

Exercise-1(B)

1. Explain the meaning of the term ‘least count of an instrument’ by taking a suitable example.

Solution:

The least count of an instrument is the smallest measurement which can be accurately taken from that particular instrument.

Example – if there are 10 divisions between 0 and 5s mark of a stop watch, the least count of that stop watch is 0.5s.

2. A boy makes a ruler with graduation in cm on it (i.e., 100 divisions in 1m). To what accuracy this ruler can measure? How can this accuracy be increased?

Solution:

Given: ruler has 100 divisions – centimeter scaling system

100 cm = 1m

Hence the accuracy the ruler can measure up to is the centimeter division.

∴ the ruler can be used to measure the length up to the accuracy of centimeter

In order to increase the accuracy, the scale must further be able to measure the next unit in-line, i.e., the millimeter division. By doing so the accuracy of the ruler can increase from centimeter to millimeter.

Hence,

1m=100cm = 10mm

1 m = 1000 mm

3. A boy measures the length of a pencil and expresses it to be 2.6cm. What is the accuracy of his measurement? Can he write it as 2.60cm?

Solution:

Given: The length of the pencil is 2.6cm.

We know that length can be expressed in different units such as metre, centimeter, millimeter etc.

Hence we can say that the measurement may be accurate but not precise enough.

The boy can write 2.6cm or can express it as 2.60cm, both are the same as the value of zero here is not significant.

4. Define least count of a vernier calipers. How do you determine it?

Solution:

The least count of a vernier caliper can be defined as the difference between the values of one main scale division and one vernier scale division. It is also referred to as vernier constant.

It can be determined using the formula:

$$\text{Least count (L.C.)} = \frac{\text{Value of one main scale division}}{\text{total number of divisions on vernier}}$$

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5. Define the term ‘Vernier constant’.

Solution:

Vernier constant can be defined as the difference between the values of one main scale division and one vernier scale division.

6. When is a vernier calipers said to be free from zero error?

Solution:

When the zero mark of the vernier scale coincides with the zero mark of the main scale, the tenth division of the vernier calipers coincides with the ninth division of the main scale. In this condition, the vernier is said to be free from zero error.

7. What is meant by zero error of a vernier calipers? How is it determined? Draw neat diagrams to explain it. How is it taken in account to get the correct measurement?

Solution:

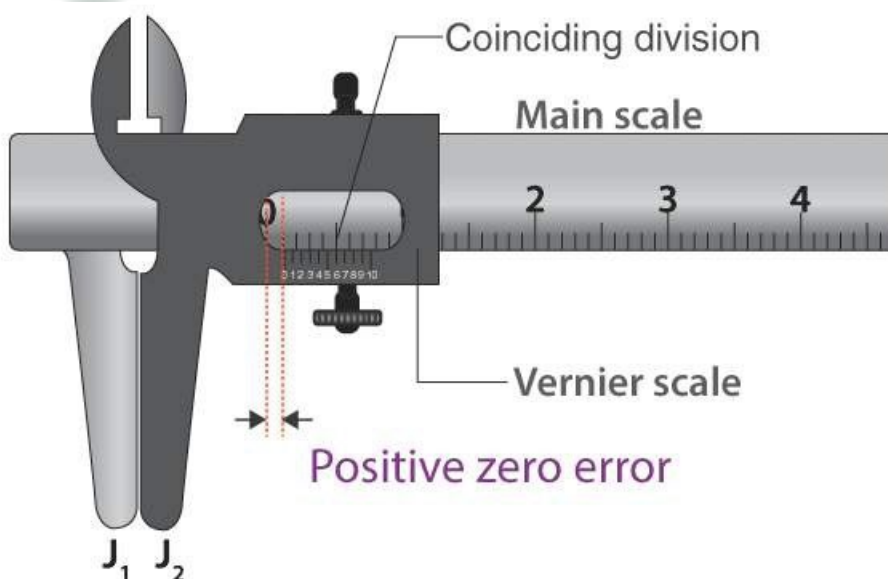
Sometimes due to mechanical errors, the zero mark of the vernier scale does not coincide with the zero mark on the main scale, in this condition, the vernier callipers is said to have a zero error.

Determination of zero error: Measure the length between the zero mark of the main scale and the zero mark of the vernier scale.

Zero errors are of two kinds, they are:

- Positive zero error
- Negative zero error

Positive zero error: if the zero mark of the vernier scale is on the right part of the zero mark of the main scale on bringing the two jaws together, it is a positive zero error.



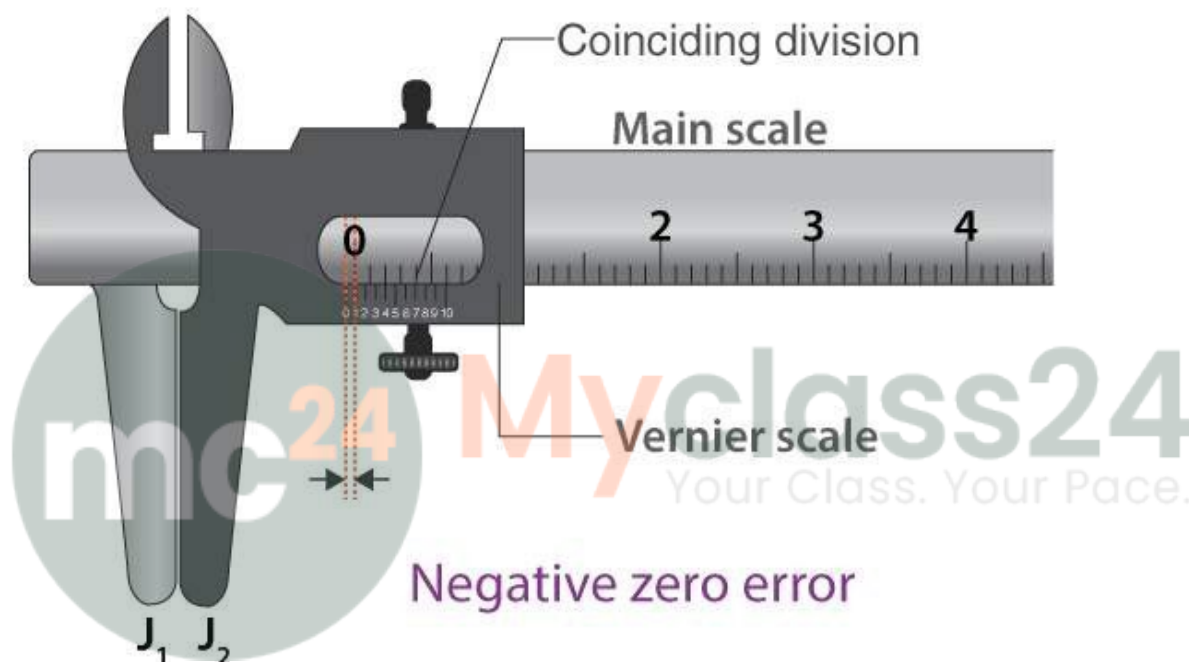
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To find positive zero error, division of the vernier scale should be noted that coincides with any division of the main scale. Zero error is obtained when this number of the vernier division is multiplied by the least count of the vernier callipers.

Here, in the example (scale), the L.C = 0.01cm. It is also observed that the 6th division of the vernier scale coincides with main scale division.

∴ zero error = 6 x L.C = 6 x 0.01cm = 0.06cm.

Negative zero error: if the zero mark of the vernier scale is on the left part of the zero mark of



the main scale upon bringing the two jaws together, it is a negative zero error.

To find negative zero error, the division of the vernier scale that coincides with any division of the main scale should be observed and noted. The number appearing at this vernier division is subtracted from the total number of divisions on the vernier scale and then the difference is multiplied by the least count.

The total number of division on the callipers is 10. Here, in the example (scale), the L.C = 0.01cm, the 6th division of the vernier scale coincides with a particular division of the main scale.

∴ zero error = - (10 - 6) x L.C = -4 x 0.01cm = -0.04cm

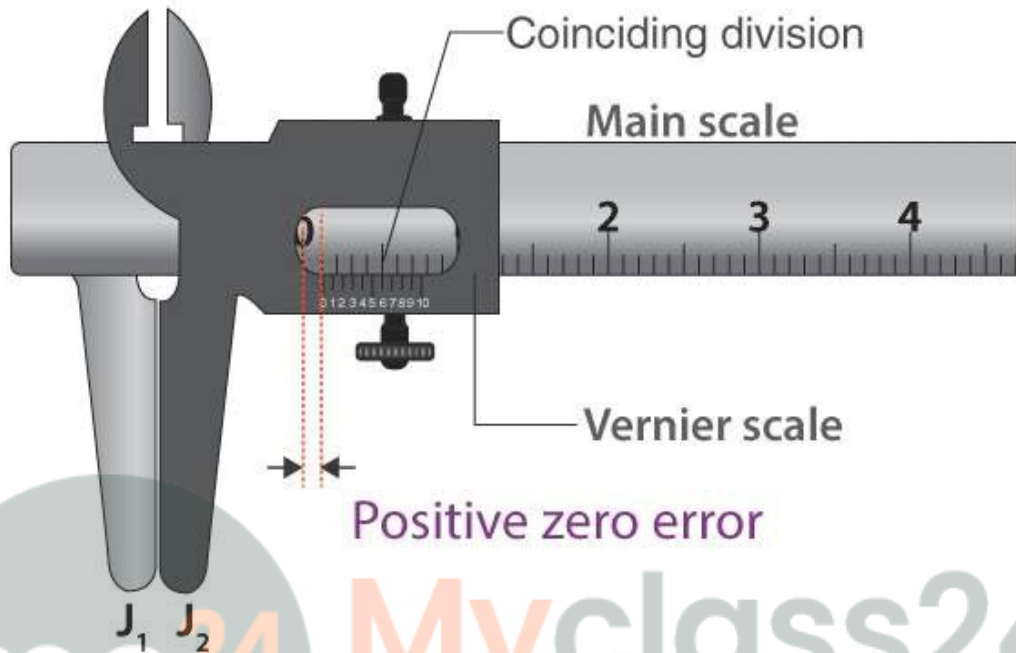
In order to correct the measurement of the vernier callipers with zero error, the zero error with proper sign is subtracted always from the observed reading.

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

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8. A vernier callipers has a zero error +0.06cm. Draw a neat labelled diagram to represent it.

Solution:



Given: L.C. = 0.01cm

As per the scale readings, main scale reading = 3.3mm

The 6th vernier division coincides with a main scale division

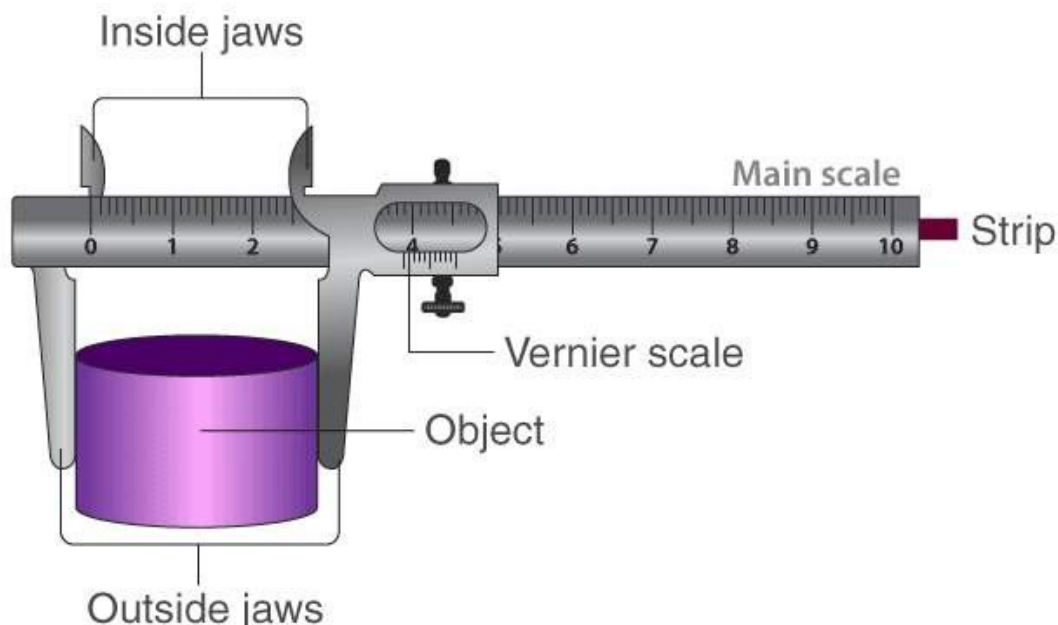
Vernier scale reading = $6 \times 0.01 \text{ cm} = 0.06\text{cm}$

Total reading = m.s.r + v.s.r = $3.3 + 0.06 = 3.36\text{cm}$

9. Draw a neat labelled diagram of a vernier callipers. Name its main parts and state their functions.

Solution:

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The various parts and their functions are:

Parts	Functions
Main scale	To measure length correct upto 1mm
Vernier scale	To measure length correct upto 0.1mm
Outside jaws	To measure length of rod, external diameter of a hollow cylinder, diameter of a sphere
Inside jaws	Measure the internal diameter of a pipe or hollow cylinder
Strip	Measure the depth of a bottle/beaker

10. State three uses of a vernier calipers.

Solution:

The three uses of vernier calipers are:

- It can be used to measure the length of an object
- It can be used to measure the diameter of a hollow cylinder
- It can be used to measure the depth of a beaker

11. Name the two scales of a vernier callipers and explain, how it is used to measure a length correct up to 0.01cm.

Solution:

Two scales of a vernier callipers are:

- Main scale - can read up till 1mm
- Vernier scale – length of 10 divisions is equal to length of 9 divisions on the main scale

The value of one division on the main scale is 1mm

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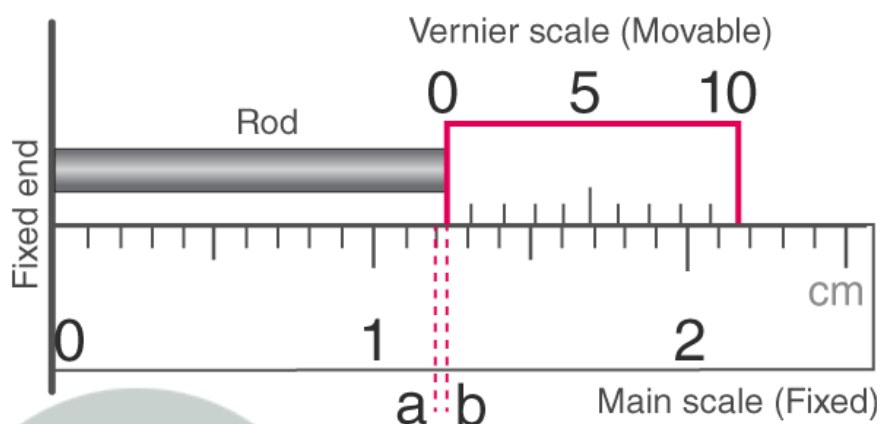
Total number of divisions on the vernier scale is 10

\therefore Least count = $1\text{mm}/10 = 0.1\text{mm} = 0.01\text{cm}$

Consequently, a vernier calipers can be used to measure a length accurately up to 0.01cm.

12. Describe in steps, how would you use a vernier calipers to measure the length of a small rod?

Solution:



Using vernier calipers to measure the length of a small rod:

- The rod is placed between the fixed end and the vernier scale as observed in the figure
- The zero mark of the vernier scale here is ahead of the 1.2cm mark on the main scale. Hence the actual rod length is the total of 1.2cm and the length between the 1.2cm marking on the main scale and 0 mark on the vernier scale (length 'ab' as seen in the figure)
- In order to know the length of 'ab', the pth division of the vernier scale is noted that coincides with ant division of the main scale.
- Length of p division on main scale = ab + length of p division on vernier scale
Length of p divisions on the main scale – length of p division on the verier scale = ab
= Length of 1 division of main scale – length of 1 division on vernier scale (p)
= p x Least Count
 \therefore Final reading = main scale reading + vernier scale reading
= 1.2cm + (p x L.C)
This gives the length of the small rod.

13. Name the part of the vernier calipers which is used to measure the following:

- External diameter of a tube**
- Internal diameter of a mug**
- Depth of a small bottle**
- Thickness of a pencil**

Solution:

- External diameter of a tube – outside jaws
- Internal diameter of a mug – Inside jaws
- Depth of a small bottle - Strip

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(d) Thickness of a pencil – Outer jaws

14. Explain the terms (i) pitch, and (ii) least count of a screw gauge. How are they determined?

Solution:

- (i) Pitch of a screw gauge – it is the distance moved by the screw through its axis along one complete rotation.
- (ii) Least count of a screw gauge – It is the distance moved by it in rotating the circular scale by one division.

Pitch & L.C of the screw gauge can be determined by:

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

For example, if a screw moved by 1mm through 1 rotation and if the circular scale has 100 divisions, then the pitch of the screw = 1mm.

The L.C = $1\text{mm}/100 = 0.01\text{mm} = 0.001\text{cm}$

15. How can the least count of a screw gauge be decreased?

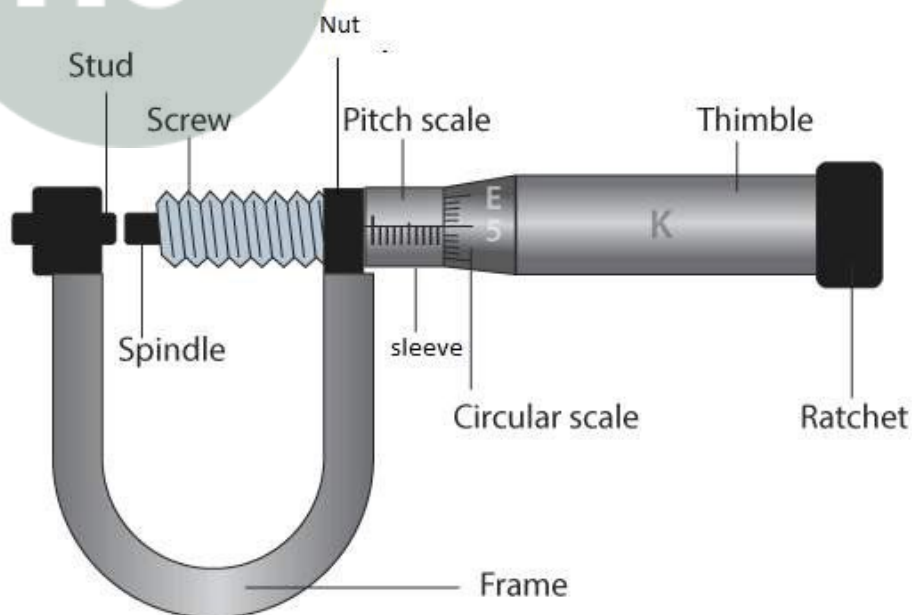
Solution:

The least count can be decreased by

- Increasing the total number of divisions on the circular scale
- Reducing the pitch

16. Draw a neat labelled diagram of a screw gauge. Name its main parts and state their functions.

Solution:



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The main parts and their functions are:

1. Ratchet – advances the screw by turning it till the object to be measured is held gently in between the spindle of the screw and the stud.
2. Sleeve – it notes the base line and the base line
3. Thimble – circular scale is marked by the thimble
4. Circular scale – reads length correctly to 0.01mm
5. Main scale – reads length to 1mm

17. State one use of a screw gauge.

Solution:

Use of screw gauge:

- It can be used to measure the diameter of a wire
- It can be used to measure thickness of a paper

18. State the purpose of ratchet in a screw gauge.

Solution:

The purpose of a ratchet in a screw gauge is that it is used to advance the screw by turning it till the object is gently held between the stud and the spindle of the screw.

19. What do you mean by zero error of a screw gauge? How is it accounted for?

Solution:

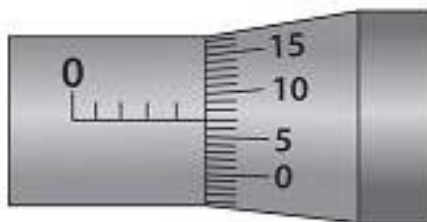
Several times, because of mechanical errors, the anvil and spindle end come in contact wherein the zero mark of the circular scale does not coincide with the main scale's base line, as it is either below or above the base line of the main scale. In this condition, the screw gauge is referred to have zero error which can be both negative and positive.

The zero error can be accounted by subtracting the zero error (with sign) from the reading observed to obtain the actual reading.

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

20. A screw gauge has a least count 0.001cm and zero error + 0.007cm. Draw a neat diagram to represent it.

Solution:



Positive zero error

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21. What is backlash error? Why is it caused? How is it avoided?

Solution:

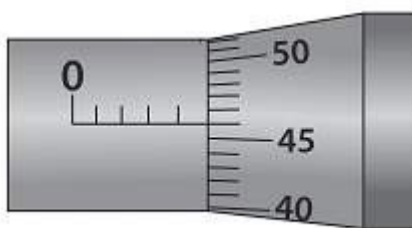
A backlash error is an error in the observation caused due to wear and tear of threads of the screw observed while reversing the direction of rotation of the thimble where the tip of the screw does not start moving in the opposite direction at once, but remains stationary for a part of rotation.

Avoid backlash error:

- While taking measurements, screw should be rotated in one direction only.

22. Describe the procedure to measure the diameter of a wire with the help of a screw gauge.

Solution:



Procedure to measure the diameter of a wire with the help of a screw gauge is as follows:

- Find the least count and the zero error of the screw gauge
- Turn the ratchet anticlockwise so as to obtain a gap between the stud A and the flat end B. Place the wire in the gap between the stud A and the flat end B. Then turn the ratchet clockwise so as to hold the given wire gently between the stud A and the flat end B of the screw.
- Make note of the main scale reading
- Make note of the division of p on the circular scale that coincides with the base line of the main scale. This circular scale division p when multiplied by the least count, gives the circular scale reading i.e., Circular scale reading = $p \times \text{L.C.}$
- Add the circular scale reading to the main scale reading to obtain the total reading (i.e., the observed diameter of the wire).
- Repeat it by keeping the wire in perpendicular direction. Take two more observations at different places of the wire and record them in the table below.

23. Name the instrument which can measure accurately the following:

- The diameter of a needle**
- The thickness of a paper**
- The internal diameter of the neck of a water bottle**
- The diameter of a pencil**

Solution:

- The diameter of a needle – screw gauge
- The thickness of a paper – screw gauge
- The internal diameter of the neck of a water bottle – vernier callipers
- The diameter of a pencil – screw gauge

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24. Which of the following measures a small length to a high accuracy: metre rule, vernier calipers, screw gauge?

Solution:

The screw gauge measures a small length to a high accuracy.

25. Name the instrument which has the least count:

- (a) 0.1mm
- (b) 1mm
- (c) 0.01mm

Solution:

- (a) 0.1mm – vernier callipers
- (b) 1mm – metre rule
- (c) 0.01mm – screw gauge

Multiple Choice Type

1. The least count of a vernier calipers is:

- (a) 1cm
- (b) 0.001cm
- (c) 0.1cm
- (d) 0.01cm

Solution:

- (c) 0.01cm

Least count is the smallest measurement that can be accurately taken with the instrument

2. A microscope has its main scale with 20 divisions in 1cm and vernier scale with 25 divisions, the length of which is equal to the length of 24 divisions of main scale. The least count of microscope is:

- (a) 0.002cm
- (b) 0.001cm
- (c) 0.02cm
- (d) 0.01cm

Solution:

- (a) 0.002cm

The least count of any instrument is the smallest measurement that can be taken accurately

3. The diameter of a thin wire can be measured by:

- (a) A vernier calipers
- (b) A metre rule
- (c) A screw gauge
- (d) None of these

Solution:

- (c) A screw gauge

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Numericals:

1. A stop watch has 10 divisions graduated between the 0 and 5s marks. What is its least count?

Solution:

Least count is the smallest value that can be measured by an instrument.

$$L.C = (5-0)/10 = 0.5s$$

2. A vernier has 10 divisions and they are equal to 9 divisions of main scale in length. If the main scale is calibrated in mm, what is its least count?

Solution:

Value of the main scale division = 1/10
Value of one main scale division

$$\therefore L.C = \frac{\text{Value of one main scale division}}{\text{total number of divisions on vernier}} = 1\text{mm}/10 = 0.1\text{mm} = 0.01\text{cm}$$

3. A microscope is provided with a main scale graduated with 20 divisions in 1cm and a vernier scale with 50 divisions on it of length same as of 49 divisions of main scale. Find the least count of the microscope.

Solution:

Given: 1 main scale division = 1/20cm

50 divisions of vernier scale = 49 divisions of main scale

1 division of vernier scale = $49 \div 50$ main scale divisions
= 0.98 main scale division

Vernier calipers:

$$\begin{aligned} L.C &= 1 \text{ main scale division} - 1 \text{ vernier scale division} \\ &= 1 \text{ main scale division} - 0.98 \text{ main scale division} \\ &= 0.02 \text{ main scale division} \end{aligned}$$

Microscope:

1 main scale division = 1/20cm

$$L.C = 0.02 \times 1/20 = 0.001\text{cm}$$

\therefore Least count of the microscope is 0.001cm

4. A boy uses a vernier calipers to measure the thickness of his pencil. He measures it to be 1.4mm. If the zero error of vernier calipers is +0.02cm, what is the correct thickness of pencil?

Solution:

Given: Thickness of the pencil = 1.4mm

Zero error = +0.02cm

Actual thickness = ?

$$\begin{aligned} \text{Correct reading} &= \text{observed reading} - \text{zero error} \\ &= 1.4\text{mm} - 0.02\text{cm} \\ &= 1.4\text{mm} - 0.2\text{mm} \end{aligned}$$

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$$= 1.2\text{mm}$$

5. A vernier calipers has its main scale graduated in mm and 10 divisions on its vernier scale are equal in length to 9mm. When the two jaws are in contact, the zero of vernier scale is ahead of zero of main scale and 3rd division of vernier scale coincides with a main scale division. Find: (i) the least count and (ii) the zero error of the vernier calipers.

Solution:

Main scale reading = 9mm

Vernier scale reading = 10

Coinciding division = 3

$$\therefore \text{L.C} = \frac{\text{Value of one main scale division}}{\text{total number of divisions on vernier}} = 1\text{mm}/10 = 0.1\text{mm}$$

Least count = 0.1mm = 0.01cm

Positive zero error = L.C x Coinciding division

$$= + (0.1\text{mm} \times 3)$$

$$= + 0.3\text{mm or } +0.03\text{cm}$$

6. The main scale of a vernier calipers is calibrated in mm and 19 divisions of main scale are equal in length to 20 divisions of vernier scale. In measuring the diameter of a cylinder by this instrument, the main scale reads 35 divisions and 4th division of vernier scale coincides with a main scale division. Find: (i) least count and (ii) radius of cylinder.

Solution:

- (i) To find the least count

Given:

20 divisions of vernier scale = 19 divisions of main scale

Least count of the vernier scale = $1/20$ mm = 0.05mm or 0.005cm

- (ii) To find the zero error of the vernier caliper

Vernier scale reading = $4 \times 0.005\text{cm} = 0.02\text{cm}$

Total reading = main scale reading + vernier scale reading

$$= 3.5\text{cm} + 0.02\text{cm}$$

$$= 3.52\text{cm}$$

Diameter = 3.52cm

Radius = $\frac{1}{2} \times \text{diameter} = \frac{1}{2} \times 3.52\text{cm} = 1.76\text{cm or } 17.6\text{mm}$

7. In a vernier calipers, there are 10 divisions on the vernier scale and 1cm on the main scale is divided in 10 parts. While measuring a length, the zero of the vernier lies just ahead of 1.8cm mark and 4th division of vernier coincides with a main scale division.

(a) Find the length

(b) If zero of vernier calipers is -0.02cm, what is the correct length?

Solution:

(a) L.C = 0.01cm

Main scale reading of vernier calipers = 1.8cm

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Coinciding division = 4th

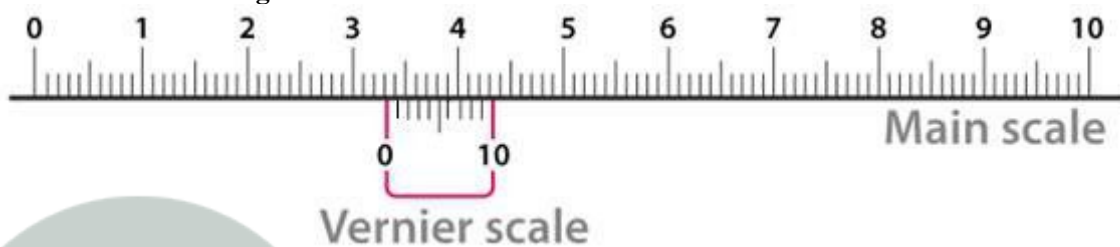
Vernier scale reading = vernier scale division \times L.C
 $= 4 \times 0.01 = 0.04\text{cm}$

Total reading = main scale reading + vernier scale reading
 $= 1.8\text{cm} + 0.04\text{cm} = 1.84\text{cm}$

(b) If zero error is -0.02cm , the correct length is

Correct reading = observed reading $-$ zero error
 $= 1.84\text{cm} - (-0.02\text{cm})$
 $= 1.86\text{cm}$

8. While measuring the length of a rod with a vernier calipers, Figure below shows the position of its scales. What is the length of the rod?



Solution:

The least count of vernier calipers = 0.01cm

Main scale reading = 3.3cm

6th division of vernier scale coincides with a division on main scale i.e., $p=6$

\therefore vernier scale reading = $6 \times 0.01 = 0.06\text{cm}$

Observed reading = main scale reading + vernier scale reading
 $= 3.3\text{cm} + 0.06\text{cm}$
 $= 3.36\text{cm}$

If the vernier calipers is free from zero error, then the true length of the rod is 3.36cm

9. The pitch of a screw gauge is 0.5mm and the head scale is divided in 100 parts. What is the least count of screw gauge?

Solution:

Given : Pitch = 0.5mm

Number of divisions on circular head = 100

Least count = $\frac{\text{Pitch}}{\text{total number of divisions on circular head}} = \frac{0.5\text{mm}}{100}$
 $= 0.005\text{mm}$ or 0.0005cm

10. The thimble of a screw gauge has 50 divisions. The spindle advances 1mm when the screw is turned through two revolutions.

(i) What is the pitch of screw gauge?

(ii) What is the least count of the screw gauge?

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Solution:

Given: Number of circular divisions = 50

Distance covered in two rotations = 1mm

(i) Pitch = $\frac{1}{2}$ x distance covered in two rotations
 $= \frac{1}{2} \times 1\text{mm} = 0.5\text{mm}$

(ii) Least count = $\frac{\text{Pitch}}{\text{total number of divisions on circular head}} = \frac{0.5\text{mm}}{50} = 0.01\text{mm}$

11. The pitch of a screw gauge is 1mm and its circular scale has 100 divisions. In measurement of the diameter of a wire, the main scale reads 2mm and 45th mark on circular scale coincides with the base line. Find:

(i) The least count, and

(ii) The diameter of the wire

Solution:

(i) Least count = $\frac{\text{Pitch}}{\text{total number of divisions on circular head}}$
 $= \frac{1\text{mm}}{100}$
 $= 0.01\text{ mm or } 0.001\text{cm}$

(ii) Diameter of the wire = main scale reading + circular scale reading
 $= 2\text{mm} + (45 \times 0.01\text{mm})$
 $= 2 + 0.45$
 $= 2.45\text{mm or } 0.245\text{cm}$

12. When a screw gauge of least count 0.01mm is used to measure the diameter of a wire, the reading on the sleeve is found to be 1mm and the reading on the thimble is found to be 27 divisions. (i) what is the diameter of the wire in cm? (ii) if the zero error is +0.005cm, what is the correct diameter?

Solution:

Reading on the sleeve = 1mm

Reading on the thimble = 27 x least count = 27 x 0.01mm = 0.27mm

Total reading = reading on the sleeve + reading on the thimble
 $= 1\text{mm} + 0.27\text{mm} = 1.27\text{mm or } 0.127\text{cm}$

Zero error = + 0.005mm

Correct reading = observed reading – zero error
 $= 1.27\text{mm} - 0.005\text{mm} = 1.265\text{mm}$

13. A screw gauge has 50 divisions on its circular scale and its screw moves by 1mm on turning it by two rotations. When the flat end of the screw is in contact with the stud, the zero of circular scale lies below the base line and 4th division of circular scale is in line with the base line. Find: (i) the pitch, (ii) the least count and (iii) the zero error, of the screw gauge.

Solution:

Given : 50 divisions on circular scale

(i) One complete rotation, or the distance travelled by the screw is the pitch
1mm movement has 2 rotations.

\therefore pitch = distance / rotation = $\frac{1}{2} = 0.5\text{mm}$

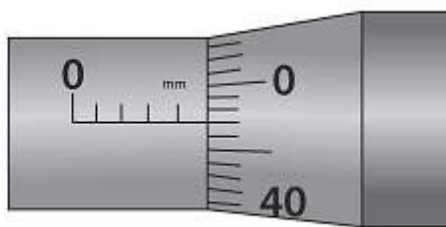
(ii) Least count = $\frac{\text{Pitch}}{\text{total number of divisions on circular head}} = \frac{0.5}{50} = 0.01\text{mm}$

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(iii) Zero error = coinciding division \times least count
 $= +4 \times 0.01\text{mm} = + 0.04\text{mm}$

14. Figure below shows the reading obtained while measuring the diameter of a wire with a screw gauge. The screw advances by 1 division on main scale when circular head is rotated once.

- Find: (i) pitch of the screw gauge,
(ii) Least count of the screw gauge, and
(iii) The diameter of the wire.



Solution:

(i) Pitch = distance covered in one revolution = 1mm

(ii) Least count = $\frac{\text{Pitch}}{\text{total number of divisions on circular head}} = \frac{1\text{mm}}{50} = 0.02\text{mm}$

(iii) Diameter of the wire = main scale reading + circular scale reading
 $= 4.94\text{mm}$

15. A screw has a pitch equal to 0.5mm. What should be the number of division on its head so as to read correct up to 0.001mm with its help?

Solution:

Given: Pitch = 0.5mm

Number of divisions = $0.5\text{mm}/0.001\text{mm} = 500$