YAKEEN NEET 2.0

2026

Units and Measurements

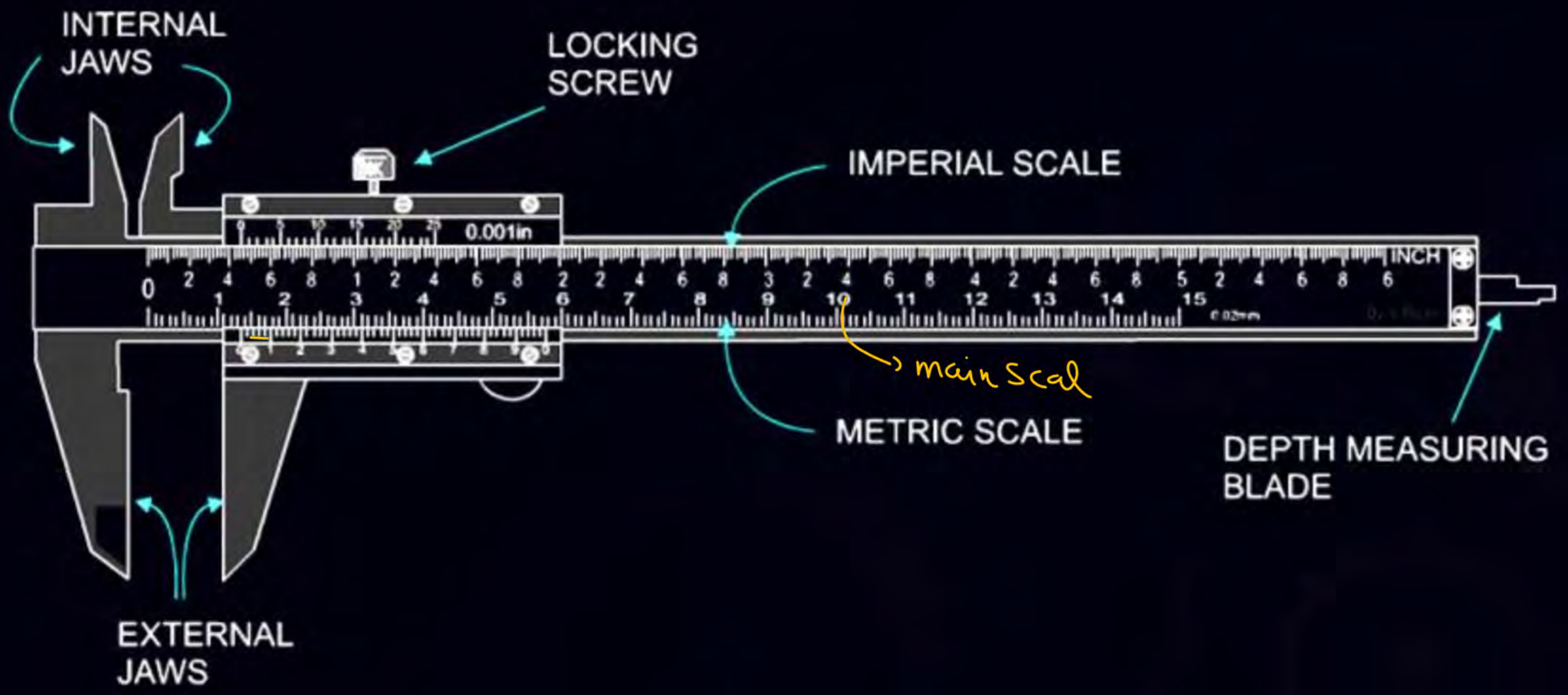
PHYSICS | Lecture - 11

By - Saleem Ahmed Sir

Topics *to be covered*

1. Vernier Caliper & Screw Gauge
2.
3.
4.

Vernier Callipers

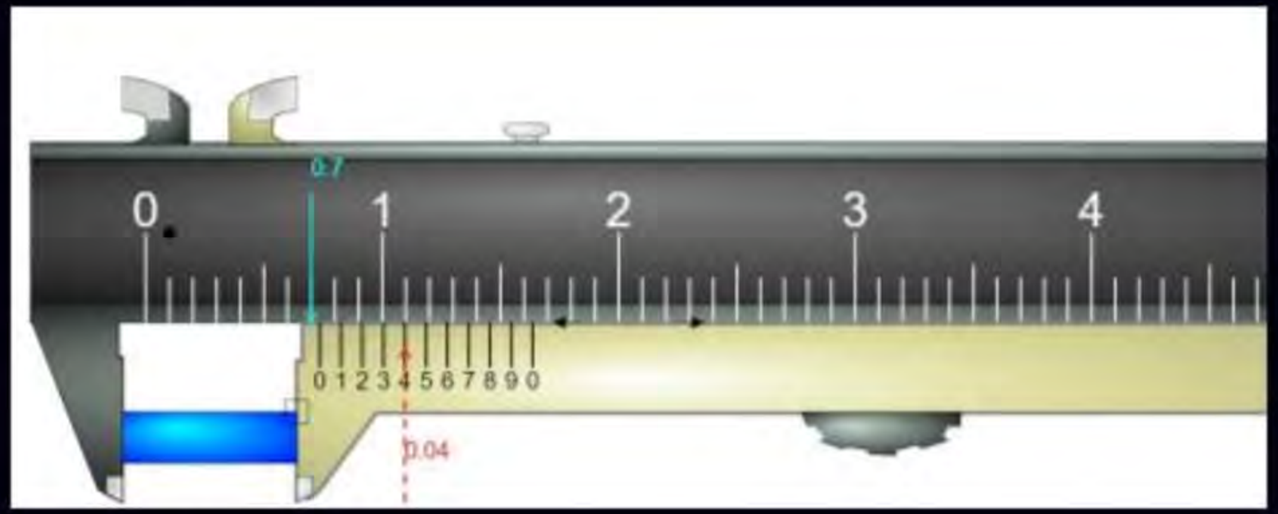


Length as measured by Vernier Calipers:

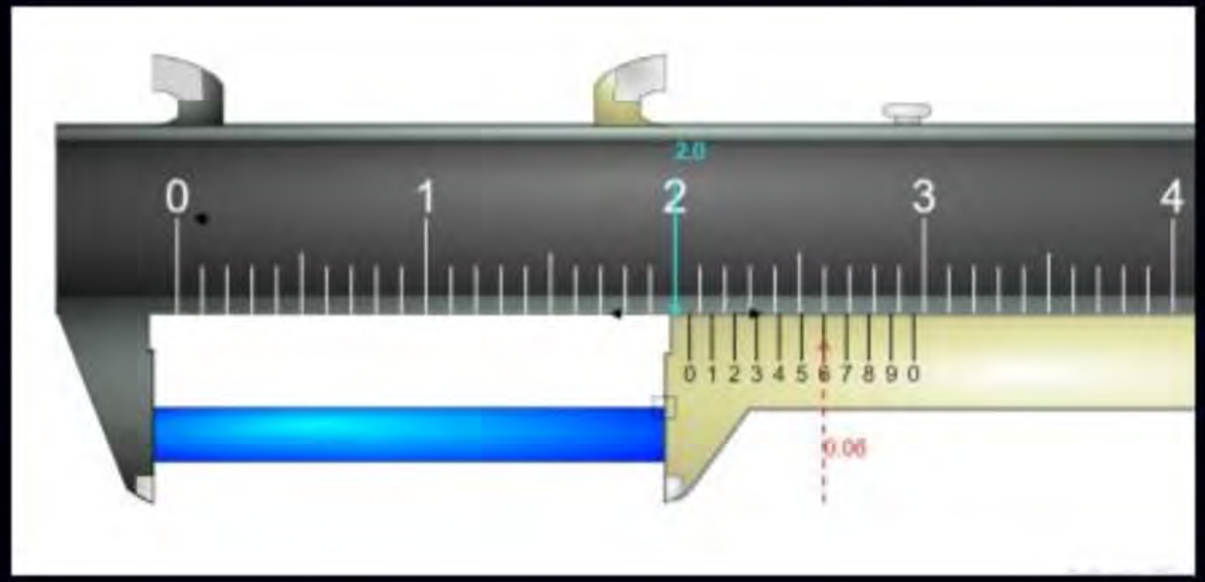
The formula for measuring the length is

L = main scale reading + least count of vernier scale × (Vernier scale division coinciding with a main scale division)

Main scale reading is given by the zeroth division of the vernier scale as shown in the figure.



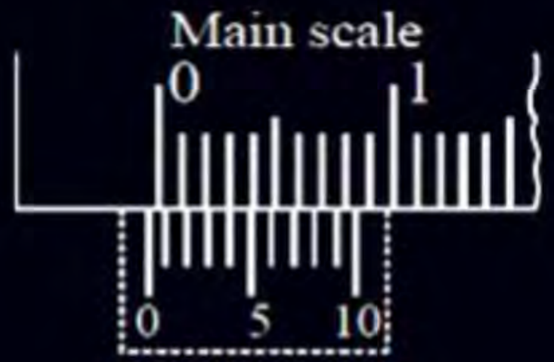
0.74 cm



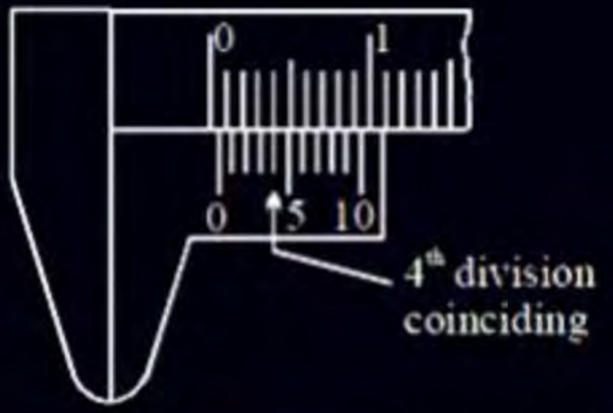
2.06 cm

Vernier scale
without zero error

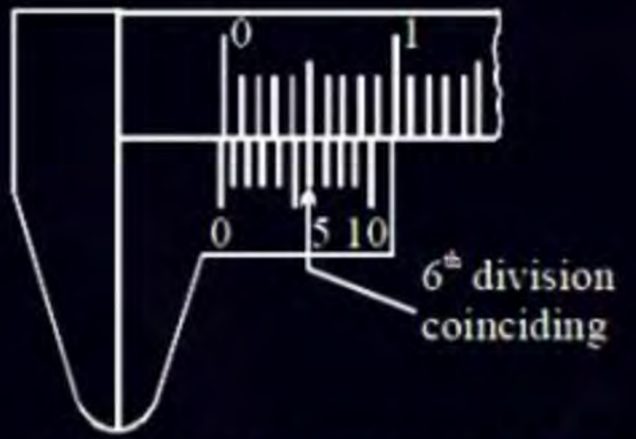
Vernier scale
with positive zero error



Vernier scale
with negative zero error

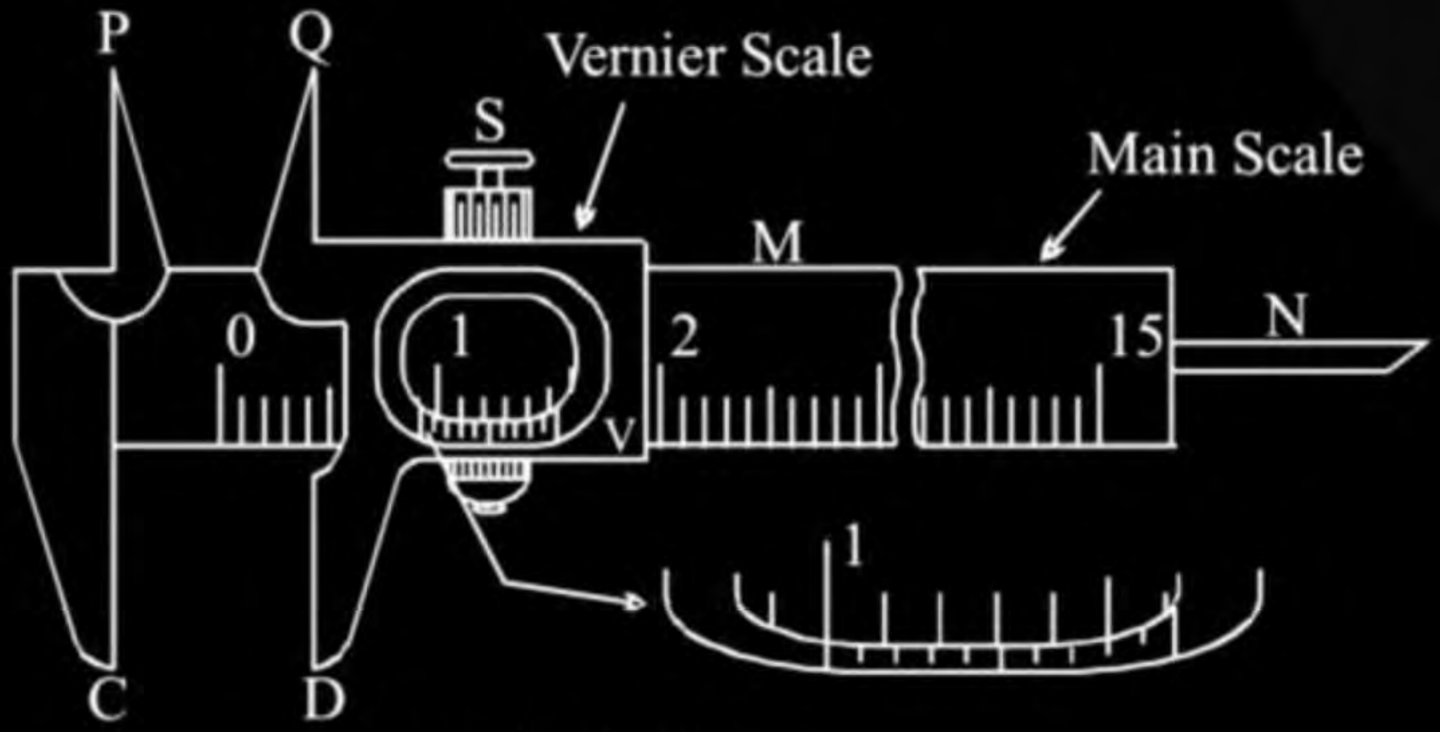


Positive zero error (+0.04 cm)



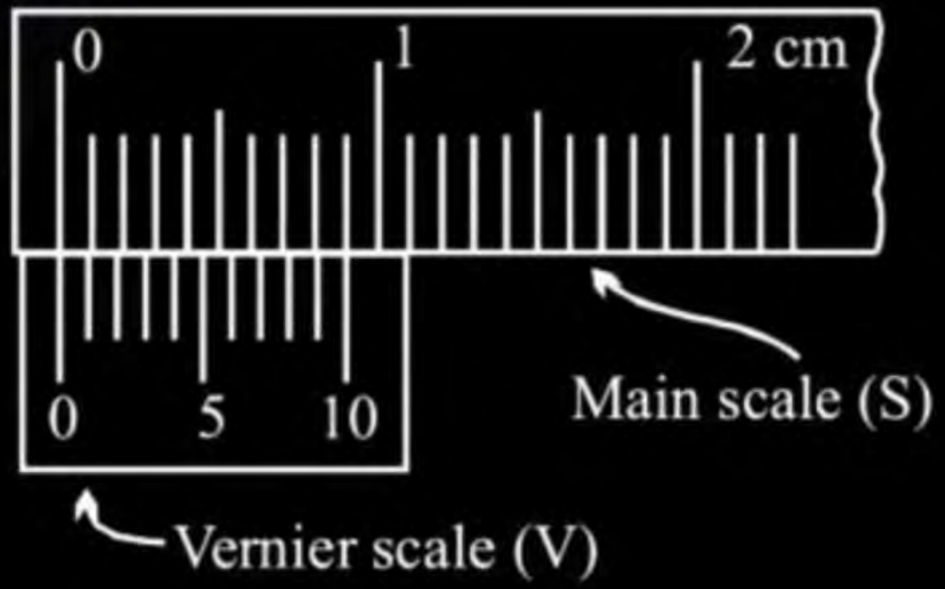
Negative zero error = (−0.04 cm)

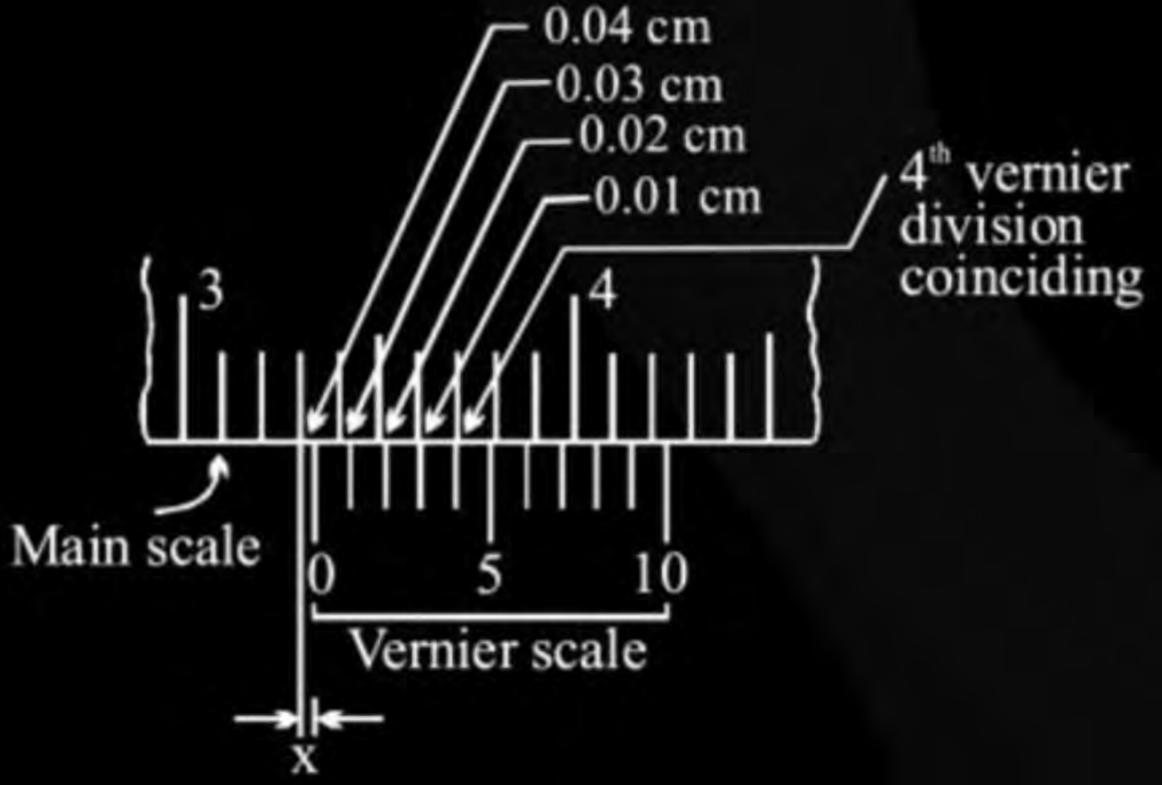
Vernier Callipers :



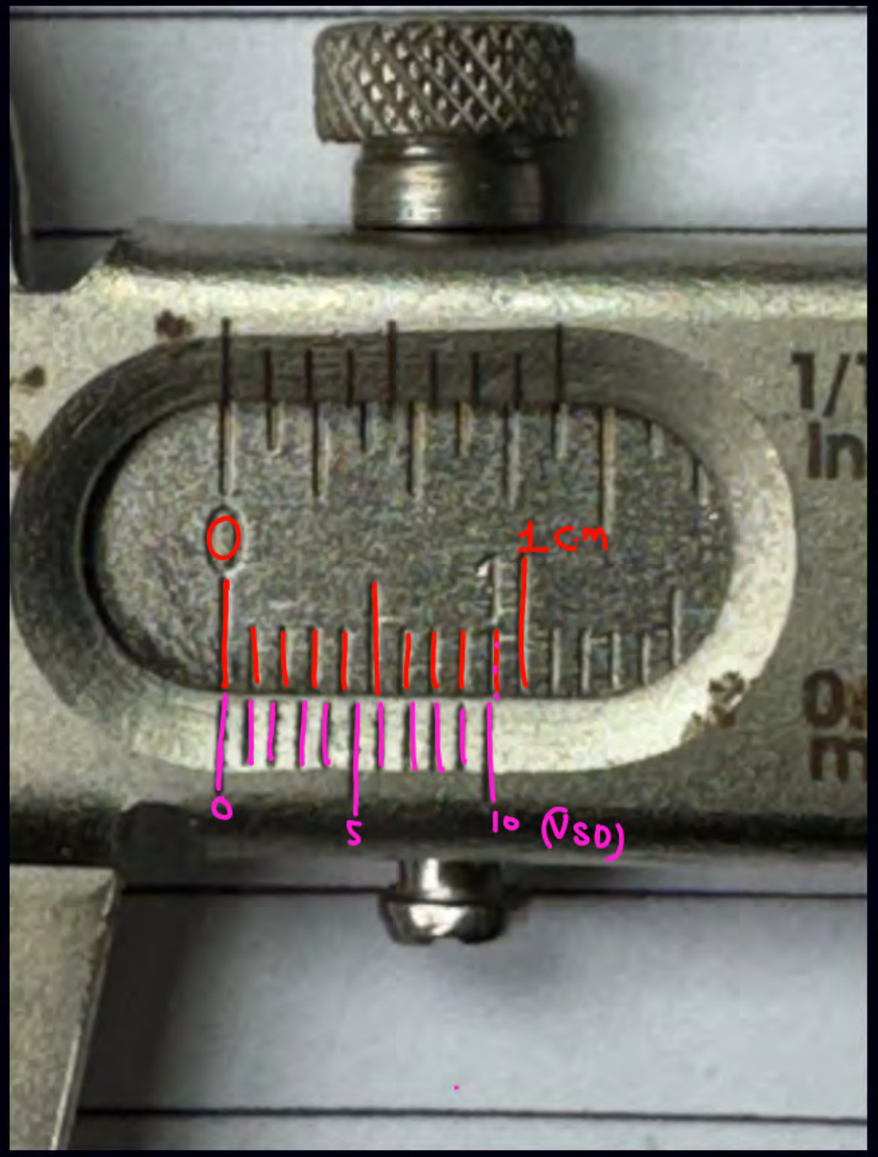
Vernier Callipers

Principle of Vernier

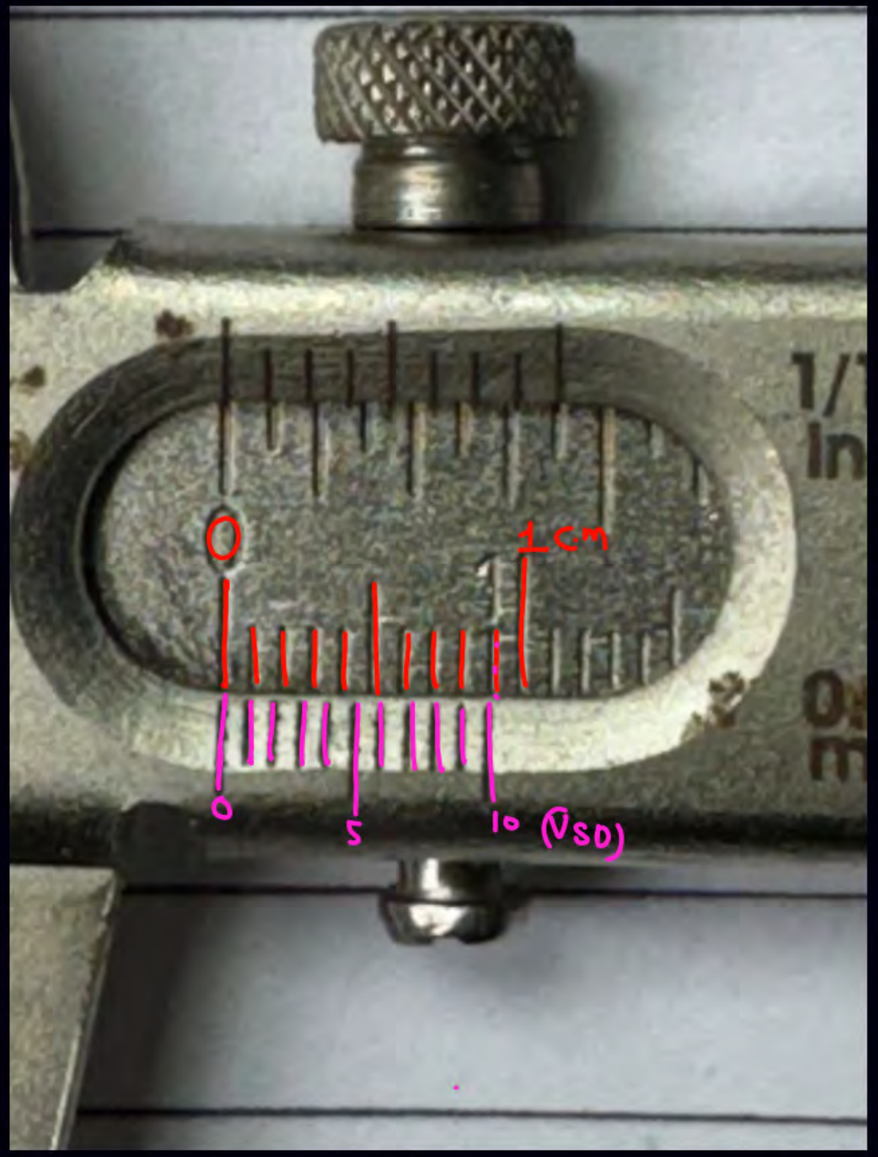




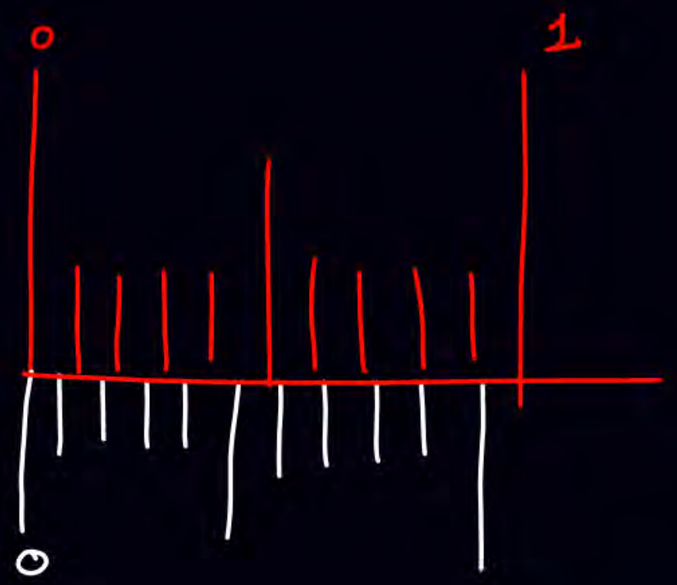
Reading a vernier with 4th division coinciding

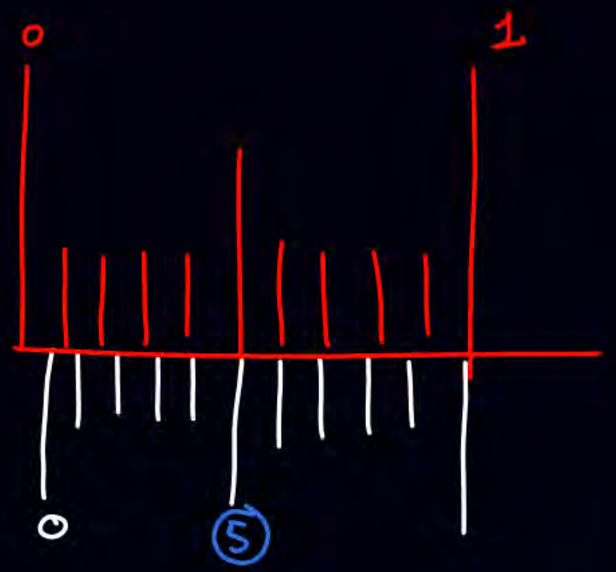

0
1cm
0
5
10 (VSD)


1/128
inch
0
1
0
10
mm


0
1cm
0
5
10 (VSD)


1/128
inch
mm
No zero error
0
1
0

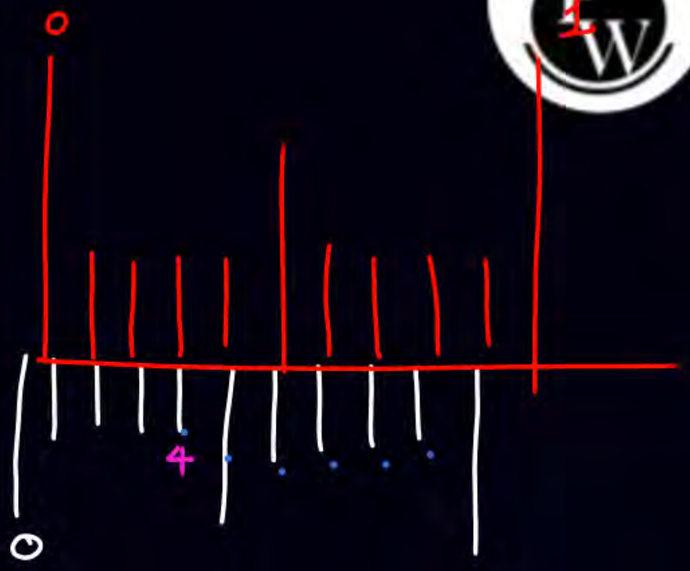




+ve Zero error

ZE = +5 X L.C

= +.05 cm



-ve Zero error

ZE = -.06 cm

Principle of Vernier

9 MSD = 10 V.S.D

$10\,VSD = 9\,MSD$

$1\,VSD = \frac{9}{10}\,MSD$

L.C = Least count = $1\,MSD - 1\,VSD$

$= 1\,MSD - \frac{9}{10}\,MSD = \frac{1}{10}\,MSD$

- N divisions on the vernier scale is equal to
- (N-1) divisions on the main scale.
- N.V.S.D. = (N-1) M.S.D.
- 1 V.S. D = $\frac{N-1}{N}$ M.S.D.

L.C = $\frac{1}{10}$ MSD

$= \frac{1}{10}(1\,mm) = 0.1\,cm$

$= 0.1\,mm$

Least count of Vernier Callipers

- The least count or Vernier constant (v.c.) is the minimum value of correct estimation of length without eye estimation. IF N division of vernier coincides with (N-1) division of main scale, then

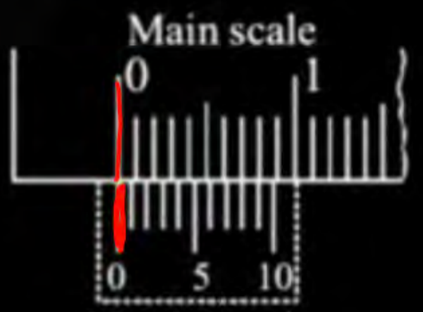
$$N(VS)=(N\text{-}1)\ ms \Rightarrow 1VS=\frac{N-1}{N}ms$$

Vernier constant = 1 ms − 1 vs $=\left(1-\frac{N-1}{N}\right)ms=\frac{1ms}{N}$, which is equal to the value of the smallest division on the main scale divided by total number of divisions on the vernier scale.

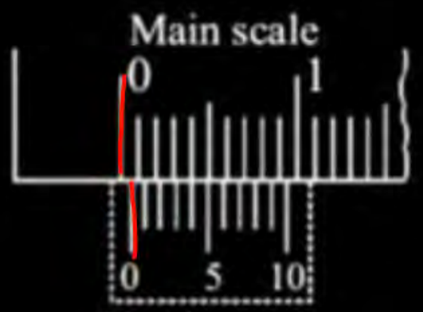
Length as measured by Vernier Callipers

- The formula for measuring the length is L = main scale reading + least count of vernier scale × Vernier scale division coinciding with a main scale division. — (Z.E)

Zero errors :

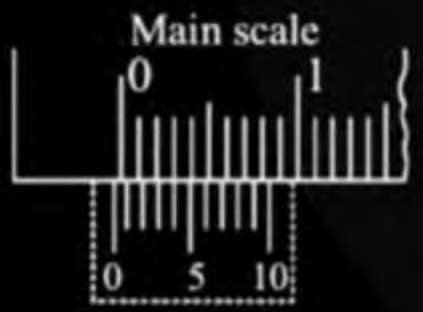


Vernier scale
without zero error



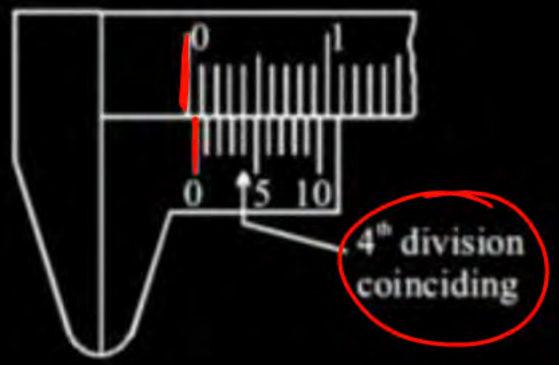
Vernier scale
with positive zero error

(i)

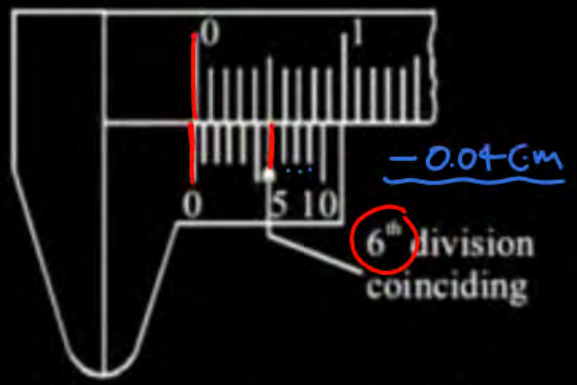


Vernier scale
with negative zero error

(ii)



Positive zero error (+0.04 cm)
and its correction



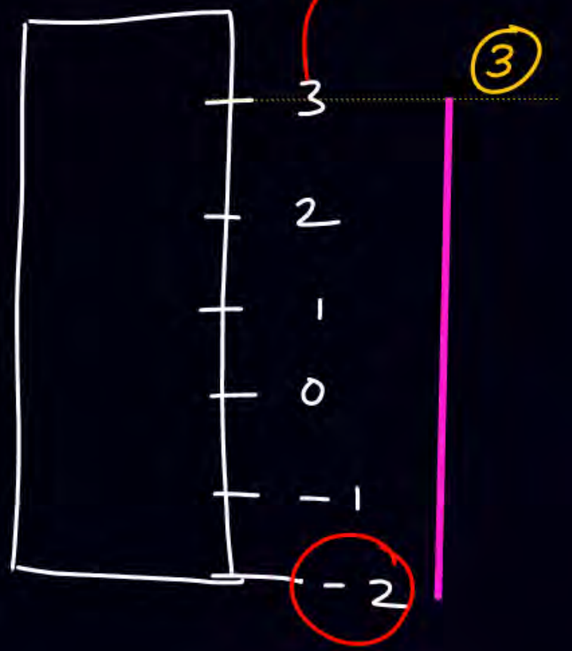
Negative zero error = (−0.04 cm)
and its correction

$7 - (+3) = 4$

$7 - 3 = 4$

Reading

$3 - (-2) = 5$



Ans 5

V.C.

10 VSD ⟶ 9 MSD

1 VSD ⟶ $\frac{9}{10}$ MSD

LC = 1 MSD − 1 VSD

$= 1\,\text{MSD} - \frac{9}{10}\,\text{MSD} = \frac{1}{10}\,\text{MSD} = \frac{1}{10} \times (.1\,\text{cm})$

$= \frac{1}{100}\,\text{cm}$

$= .01\,\text{cm}$

L.C

A Vernier calipers has 1 mm marks on the main scale. It has 20 equal divisions on the Vernier scale which match with 16 main scale divisions. For this Vernier, the least count is **[JEE 2010]**

Ans : D

A 0.02 mm

B 0.05 mm

C 0.1 mm

D 0.2 mm

$20\,VSD = 16\,MSD$

$1\,VSD = \frac{16}{20}\,MSD$

$LC = 1\,MSD - 1\,VSD = 1\,MSD - \frac{16}{20}\,MSD$

$= \frac{4}{20}\,MSD = \frac{4}{20} \times 1\,mm$

$= \frac{1}{5}\,mm$

$= 0.2\,mm$

(L.C)

The Vernier of a circular scale is divided in to 30 divisions, which coincides with 29 main scale divisions. If each main scale division is $(1/2)°$, the least count of the instrument is

Ans : B

$30\,VSD = 29\,MSD$

$1\,VSD = \frac{29}{30}\,MSD$

$LC = 1\,MSD - 1\,VSD = 1\,MSD - \frac{29}{30}\,MSD = \frac{1}{30}\,MSD$

$= \frac{1}{30} \times \frac{1}{2^{\circ}} =$

A $0.1'$

B $1'$

C $10'$

D $30'$

How to take reading of a Vernier scale

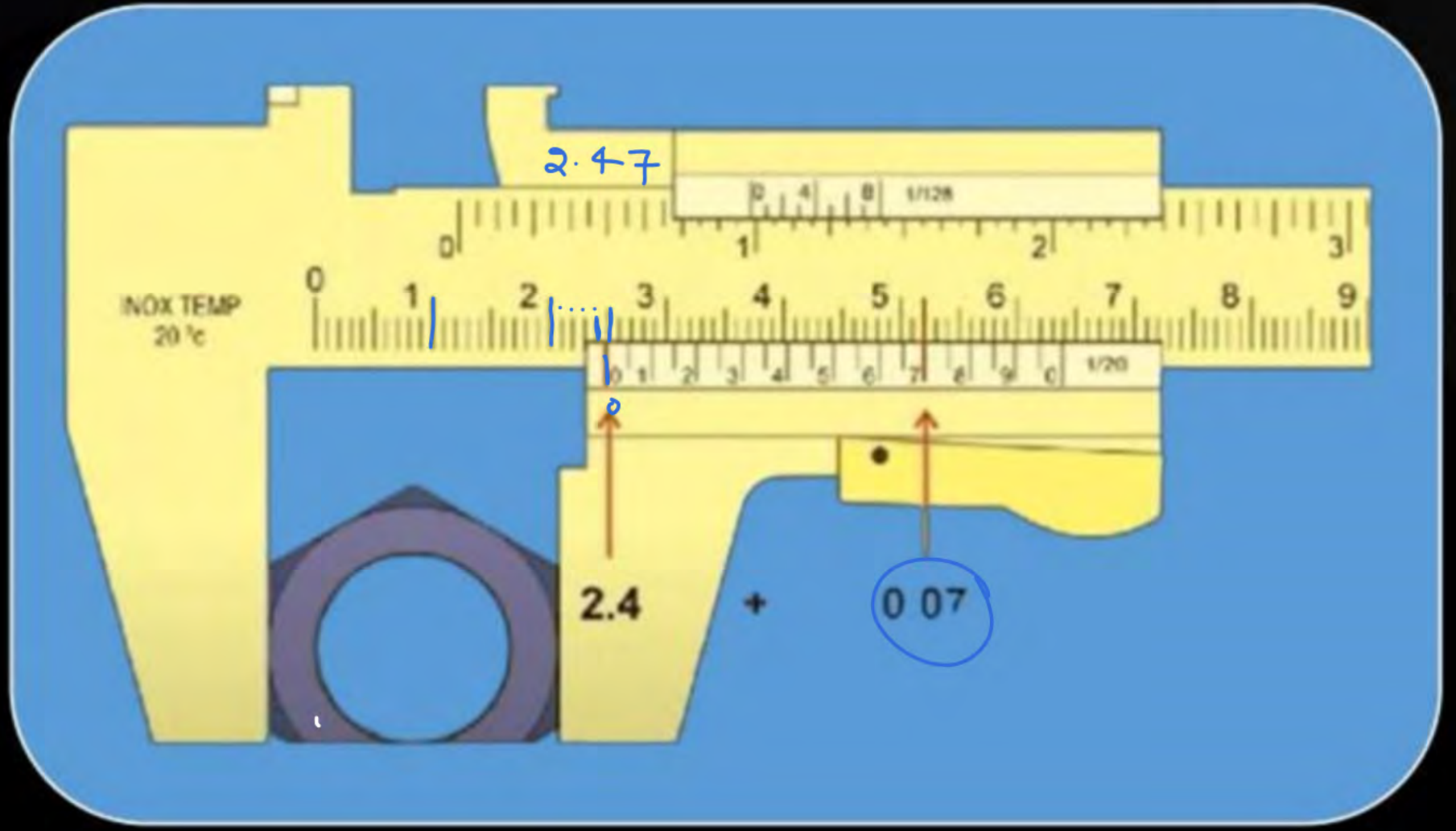
1·2cm + 3 × ·01cm

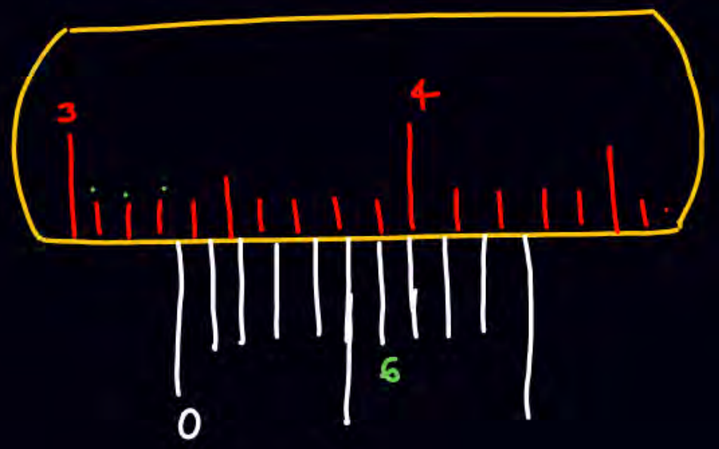
= 1·23 cm

L.C = 0.1 mm = 0.01 cm

- Main Scale reading = 1.2 cm;
- Vernier scale reading = 3 × LC = 3 × 0.01 cm = 0.03 cm
- So, Reading = 1.2 + 0.03 = 1.23 cm

Another Example





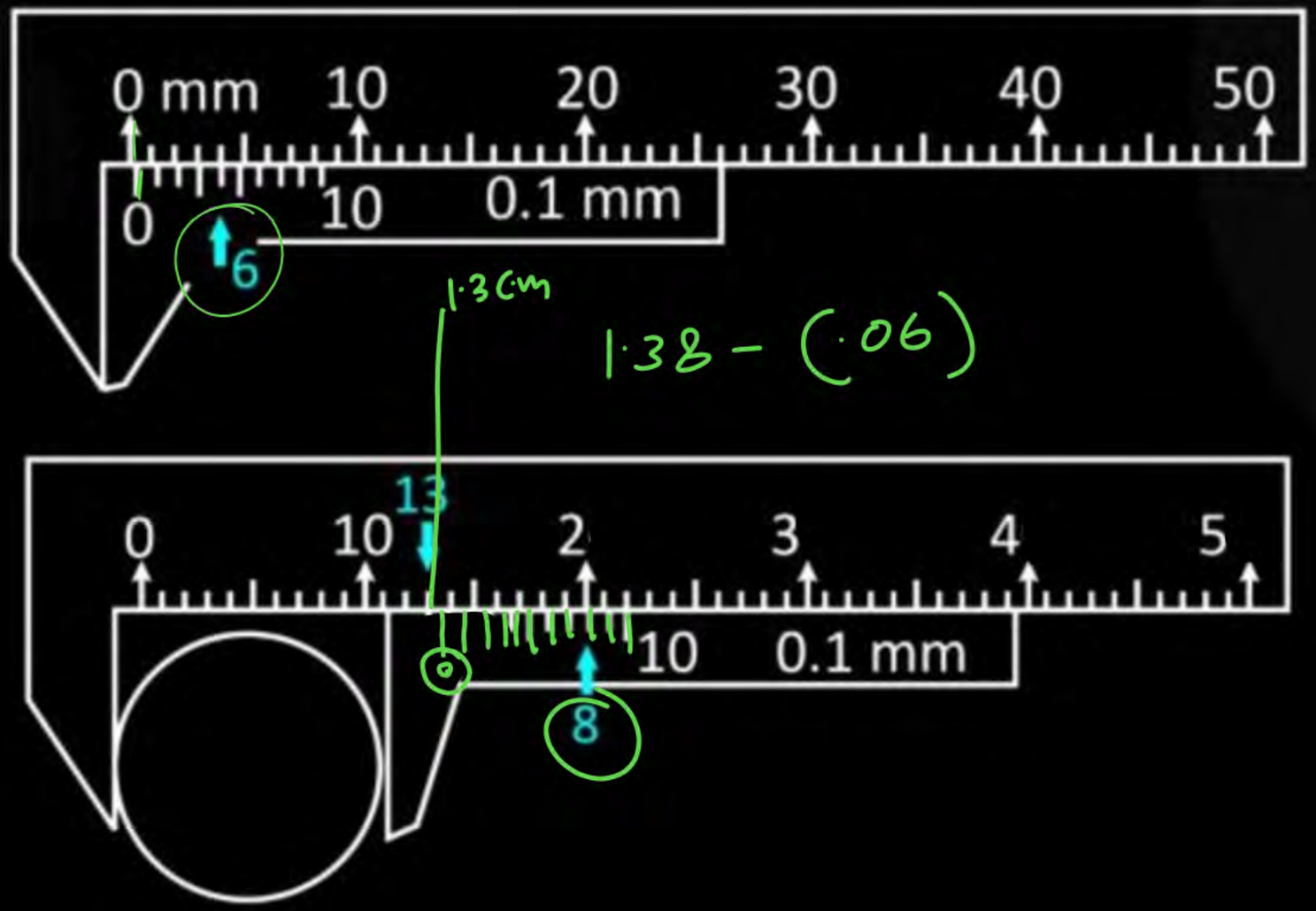
3.36

3.3 + L.C x Coincidence

3.3 + .01 x 6 = 3.36 cm

$3.4 + .01 \times 5$

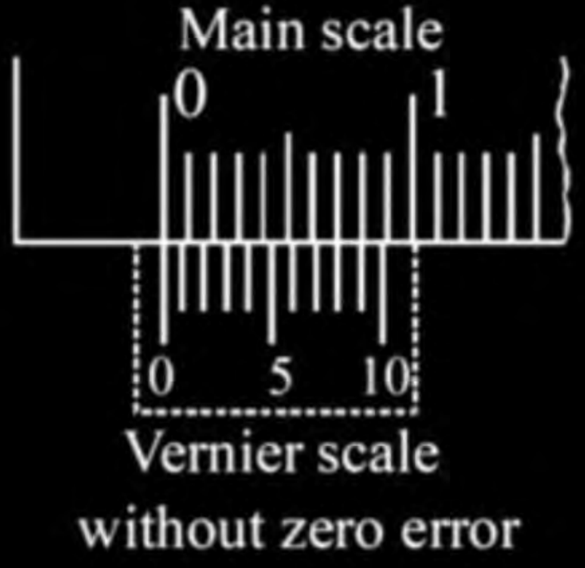
$= 3.45$


0 mm 10 20 30 40 50
0
10 0.1 mm
6
1·3 cm
1·38 - (·06)
0 10 2 3 4 5
13
10 0.1 mm
0
8

Zero Error

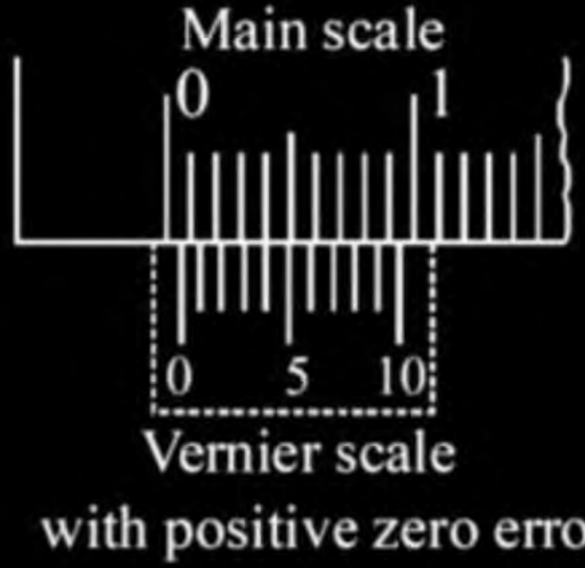
Types of Zero Error in vernier calipers

(i) Negative Zero error

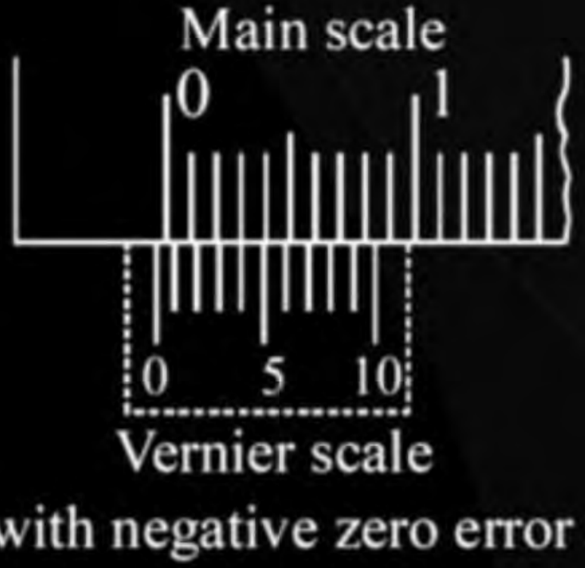


without zero error

(ii) Positive Zero error



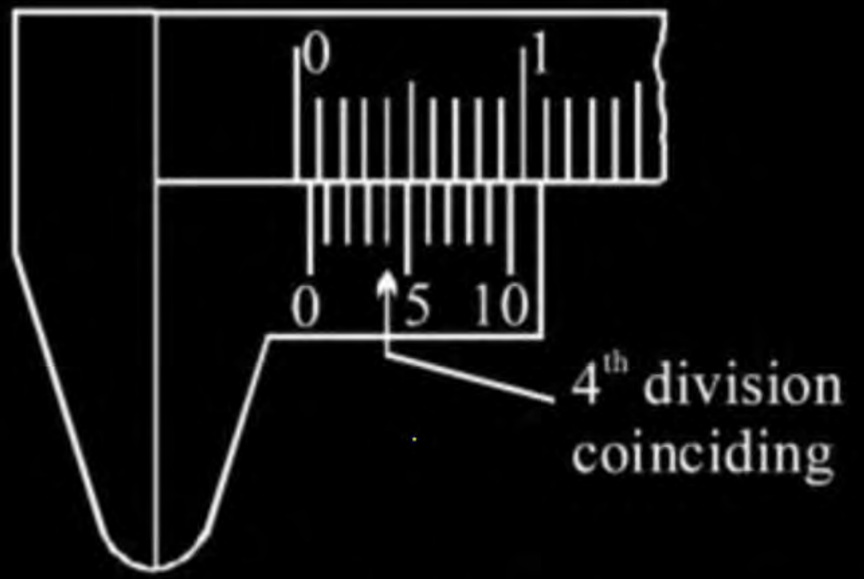
with positive zero error



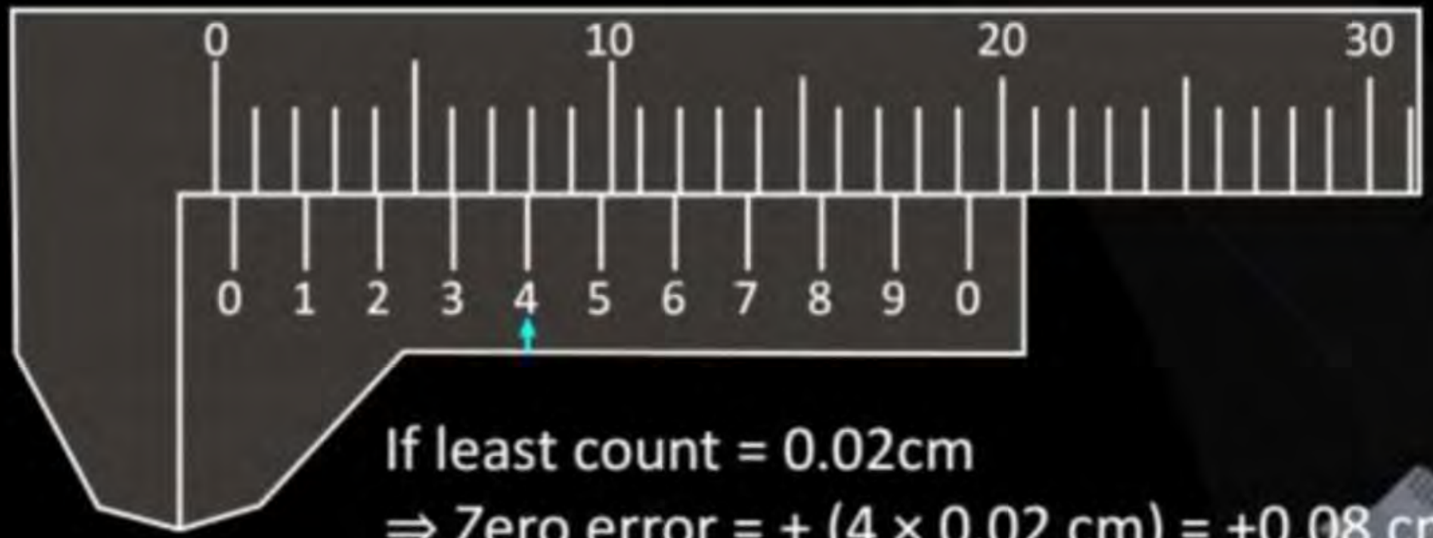
with negative zero error

Positive Zero Error

When the jaws of the vernier calipers are closed, and if the zero mark on the auxiliary (vernier) scale lies to the right of the main scale zero-mark, then error is called Positive Zero error.



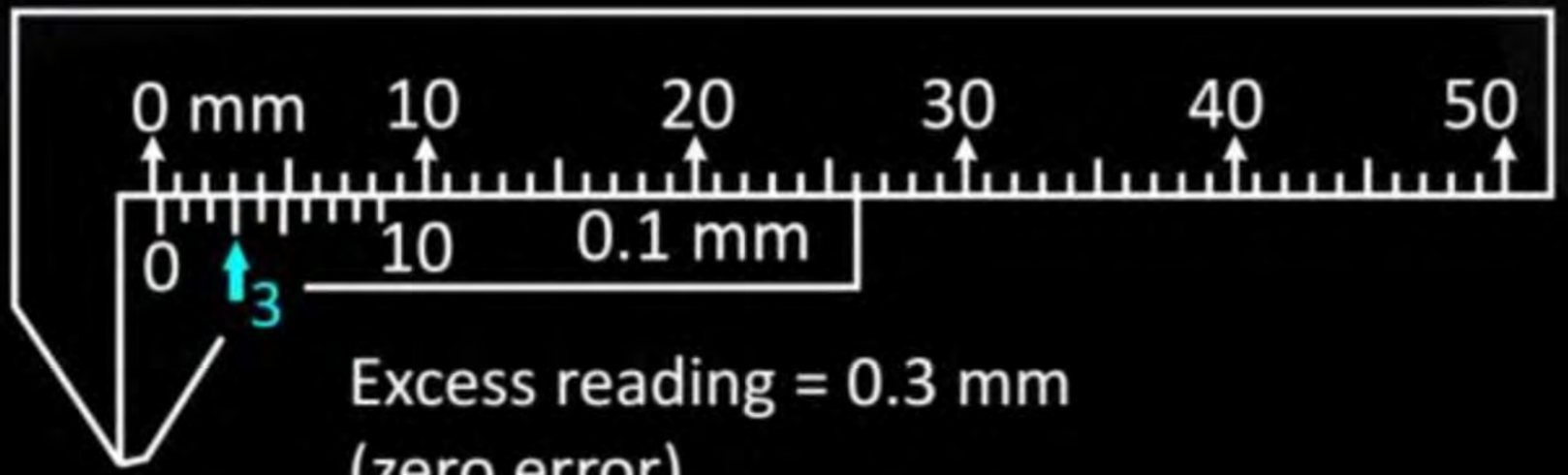
Positive zero error (+0.04 cm)



If least count = 0.02cm

⇒ Zero error = + (4 × 0.02 cm) = +0.08 cm

when the jaws are closed and if the reading is 0.3 mm, the zero error is referred to as +0.3 mm.



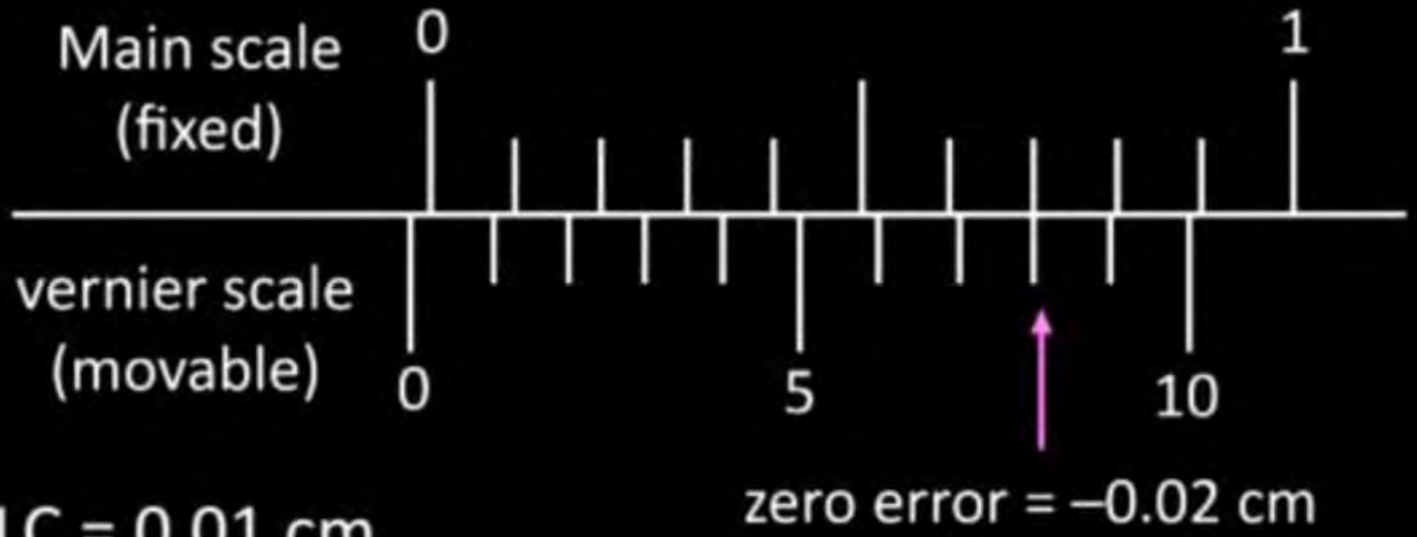
Excess reading = 0.3 mm
(zero error)

So, the zero correction should be subtracted from the reading which is measured

Negative zero error

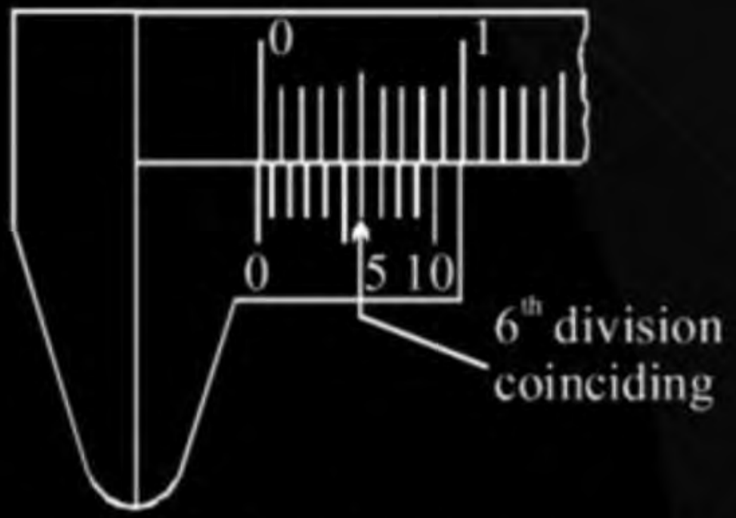
When the jaws of the vernier calipers are in contact, and if the first mark on the auxiliary (Vernier) scale lies to the left of zero of main scale such an error is called Negative Zero error.

Negative zero error = –[Total no. of vsd – coinciding] × L.C.



LC = 0.01 cm

Zero error = – (10 – 8) × 0.01 = –0.02 cm



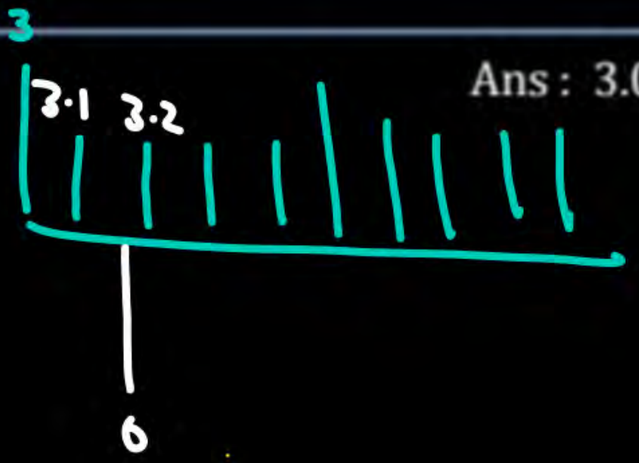
Negative zero error = (–0.04 cm)

The main scale of a vernier calipers reads in millimeter and its vernier is divided into 10 divisions which coincide with 9 divisions of the main scale. When the two jaws of the instrument touch each other the seventh division of the vernier scale coincide with a scale division and the zero of the vernier lies to the right of the zero of main scale. Furthermore, when a cylinder is tightly placed along its length between the two jaws, the zero of the vernier scale lies slightly to the left of 3.2 cm; and the fourth vernier division coincides with a scale division. Calculate the measured length of the cylinder.

LC = .01 cm ZE = 7 × LC = .07

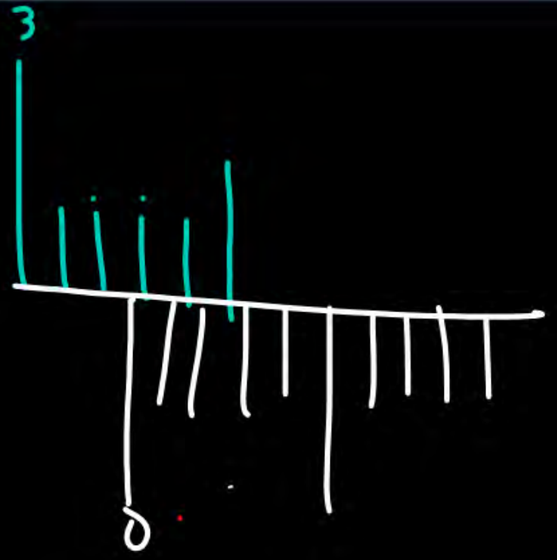
3.1 + 4 × LC − .07

3.14 − .07 = 3.07



Ans : 3.07 cm

Least count of a vernier calipers is 0.01 cm. When the two jaws of the instrument touch each other, the 5^{th} division of the vernier scale coincide with a main scale division and the zero of the vernier scale lies to the left of the zero of the main scale. Furthermore, while measuring the diameter of a sphere, the zero mark of the vernier scale lies between 3.2 cm and 3.3 cm and the 7^{th} vernier division coincides with a main scale division. Calculate the diameter of the sphere. Z.E = −.05



$3.27 - (-.05) = 3.32$ cm.

Ans : 3.32 cm

A Vernier callipers has 1 mm marks on the main scale. It has 20 equal divisions on the Vernier scale which match with 16 main scale divisions. For this Vernier calipers, the least count is: **[JEE 2010]**

A 0.02 mm

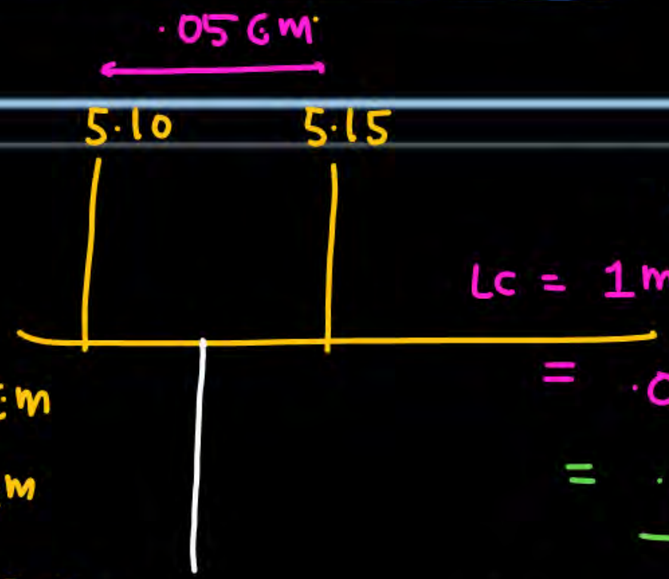
B 0.05 mm

C 0.1 mm

D 0.2 mm

$\frac{49}{1000}$

The diameter of a cylinder is measured using a Vernier callipers with no zero error. It is found that the zero of the Vernier scale lies between 5.10 cm and 5.15 cm of the main scale. The Vernier scale has50 divisions equivalent to 2.45 cm. The 24th division of the Vernier scale exactly coincides with one of the main scale divisions. The diameter of the cylinder is : **[JEE-Advance 2013]**



50 VSD = 2.45 cm

1 VSD = $\frac{2.45}{50}$ cm

= .049 cm

LC = 1 MSD − 1 VSD

= .05 cm − .049 cm

= .001 cm

5.10 cm + LC × 24 − ZE

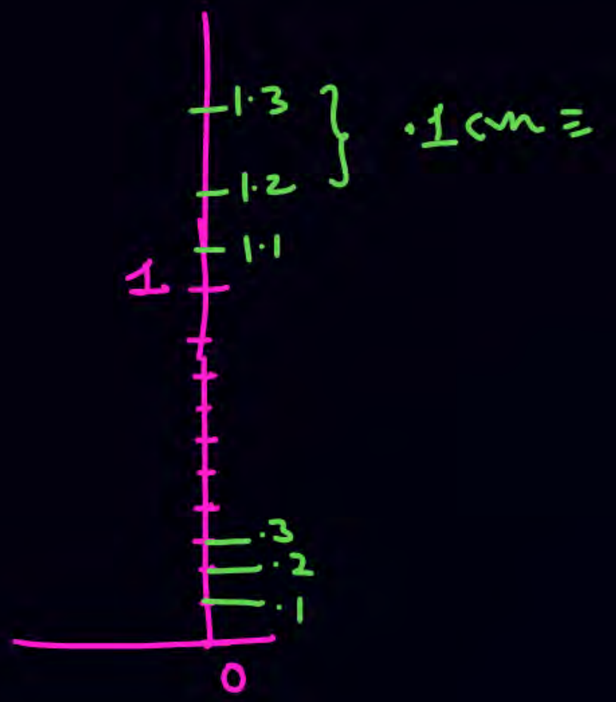
Ans 5.10 + 24 × .001

A. 5.112 cm

B. 5.124 cm

C. 5.136 cm

D. 5.148 cm


1·3
1·2
1·1
1
·3
·2
·1
0
·1 cm =

In an experiment the angles are required to be measured using an instrument 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half-a-degree (=0.5°), then the least count of the instrument is :

[AIEEE - 2009]

Ans : (C)

A One degree

B Half degree

$\frac{1}{60} = 1'$

C One minute

D Half minute

A spectrometer gives the following reading when used to measure the angle of a prism. Main scale reading : 58.5 degree. Vernier scale reading : 09 divisions. Given that 1 division on main scale corresponds to 0.5 degree. Total divisions on the vernier scale is 30 and match with 29 divisions of the main scale. The angle of the prism from the above data :

[AIEEE - 2012]

30 VSD = 29 MSD

1 VSD = $\frac{29}{30}$ MSD

LC = 1 MSD − $\frac{29}{30}$ MSD = $\frac{1}{30}$ MSD = $\frac{1}{30} \times \frac{1}{2}$

= $\frac{1}{60}$

58.5 + 9 × LC

= 58.5 + 9 × $\frac{1}{60}$

= 58.5 + .15

Ans : (D)

A 59 degree

B 58.59 degree

C 58.77 degree

D 58.65 degree

19. Consider a Vernier callipers in which each 1 cm on the main scale is divided into 8 equal divisions and a screw gauge with 100 divisions on its circular scale. In the Vernier callipers, 5 divisions of the Vernier scale coincide with 4 divisions on the main scale and in the screw gauge, one complete rotation of the circular scale moves it by two divisions on the linear scale. Then :

[JEE-Advance 2015]

(A) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01 mm.

(B) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.005 mm.

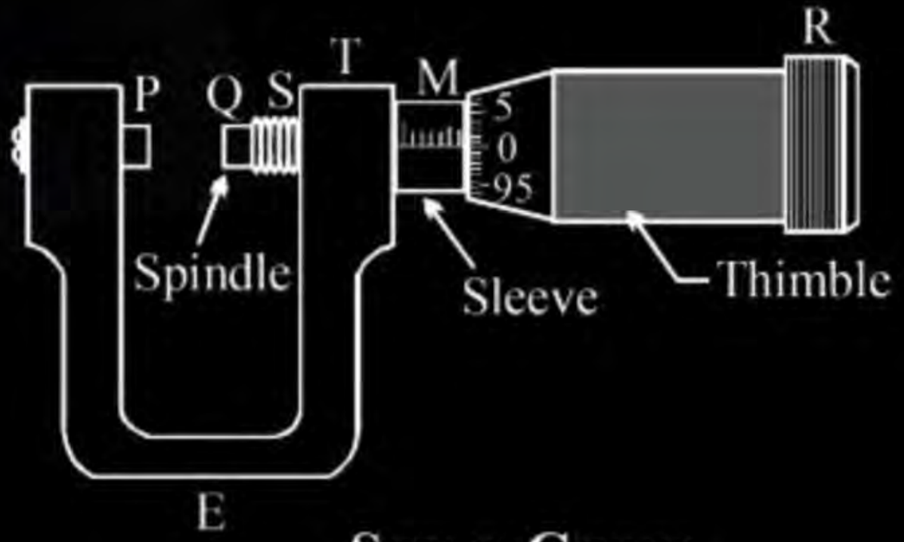
(C) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01 mm.

(D) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.005 mm.

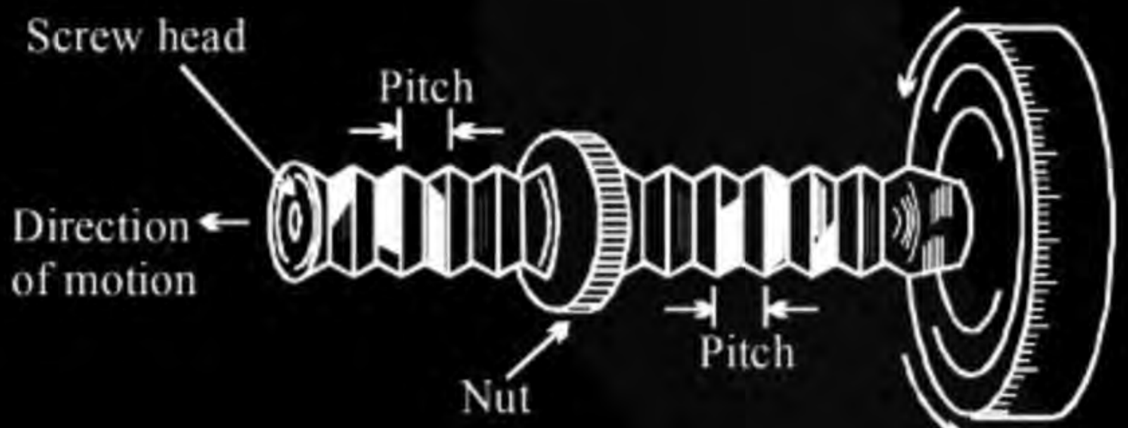
एक वर्नियर कैलीपर्स में मुख्य पैमाने का 1 cm 8 बराबर भागों में विभक्त है तथा एक पेंचमापी के वृत्ताकार पै[illegible] 100

* Least count $= \dfrac{\text{Pitch}}{\text{No. of div on circular scale}}$

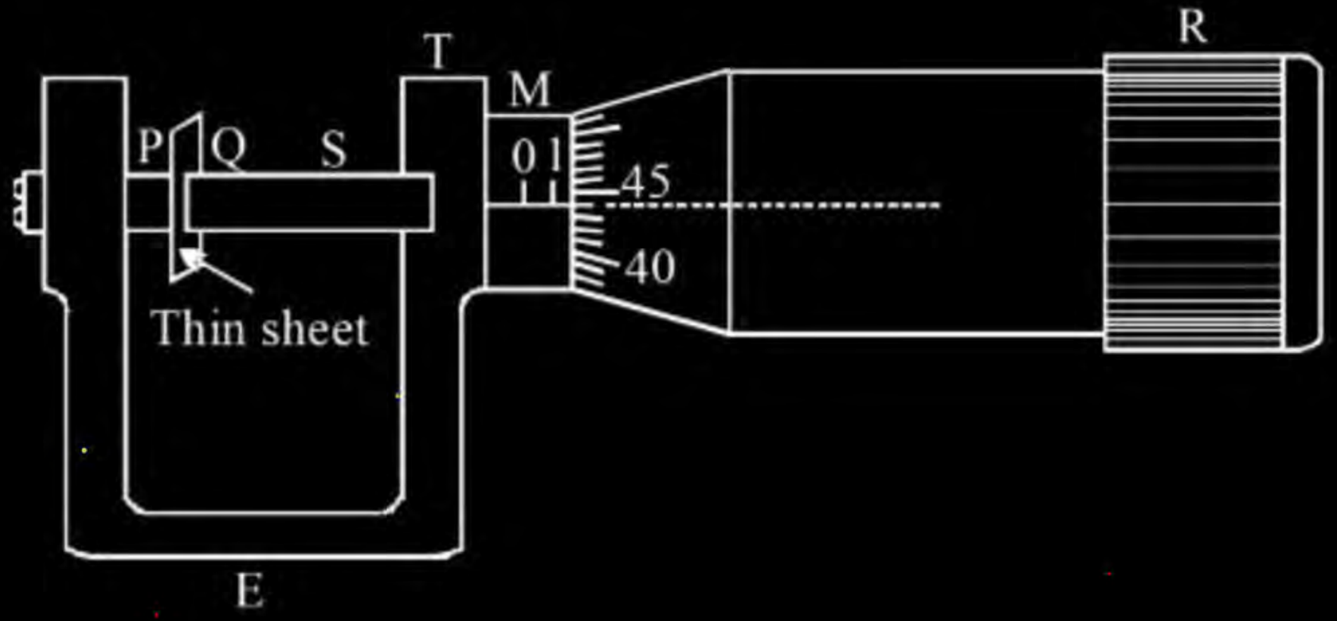
* Reading = Main scale Reading + (Coinciding div.) X L.C. − (Z.E.)



Screw Gauge



Principle of a micrometer



* No. of div. of circular scale ≡ 100
* Value of Reading of 1 MSD ≡ Pitch
≡ 1 mm

$$L.C = \frac{\text{Pitch}}{\text{No. of SD}} = \frac{1\,mm}{100}$$

$3mm + 45 \times \frac{1}{100}\,mm$

3.45

* No. of div. of circular scale ≡ 50

pitch ≡ 1 mm

$$L.C = \frac{1\,mm}{50}$$

$4mm + 24 \times \frac{1}{50}\,mm$

$3 + 32 \times \frac{1}{50}$

50 ⟶ 1 mm

182 ⟶ $\frac{1}{50} \times 182$

$$LC = \frac{\text{pitch}}{\text{No. of div}} = \frac{1\,mm}{50}$$

7 पाठ्यांक $+ LC \times 28$

$7\,mm + \frac{1}{50} \times 28$

$= 7.56\,mm$

50 डिवीजन

1 पाठ्यांक $\longrightarrow$ pitch $= 1\,mm$

$350 + 28 \equiv$ 378 डिवीजन

50 डिवीजन $\longrightarrow$ $1\,mm$

378 " $\longrightarrow$ $\frac{1}{50} \times 378\,mm$

$= 7.56\,mm$

pitch ⟶ 1 mm

4 चक्कर ⟶ 4 × pitch

$$LC = \frac{\text{pitch}}{\text{No of div}} = \frac{1\text{ mm}}{100}$$

100 डंडी ⟶ 1 mm

481 ⟶ $\frac{1}{100} \times 481$

$= 4.81$

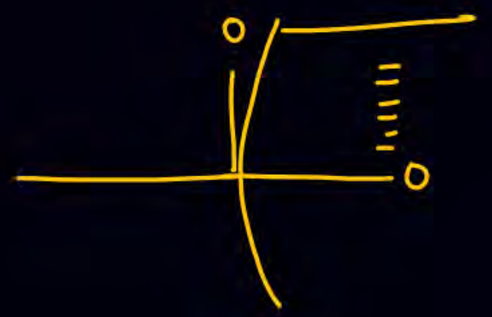
Read = no. of चक्कर × pitch + सामने वाला डंडी × LC —(ZE)

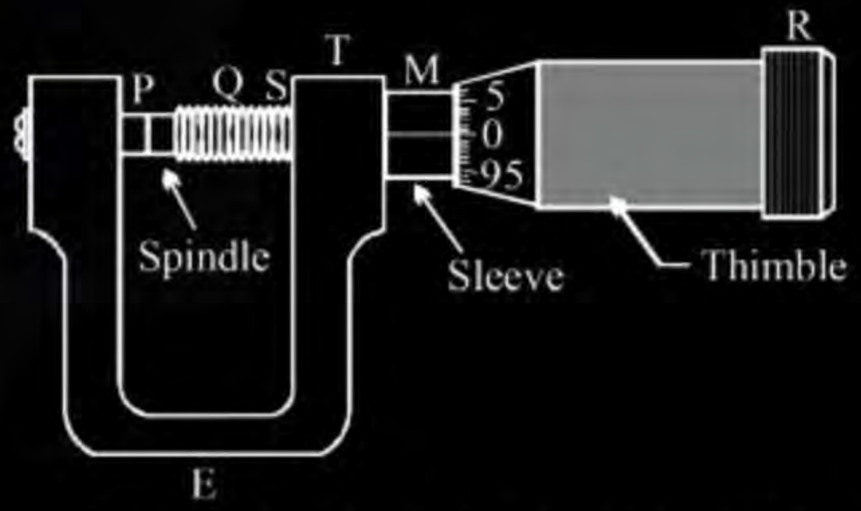
$$= 4 \times 1\text{ mm} + 81 \times \frac{1}{100}\text{ mm} = \underline{\underline{4.81\text{ mm}}}$$

Reading = (No. of चक्कर) x pitch + सामने वाला डंडा x L.C − (Z.E)

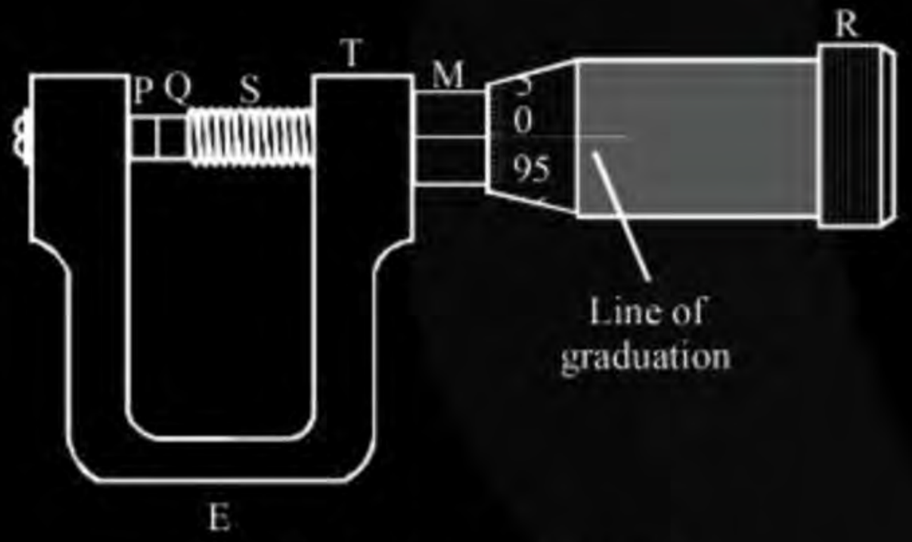
$$L.C. = \frac{\text{pitch}}{\text{Total no. of div.-on circular scale}}$$

No. of div on circular scale = 100

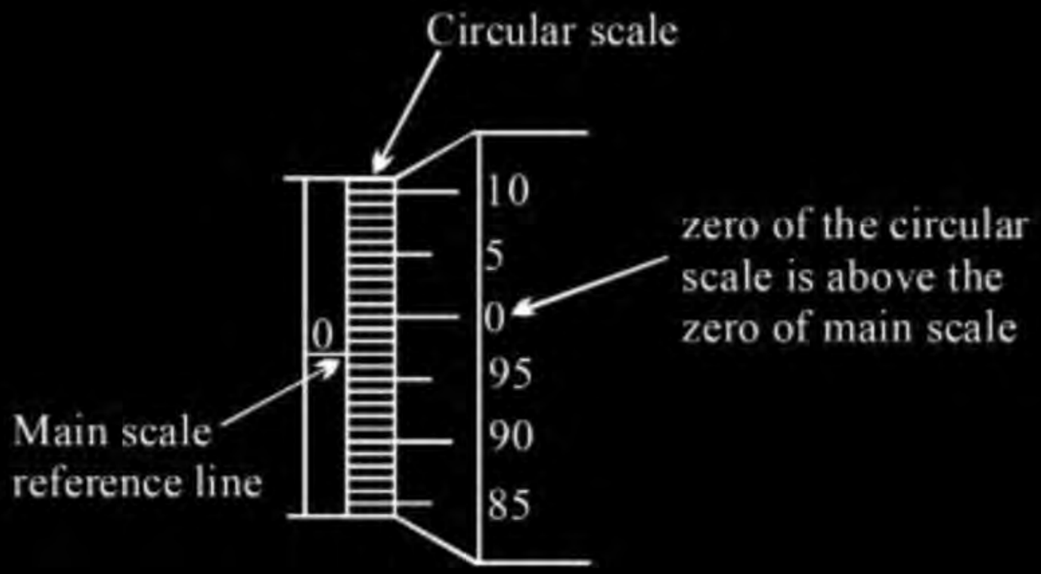


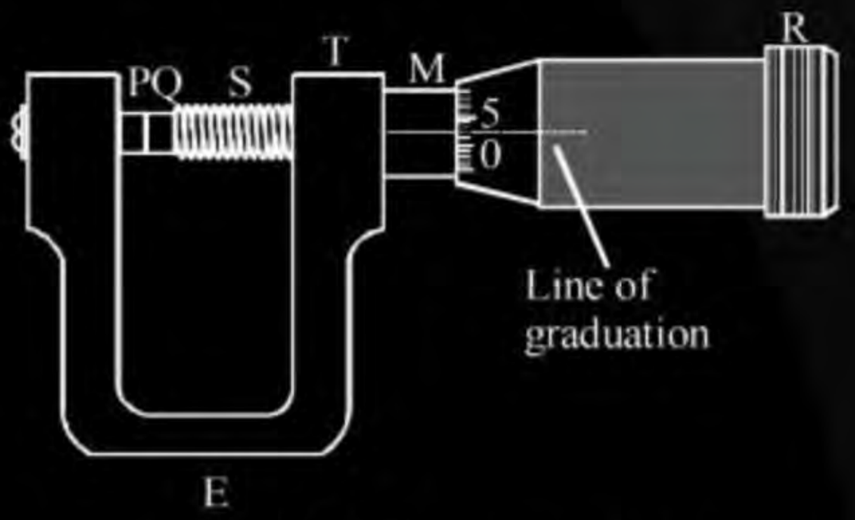


Screw gauge with no zero error



Negative zero error
(3 division error) i.e., - 0.003 cm



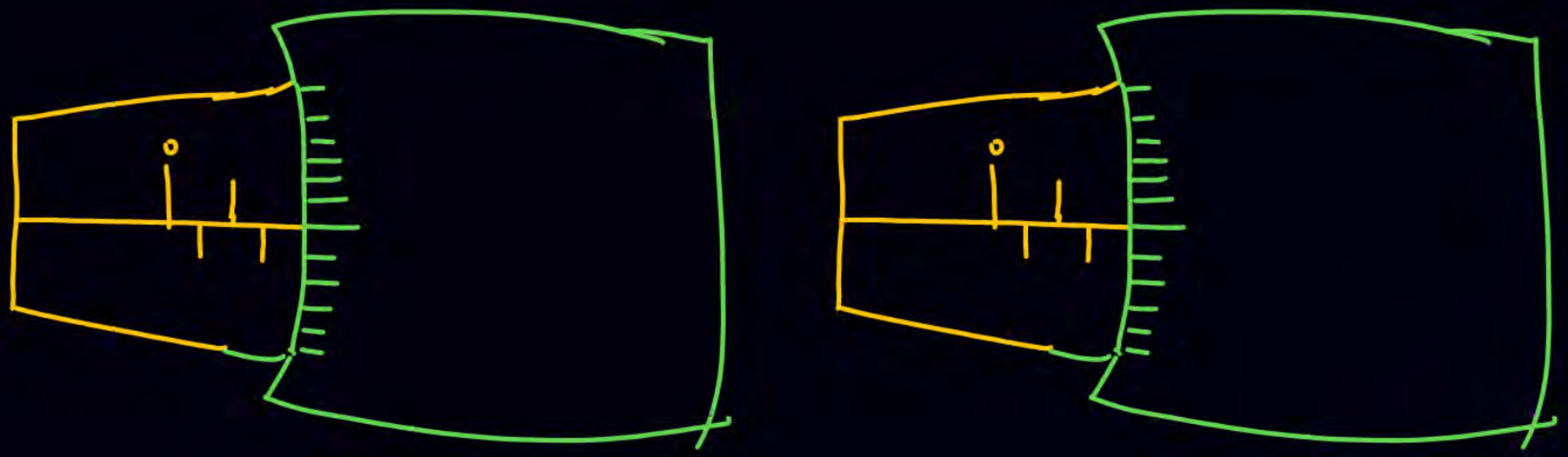


Positive zero error
(2 division error) i.e., + 0.002 cm

Constants of the Screw Gauge

(a) **Pitch :** The translational motion of the screw is directly proportional to the total rotation of the head. The pitch of the instrument is the distance between two consecutive threads of the screw which is equal to the distance moved by the screw due to one complete rotation of the cap. Thus for 10 rotation of cap = 5 mm, then pitch = 0.5 mm

(b) **Least count :** In this case also, the minimum (or least) measurement (or count) of length is equal to one division on the head scale which is equal to pitch divided by the total cap divisions. Thus is the aforesaid Illustration, if the total cap division is 100, then least count = 0.5 mm / 100 = 0.005 mm



(c) Measurement of length by screw gauge :

L = n × pitch + f × least count, where *n* = main scale reading & f = caps scale reading

Zero error : In a perfect instrument the zero of the head scale coincides with the line of graduation along the screw axis with no zero-error, otherwise the instruments is said to have zero-error which is equal to the cap reading with the gap closed. This error is positive when zero line or reference line of the cap lies below the line of graduation and versa. The corresponding will be just opposite.

284 505

50 → $\frac{1}{2} \times \frac{1}{50} \times 284 = 2.84$

The pitch of a screw gauge is 0.5 mm and there are 50 divisions on the circular scale. In measuring the thickness of a metal plate, there are five divisions on the pitch scale (or main scale) and thirty fourth division coincides with the reference line. Calculate the thickness of the metal plate.

Ans : 2.84 mm

pitch = $\frac{1}{2}$ mm

50 डुड्डे

$L.C. = \frac{\text{pitch}}{\text{No of div.}} = \frac{\frac{1}{2}\text{mm}}{50} = \frac{1}{100}\text{mm}$

Ans $5 \times \text{pitch} + 34 \times L.C$

$5 \times \frac{1}{2} + 34 \times \frac{1}{100}\text{mm} = 2.84\text{mm}$

The pitch of a screw gauge is 1 mm and there are 50 divisions on its cap. When nothing is put in between the studs, 44th division of the circular scale coincides with the reference line zero of the main scale is not visible. When a glass plate is placed between the studs, the main scale reads three divisions and the circular scale reads 26 divisions. Calculate the thickness of the plate.

Z.E = − 6 X L.C

LC = $\frac{1}{50}$ mm

Ans : $R_t = 3.64$ mm

3 X pitch + 26 X LC − (−6 X L.C)

= 3 X 1mm + 32 X $\frac{1}{50}$ = 3.64 mm

When the gap is closed without placing any object in the screw gauge whose least count is 0.005 mm, the 5th division on its circular scale coincides with the reference line on main scale, and when a small sphere is placed reading on main scale advances by 4 divisions, whereas circular scale reading advances by five times to the corresponding reading when no object was placed. There are 200 divisions on the circular scale. The radius of the sphere is

$= 4 \times \text{pitch} + 25 \times \text{L.C} - (+5\,\text{L.C})$

$= 4 \times (1\text{mm}) + 20 \times \frac{5}{1000}$

$= 4.1$ mm ≡ Daimeter

Ans : (D)

LC = .005mm = $\frac{\text{pitch}}{\text{No. div.}}$

Z.E = +5 L.C.

pitch = .005 × 200

= 1mm

(A) 4.10 mm

(B) 4.05 mm

(C) 2.10 mm

(D) 2.05 mm

The circular divisions of shown screw gauge are 50. It moves 0.5 mm on main scale in one rotation. The diameter of the ball is **[JEE 2006]**

Ans : (C)

A 2.25 mm

B 2.20 mm

C 1.20 mm

D 1.25 mm

Two full turns of the circular scale of gauge cover a distance of 1 mm on scale. The total number of divisions on circular scale is 50. Further, it is found that screw gauge has a zero error of –0.03 mm. While measuring the diameter of a thin wire a student notes the main scale reading of 3 mm and the number of circular scale division in line, with the main scale as 35. The diameter of the wire is **[AIEEE – 2008]**

1 चक्कर $= \frac{1}{2}$ mm = pitch

Ans : (D)

$LC = \frac{\frac{1}{2}\text{mm}}{50}$

A 3.32 mm

B 3.73 mm

$3\text{mm} + 35 \times LC - (-0.03)$

C 3.67 mm

D 3.38 mm

$3\text{mm} + \frac{35}{100}\text{mm} + 0.03\text{mm}$

A screw gauge gives the following reading when used to measure the diameter of a wire. Main scale reading : 0 mm. Circular scale reading : 52 divisions Given that 1 mm on main scale corresponds to 100 divisions of the circular scale. The diameter of wire from the above date is :

[AIEEE - 2011]

Ans : (D)

A 0.026 cm

B 0.005 cm

C 0.52 cm

D 0.052 cm

A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of Aluminium. Before starting the measurement , it is found that when the two jaws of the screw gauge are brought in contact, the 45th division coincides with the main scaleline and that the zero of the main scale is barely visible. What is the thickness of the sheet if the mainscale reading is 0.5 mm and the 25th division coincides with the main scale line? **[JEE – Main 2016]**

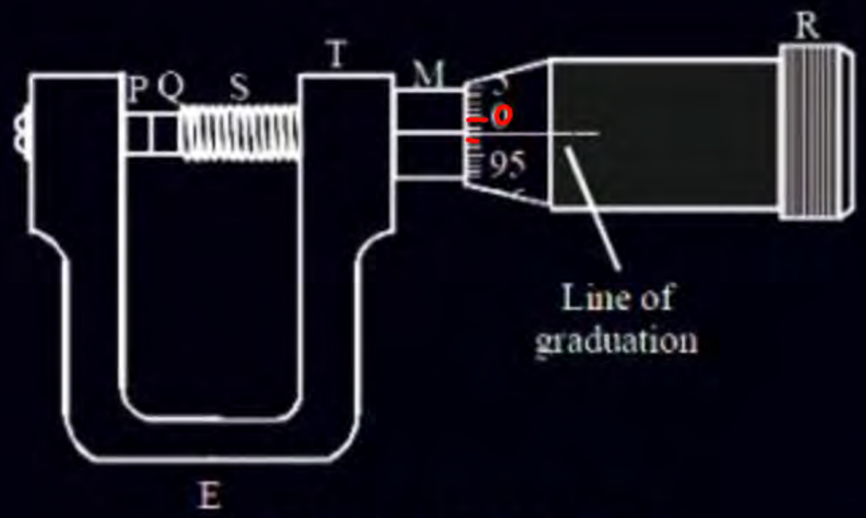
$LC = \frac{0.5\,mm}{50} = \frac{1}{100}\,mm = 0.01\,mm$

$ZE = -5 \times LC$

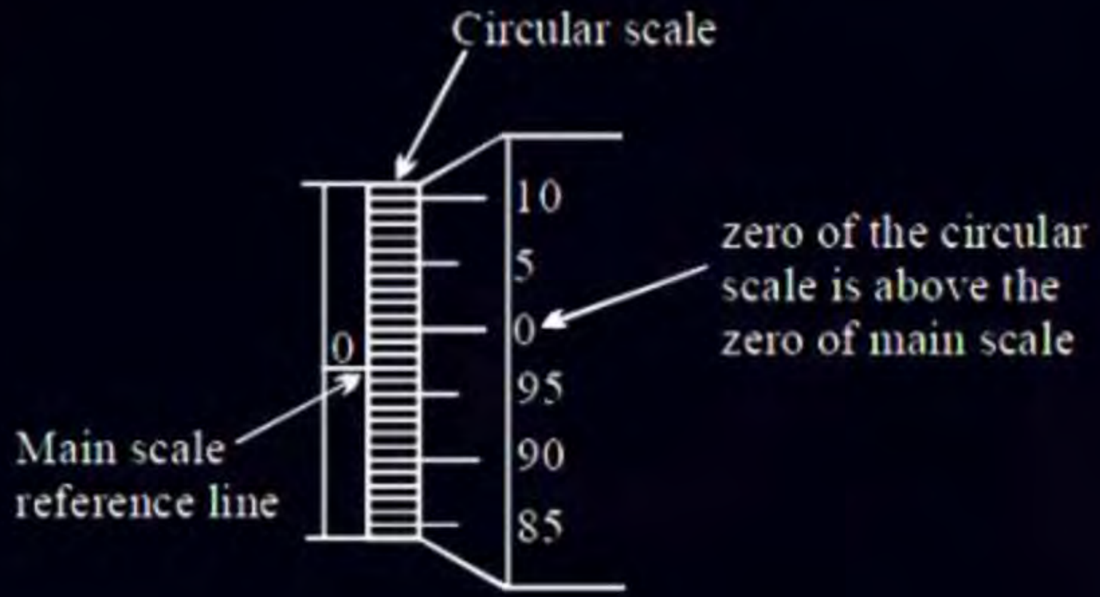
$0.5\,mm + 25 \times LC - (-5 \times LC)$

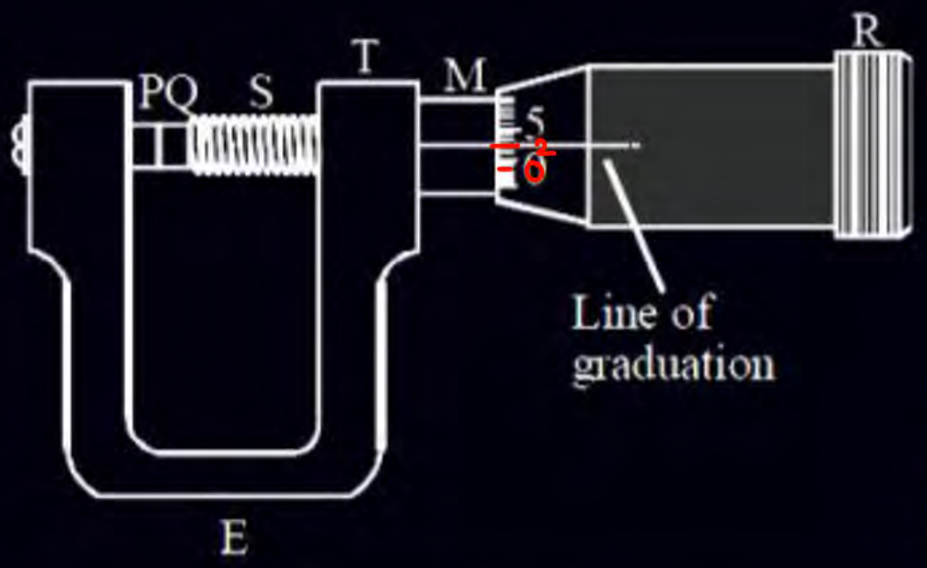
SCREW GAUGE (OR MICROMETER SCREW)

Zero error



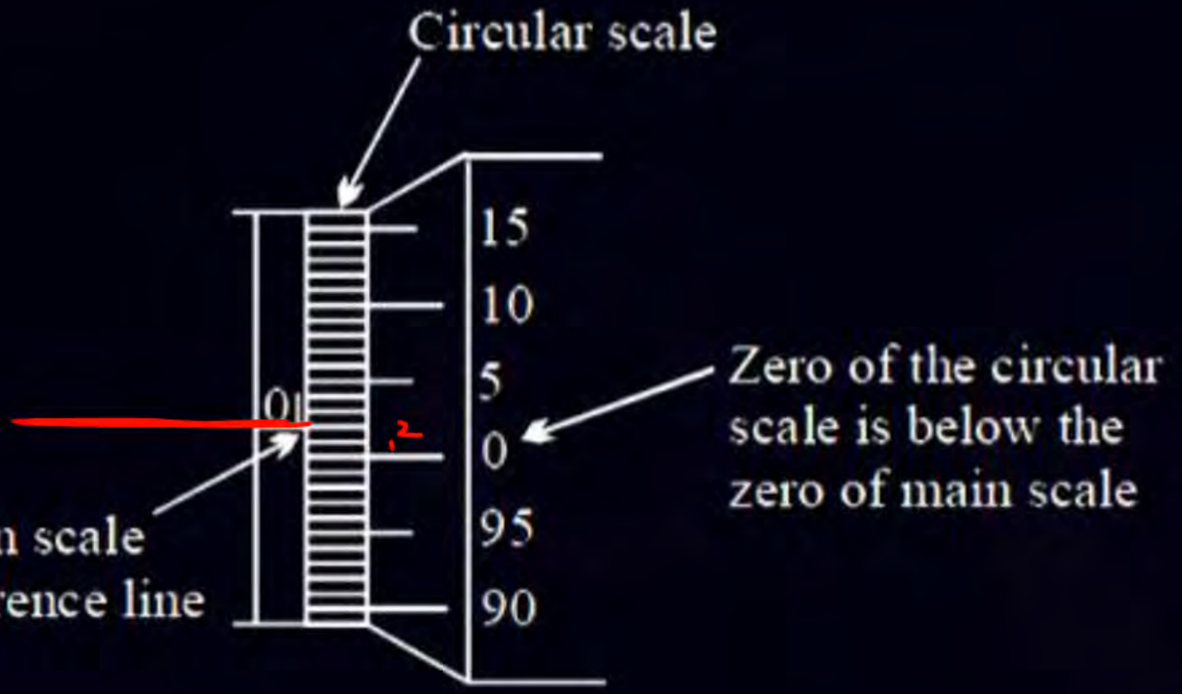
Negative zero error
(3 division error) i.e.. - 0.003 cm





Positive zero error

(2 division error) i.e., + 0.002 cm



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Thus for 10 rotation of cap = 5 mm, then pitch = 0.5 mm

(b) Least count : In this case also, the minimum (or least) measurement (or count) of length is equal to one division on the head scale which is equal to pitch divided by the total cap divisions. Thus in the aforesaid Illustration:,
if the total cap division is 100, then least count = 0.5mm/100 = 0.005 mm

$$\text{Least count of a screw gauge} = \frac{1\text{ mm} \rightarrow \text{pitch of screw}}{100 \rightarrow \text{number of divisions on circular scale}}$$


X1/100mm


X1/100mm

THANK YOU