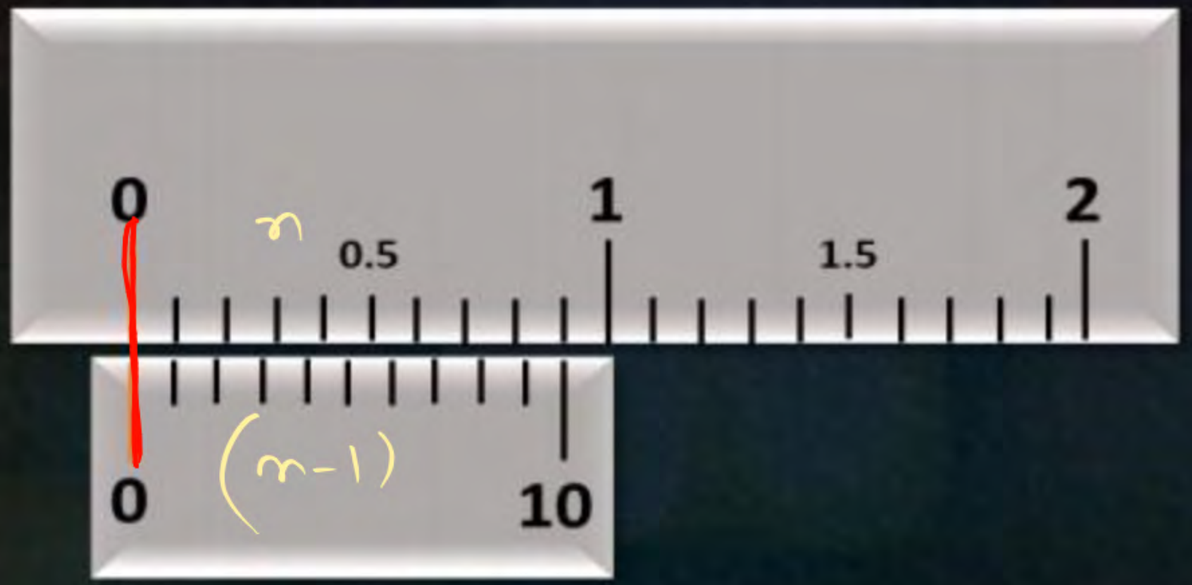
	Part	
1.	Outside jaws	To measure the length of a rod, diameter of a sphere, external diameter of a hollow cylinder.
2.	Inside jaws	To measure the internal diameter of a hollow cylinder or pipe.
3.	Strip	To measure the depth of a beaker or a bottle.
4.	Main scale	To measure length correct up to 1 mm.
5.	Vernier scale	Helps to measure length correct up to 0.1 mm.

Vernier Callipers



Principle of Vernier

- Pierre Vernier devised a method by which length up to 2nd decimal place of a cm i.e., correct up to 0.1 mm (or 0.01cm) can be measured. In this technique.
- Two scales are used. One scale, called the **main scale**, is fixed, while the other scale, called the **vernier scale**, slides along the main scale.
- The main scale is graduated with value of one division on it equal to 1 mm.
- The graduations on the vernier scale are such that the length of n divisions on vernier scale is equal to the length of $(n - 1)$ divisions of the main scale.


0
1
2
0.5
1.5
0
10
n
(n-1)

0
1
2
0.5
1.5
0
10
n
(n-1)

Principle of Vernier

- Generally, a vernier scale has 10 divisions and the total length of these 10 divisions is equal to the length of 10 – 1 = 9 divisions of the main scale i.e., equal to 9 mm.
- Thus each division of the vernier scale is of length 0.9 mm (i.e., smaller in size by 1/10 mm than a division on the main scale). This difference is utilized as least count for the measurement.

Least Count of Vernier or Vernier Constnat

- The least count of vernier is equal to the difference between the values of one main scale division and one vernier scale division.
- It is also called the vernier constant. ,

- Vernier constant or least count of vernier,

  (L.C. = value of 1 main scale division − value of 1 vernier scale division)

Least Count of Vernier or Vernier Constnat

Let n divisions on vernier be of length equal to that of $(n-1)$ divisions on main scale and the value of 1 main scale division be x. Then

Value of n divisions on vernier $= (n-1)x$

$\therefore$ Value of 1 division on vernier $= \frac{(n-1)x}{n}$

(L.C. = value of 1 main scale division − value of 1 vernier scale division)

$$\text{L.C.} = x - \frac{(n-1)x}{n} = \frac{x}{n}$$

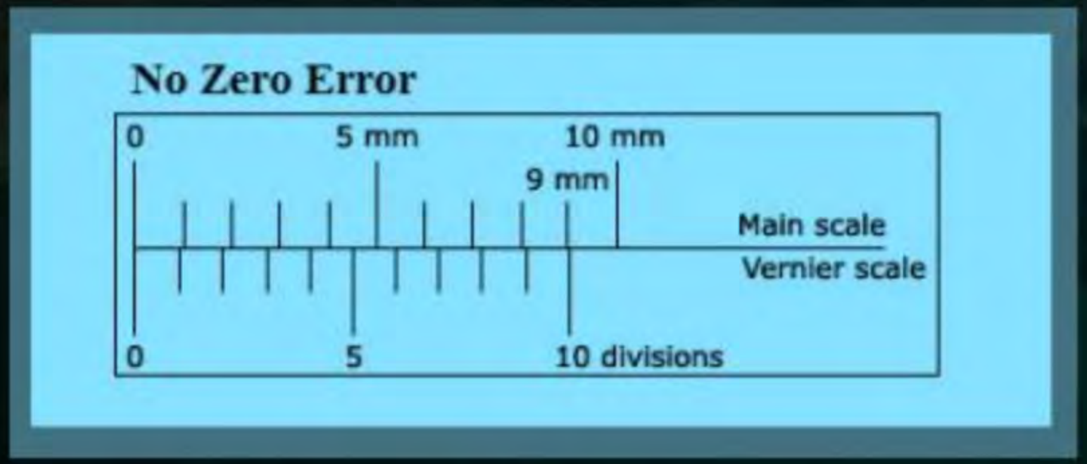
$$\text{i.e., L.C.} = \frac{\text{Value of one main scale division } (x)}{\text{Total number of divisions on vernier } (n)}$$

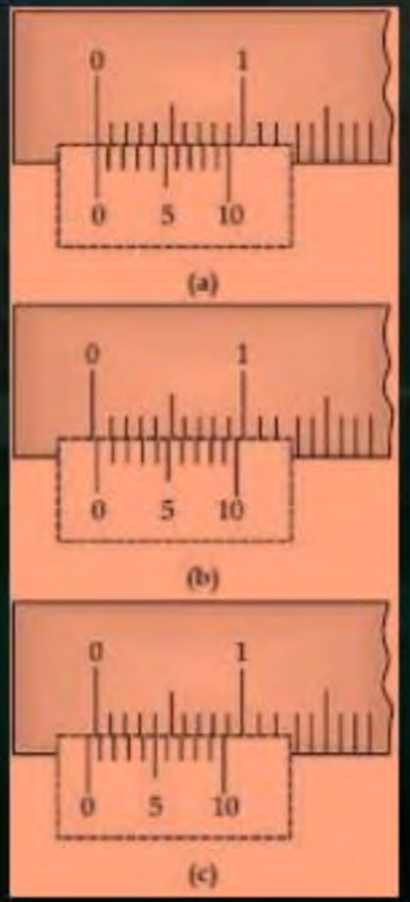
Zero Error Vernier Callipers

Kinds of zero error: The zero error is of the following two kinds:

(i) Positive zero error, and

(ii) Negative zero error.





Zero Error Vernier Callipers

(i) Positive zero error:

Positive zero error

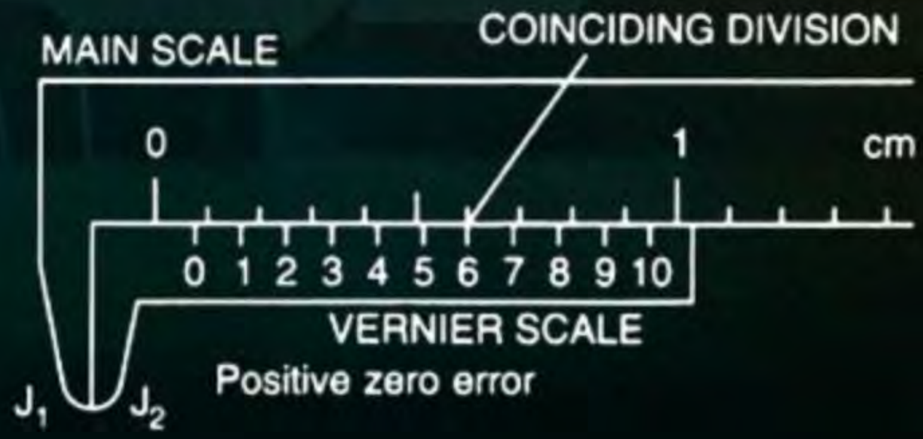
Zero Error Vernier Callipers

(i) Positive zero error:

- On bringing the jaws together, if zero mark of the Vernier scale is on the right of zero mark of the Vernier scale is on the right of zero mark of the main scale, the zero error is said to be positive.
- The positive zero error. The positive zero error is equal to the length between the zero mark of the Vernier scale from the zero mark of the main scale.

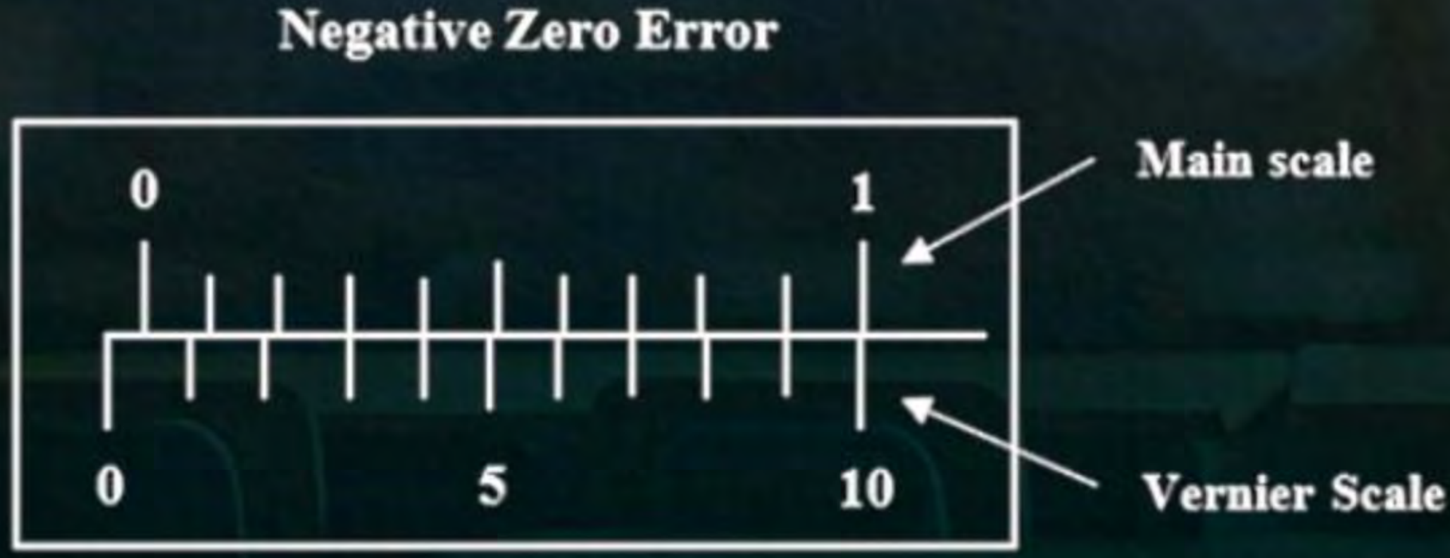
$\therefore$ Zero error = + 6 × L.C. = + 6 × 0.01 cm

= + 0.06 cm



Zero Error Vernier Callipers

(ii) Negative zero error:



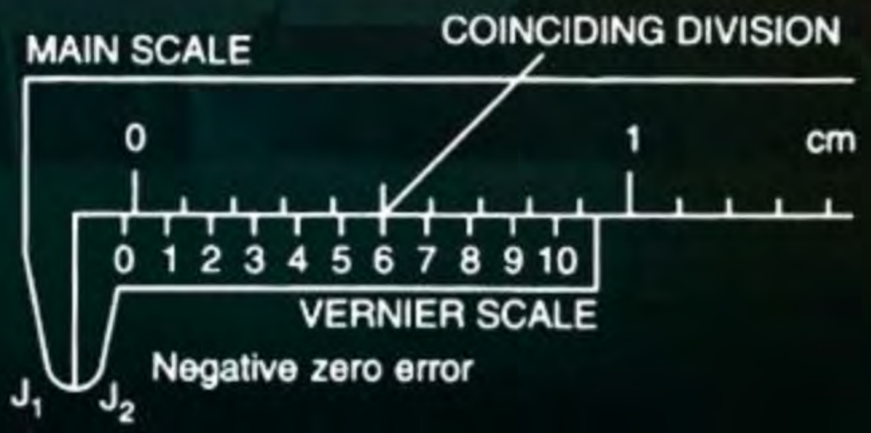
Zero Error Vernier Callipers

(ii) Negative zero error:

- On bringing the two jaws together, if zero mark of the Vernier scale is to the left of zero mark of the main scale, the zero error is said to be negative. Shows the two scales of a Vernier calipers with negative zero error.
- The negative zero error is equal to the length between the zero mark of the main scale from the zero mark of the Vernier scale.

Zero error = – (10 – 6) × L.C.

= – 4 × 0.01 cm = **–0.04 cm.**



Zero Error Vernier Callipers

Correction due to zero error
(correct measurement with a vernier callipers having a zero error)

To get the correct reading, the zero error with its proper sign is always subtracted from the observed reading. i.e.,

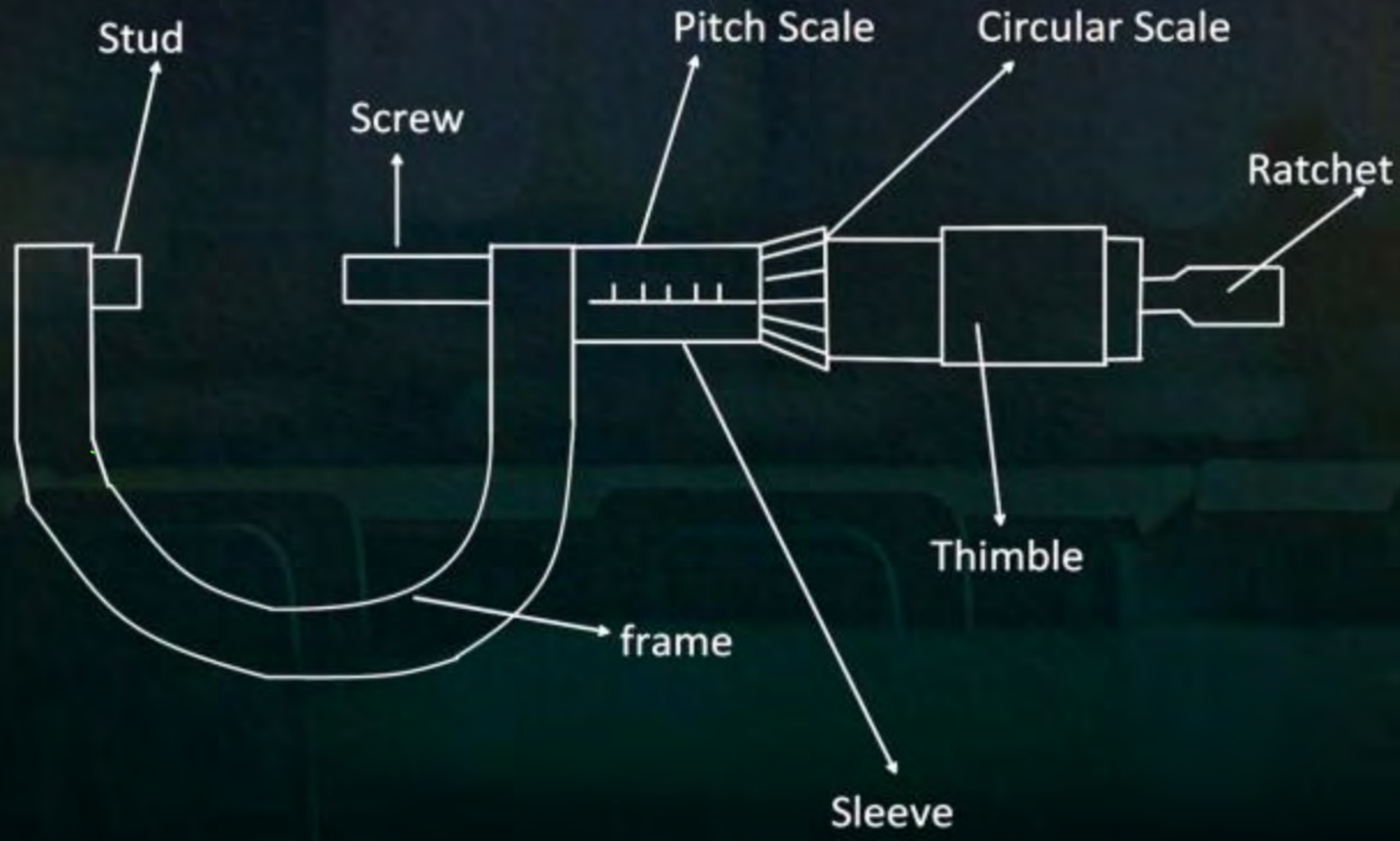
Correct reading = Observed reading – Zero error

Thus the positive zero error gets subtracted from the observed reading, while the negative zero error gets added to the observed reading.

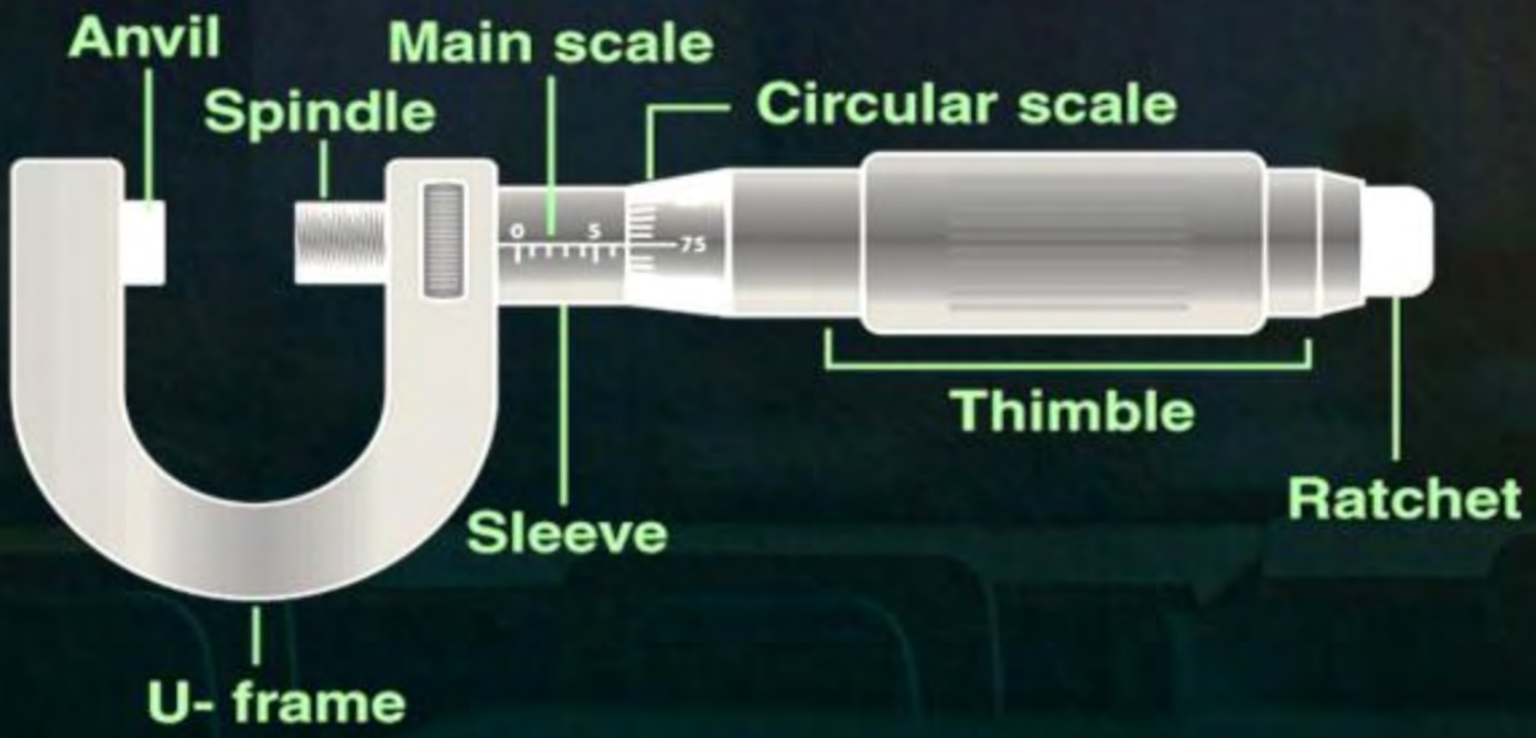
Screw Gauge

A screw gauge works on the principle of a screw. It is used to measure the diameter of a wire or thickness of a paper, etc., usually up to an accuracy of third decimal place of a cm (i.e., correct up to 0.001 cm). However, the least count of a micrometer screw gauge is 1 μ (or 0.0001 cm).

Screw Gauge


Stud
Screw
Pitch Scale
Circular Scale
Ratchet
Thimble
frame
Sleeve

Screw Gauge



Screw Gauge

Screw Gauge

Stud
Screw
Pitch scale
Thimble
0
5
Circular scale
Ratchet
Frame

Screw Gauge

A screw gauge is shown in Fig.. It has a U-shaped frame with a flat end A called the stud at one end and a nut N with a cylindrical sleeve at the other end. Both the nut and sleeve are threaded from inside. A screw with its one flat end B can be moved inside the nut N by rotating its head which is in form of a hollow cylinder (or thimble) provided at the other end of the screw.

Screw Gauge

A reference line or base line graduated in mm is drawn on the cylindrical sleeve, parallel to the axis of the screw. This is the main scale. The hollow cylinder (or thimble) is also graduated and it is divided into 100 equal parts. This is the circular scale (or head scale). The thimble is attached with a ratchet by a spring. The screw is always rotated by turning the ratchet. As soon as the flat end B of the screw comes in contact either with the stud A or with the object in between A and B, any further rotation of the ratchet does not move the screw linearly to press B against A (or the object). Thus a ratchet helps in holding the given object gently between the stud A and the end B of the screw.

Screw Gauge

Part	Function
1. Ratchet	To advance the screw by turning it till the object is gently held between the stud and spindle of the screw.
2. Sleeve	To mark main scale and base line.
3. Thimble	To mark circular scale.
4. Main scale	To read length correct up to 1 mm.
5. Circular scale	Helps to read length correct up to 0.01 mm.

Pitch and Least Count of a Screw Gauge

The pitch of a screw gauge is the linear distance moved by its screw on the main scale when the circular scale is given one complete rotation.

Pitch and Least Count of a Screw Gauge

However, the least count of a screw gauge is the linear distance moved by its screw along the main scale when the circular scale is rotated by one division on it. Thus,

Least count of screw gauge.

$$\text{L.C.} = \frac{\text{Pitch of the screw gauge}}{\text{Total number of divisions on its circular scale}}$$

Zero Error in a Screw Gauge

Kinds of zero error:

The zero error is of the following two kinds:

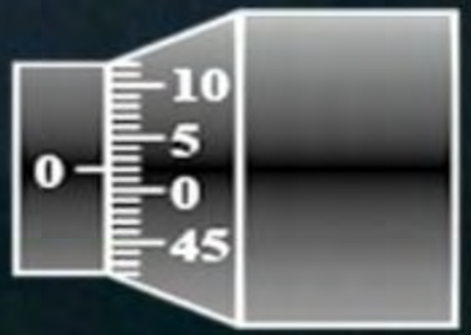
(i) Positive zero error, and

(ii) Negative zero error.

Zero Error in a Screw Gauge

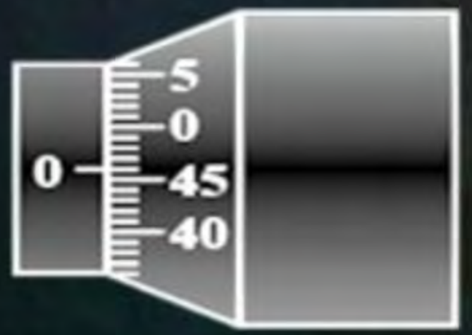
(a)

No zero error



(b)

Positive zero error



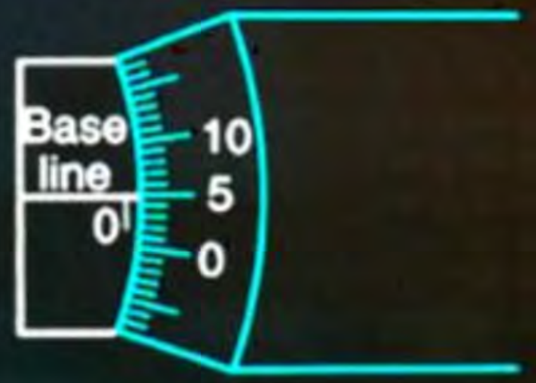
(c)

Negative zero error

Zero Error in a Screw Gauge

(i) Positive Zero Error:

If on bringing the flat and B of the screw in contact with the stud A, the zero mark on the circular scale is below the base line of main scale, the zero error is said to be positive.



In Figure, the 5^{th} division of circular scale coincides with the base line. If the least count of the screw gauge is 0.001 cm,

Then zero error = +5 × 0.001 cm = + 0.005 cm.

Zero Error in a Screw Gauge

(ii) Negative Zero Error:

If on bringing the flat end B of the screw in contact with the stud A, the zero mark on the circular scale is above the base line of main scale, the zero error is said to be negative.

In Figure, 95^{th} division of circular scale coincides with the base line and total number of divisions on the circular scale are 100. If least count of the screw gauge is 0.001 cm, then zero error

$= -(100 - 95) \times 0.001$ cm $= -0.005$ cm.

Backlash Error

Sometimes due to wear and tear of threads of screw, it is observed that on reversing the direction of rotation of the thimble, the tip of the screw does not start moving in the opposite direction at once, but it remains stationary for a part of rotation. This causes error in the observation which is called the backlash error.

To avoid the backlash error, while taking the measurements, the screw should be rotated in one direction only. If it is required to change the direction of rotation of the screw, do not change the direction of rotation at once. Move the screw still further, stop there for a while and then rotate it in the reverse direction.

Correction due to zero error i.e., correct reading with a screw gauge having a zero error.

Correct reading = observed reading – zero error (with sign)

Question

The least count of a vernier callipers is:

A 1 cm

B 0.001 cm

C 0.1 cm

D 0.01 cm

Question

The least count of a vernier callipers is:

A 1 cm

B 0.001 cm

C 0.1 cm

D 0.01 cm

ANSWER

(C) 0.01 cm

Question

The diameter of a thin wire can be measured by:

A. a vernier callipers

B. a metre rule

C. a screw gauge

D. none of these

Question

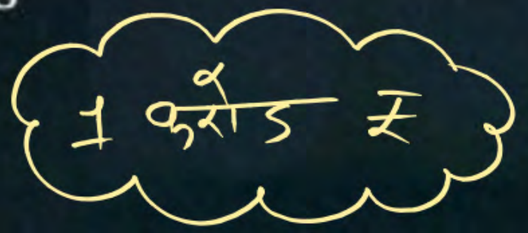
The diameter of a thin wire can be measured by:

(A) a vernier callipers

(B) a metre rule

(C) a screw gauge

(D) none of these



ANSWER

(C) a screw gauge

Question

The diameter of the wire can be accuratels measured by

A Vernier calipers

B Meter rule

C A screw gauge

D Any of these

Question

The diameter of the wire can be accuratels measured by

(A) Vernier calipers

(B) Meter rule

(C) A screw gauge

(D) Any of these

ANSWER

(C) A screw gauge

Question

The least count of meter rule is

A 1 cm

B 1 m

C 0.1 cm

D 0.01 cm

Question

The least count of meter rule is

(A) 1 cm

(B) 1 m

(C) 0.1 cm

(D) 0.01 cm

ANSWER

(C) 0.1 cm

Thank you