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NAME: Rajasree Laha

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•Slide callipers•

Slide callipers and its use:

• **Construction:** Slide callipers consists of a steel plate at one edge of which a centimetre scale (cm) is marked white at its other edge an inch scale is marked. At right angles to the steel plate there are two jaws, one of which is fixed at one end of the plate while the other jaw is provided with a vernier scale and can slide over the main scale on the plate. When the two jaws touch each other the gap between them becomes zero and the zero-line of the vernier usually coincides with that of the scale. If it does not happen so, then there is a zero error in the instrument and this should be determined for correct result. Sometimes a narrow thin steel strip is attached parallel to the plate, which can move with the movable jaw. This is useful for depth measurement.

• **measurement:** At first the vernier constant is to be determined.

The movable jaw is drawn outward to create a gap between the two jaws. If we are to measure the length of a small rod or diameter of a bob, it should be put between the jaws. If we are to measure the internal diameter of a hollow cylinder the jaws are to be put into the hollow of the cylinder. The position of the sliding jaw is then adjusted till the jaw B touches one end of the object or the jaw touches the inner surface of the hollow cylinder. Now let the value of integral number of main scale divisions, remaining just on the left side of zero-line of vernier be S cm. If a certain number of divisions of the vernier scale (say v.r.) are seen to coincide with the main scale then the value of the fraction of one scale division, just on the left of the zero line of vernier, would be $v = (v.r.) \times (v.c.)$ cm. Hence the total length of the gap between the two jaws is,

$$l = S + (v.r.) \times (v.c.) = S + v \text{ cm}$$

• **Zero error:** To find the zero error of the instrument, the two jaws are put in contact with each other. If zero-~~error~~ lines of the main and vernier scales coincide then zero-error does not exist. But if zero-lines of main and vernier scales do not coincide then zero-error exists. suppose the zero line of vernier is on the right of the zero-line of the main scale. If y divisions of vernier (counted from the left end of the vernier scale) are now found to coincide with a certain mark of the main scale, then zero error $e = +y \times v.c.$ Here the error is taken to be positive and it is to be substracted from the measured length.

On the other hand if the zero-line of the vernier is on the left of the zero-line of the main scale then error is taken to be negative and it is to be added to the mesured length. Here if y divisions of vernier (counted from the right end of the vernier scale)

are found to coincide with a certain mark of the main scale, then zero-error $e = -y \times v.c.$ thus,
corrected length = measured length $- e$.

- **Experimental data:**

(A) calculation of vernier constant:

value of 1 smallest main scale division = 0.1 cm
10 divisions of the vernier scale = 9 divisions of main scale

$$\therefore 1 \, v.d = \frac{9}{10} \, s.d$$

$$\therefore v.c = 1 \, s.d - 1 \, v.d.$$

$$= \left(1 - \frac{9}{10}\right) s.d$$

$$= \left(1 - \frac{9}{10}\right) s.d$$

$$= \frac{1}{10} \times 0.1 \, cm \quad [\because 1 \, s.d = 0.1 \, cm]$$

$$= 0.01 \, cm$$

(B) Zero error – There is no zero-error.

(C) Data for length or diameter:

No. of observation	main Scale (S) reading (cm)	vernier (v.r) reading (cm)	Total Reading = $(S + v.r \times v.c)$ cm	Average (cm)
1	1.4	7	$1.4 + 7 \times 0.01 = 1.47$	$\frac{1.47 + 1.49 + 1.47}{3} = 1.47$
2.	1.4	9	$1.4 + 9 \times 0.01 = 1.49$	
3.	1.4	7	$1.4 + 7 \times 0.01 = 1.47$	

09.12.21

- Spherometer:~

Spherometer and its use:

- Description: Spherometer is an instrument specially designed for the measurement of the radius of curvature of a spherical surface. It is also used to find the thickness of very thin plates. It consists of an accurately cut screw at the head of which a circular disc, having uniform graduations at its rim, is fixed. This screw can move within a nut situated at the centre of a three-legged frame. The ends of the three legs are on the vetrices of an equilateral triangle. The disc can be rotated by turning the milled head and the linear shift of the screw can be obtained from a linear scale, kept by the side of the disc.

• Theory of measuring the radius of curvature of a spherical surface:

If the screw moves linearly by P mm during one complete rotation of the circular disc at its head (the rim of the circular disc is divided into N equal parts) then the pitch and least count of the instrument are respectively given by,
pitch = P mm and least count = l.C = P/N mm

Let the screw touch consecutively the spherical surface and a base plate (which is always in the plane). If for this purpose, the circular disc at the head of the screw is given m complete rotations of the screw is given m complete rotations and also an extra n divisions of the circular scale then the linear shift of the screw would be,

$h' = (mN + n) \times (l.C)$ mm; or, $h = (h'/10)$ cm

If the mean distance between any two consecutive outer legs of the spherometer be d cm then the radius of curvature of the given surface is given by,

$r = d^2/6h + h/2$ cm

- Experimental data:

(A) Determination of least count (L.C):

value of each division of the linear scale $= s = 1$ mm

No. of divisions on the circular disc $= N = 100$

Pitch of the screw $= P = 1$ mm

Least count of the instrument $= L.C = P/N = 0.01$ mm

Distance between the outer legs $= d = (4.2 + 4.2 + 4.2)/3$

$= 4.2$ cm

(B) Determination of h:

observation no.	M.S.R A (mm)	C.S.R	C.S.R×n×L.C =B (mm)	Total h = A+B (mm)
1.	2	20	20×0.01 = 0.20	2 + 2.20 = 2.2

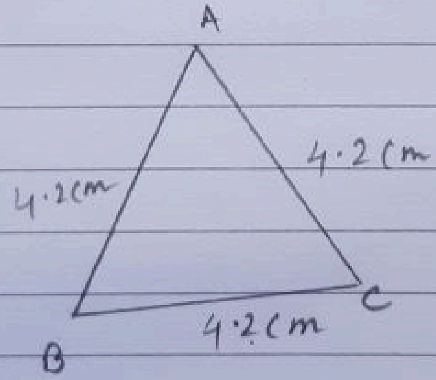
2.	2	39	$39 \times 0.01 = 0.39$	$2 + 0.39 = 2.39$
3.	2	22	$22 \times 0.01 = 0.22$	$2 + 0.22 = 2.22$
4.	2	31	$31 \times 0.01 = 0.31$	$2 + 0.31 = 2.31$

16.12.21

$$\text{Mean } h = \frac{2.2 + 2.39 + 2.22 + 2.31}{4}$$

$h = 2.28$ mm

$h = 0.228$ cm



(c) determination of d:-

$$\text{mean } d = \frac{4.2 + 4.2 + 4.2}{3}$$

$\Rightarrow d = 4.2$ cm

- Calculation

$$R = \frac{d^2}{6h} + \frac{h}{2}$$

$$= \frac{(4\cdot2)^2}{6\times0\cdot228} + \frac{0\cdot228}{2}$$

$$= 12\cdot89 + 0\cdot114$$

$$= 13\cdot004\,cm$$

$\therefore R = 13\cdot004\,cm$

• Screw gauge :~

• Screw gauge and its use •

• **Construction:~** It consists of a U-shapped piece of a solid steel one arm of which carries a fixed stud while the other arm carries hollow cylinder within which an accurate screw having plane face at its end, can move. on the upper surface of the cylinder there is a horizontal reference line at right angles to which a linear scale, graduated in mm is marked. The screw head is fitted with a cylindrical cap and a milled head. The bevelled edge of the cap is provided with a uniform circular scale. when the screw is moved inward to touch its plane face with the fixed plane face the zero-line of the circular scale coincides with the reference line while the circular edge of the cap conincides with the zero-line of the linear scale. If it does not happen so then there is instrumental error (zero-error) and this should be determined for correct result.

• Theory of measurement •

If the screw moves linearly by p mm, when the cylindrical cap of the screw, having N equal divisions at its edge, is revolved to perform one complete rotation then Pitch (= p) and least count (= L.C) of the instrument and respectively given by,

pitch = p mm and least count = L.C = p/N mm

For a given gap between the fixed face A and movable face, let the value of integral numbers of divisions of the linear scale, remaining on the left side of the bevelled edge of the cap, be m mm. Again if the reading of the circular scale, corresponding to the reference line be then the value of those divisions of the circular scale would be $c = (C.S.R) \times (L.C \text{ in mm})$ mm

$d = L.S.R + C.S.R \times L.C.$

$= (m + c)$ mm

d = the diameter of a wire

- Zero error – To find the zero-error of the instrument, the screw is rotated by its milled head till the plane faces touch each other. If now the zero-~~error~~ line of the circular scale coincides with the reference line then no zero-error will exist. But a zero-error of magnitude e will exist, if the reference line coincides with a line on the circular scale, which is y divisions away from the zero-line of the circular scale. The error e will be taken positive or negative according as those y divisions of the circular scale (measured with respect to reference line) are remaining on the positive side of the circular scale (i.e, towards the side of 10 of the circular scale) or on the negative side of the circular scale (i.e., towards the side of 90 of the circular scale). Thus the zero-error of the instrument is,

$e = \pm y \times (\text{l.c. in mm}) = \pm \quad \text{mm}$

Now the corrected length (diameter) will be given by,

measured length – ($\pm$ zero-error) = $d - e$.

- **Experimental data :~**

(A) Calculation of least count:

Smallest division of the linear scale = S = 1 mm
Pitch of the screw = P = 1 mm
Numbers of divisions on the circular scale = N = 100.
Least count of instrument = L.C. = P/N = 0.001 mm

(B) Instrumental error:

There is no error in instrument.

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(C) Data for diameter:

Sl.No.	main scale(A)	circular scale(B)	Total Reading (A+B×L.C)	Average
1	0.5	39	0.5+39×0.001 =0.539	
2	0.5	43	0.5+43×0.001 =0.543	0.543
3	0.5	46	0.5+46×0.001 =0.546	

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