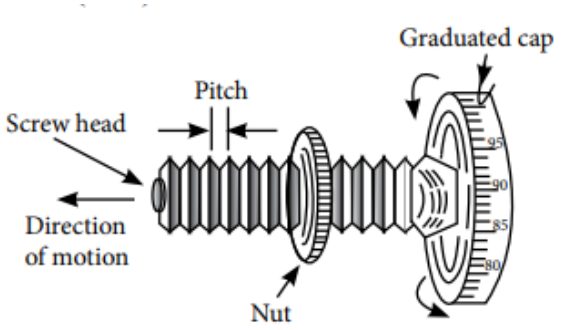
Experiment - 2 : Screw Guage : Its use to determine thickness/diameter of thin sheet/wire.

Principle

The thread on a screw is helically cut. As you rotate it clockwise or anticlockwise, it advances linearly in opposite directions.

The linear distance moved by a screw during one complete rotation of the screw is called its pitch. It is equal to the distance between the two successive threads of the screw along its axis. In a standard screw guage, the pitch is 1 mm, and the screw cap is graduated into 100 units. Thus, when the screw is turned by one unit, it

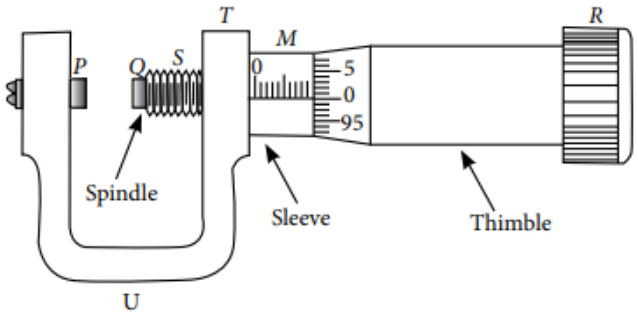
$$\text{advances by } \left(\frac{1}{100}\right) \text{ mm.}$$



This is the least count of the screw guage

$$\text{Least count of screw guage} = \frac{\text{Pitch}}{\text{Total number of divisions on circular scale}}$$

Construction



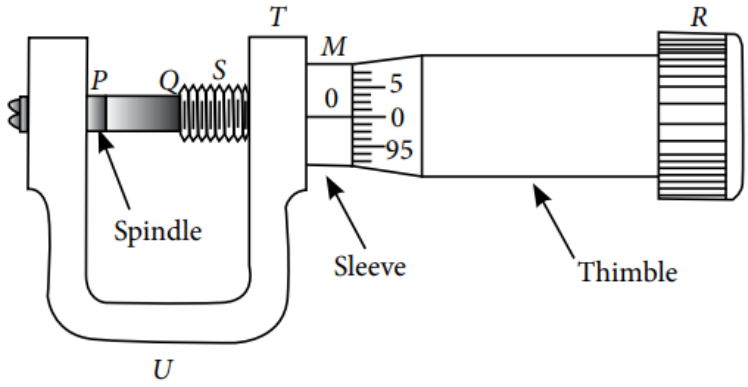
It consists of a U-shaped frame of gun metal. At one end of U, a small metal piece P having a plane face is attached to it. This is the stud. To the other end of U is the fixed tubular hub T as shown. The inner side of T is threaded and has a screw of gun metal having its front face Q as plane. Q is called the spindle. Gun metal has the property of having very less wear and tear. The tubular hub extends a few

centimeters beyond the U-frame. This is the sleeve. The sleeve is graduated in cm and mm. This is called the pitch scale or the main scale. It has a base line which lies along the axis of the hub. This is called line of graduation.

A hollow cylindrical cap known as the 'thimble' is attached to the right-hand end of the screw S. This cap can freely rotate about the hub. Rotating the cap, makes the spindle Q move in or out. The circular cap is divided into 100 or 50 equal parts. It is called the circular scale or the head scale. A ratchet R fixed to the right-hand end of the cap, avoids undue tightening of the screw. The object to be measured is gripped between P and Q by rotating the ratchet suitably. Once the object is gripped between P and Q, the ratchet R freely rotates making a cranking sound, but the screw does not rotate any more. This prevents the object from undergoing any change in its dimension.

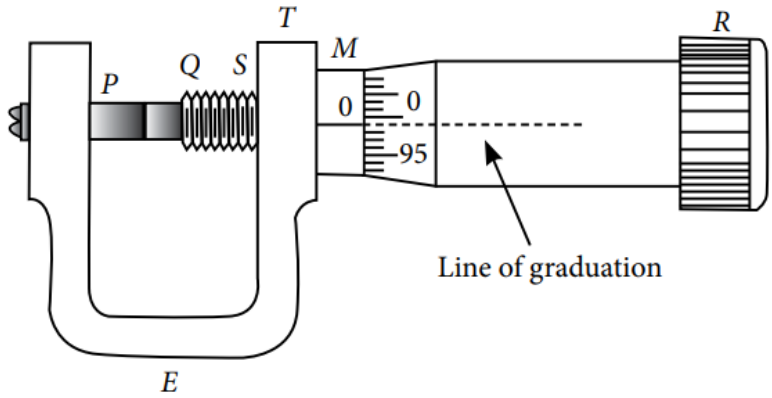
Zero Error

In a screw guage with no zero error, when P and Q touch each other, the zero of the main scale will lie along the line of graduation and the edge of the head scale lies exactly in front of the zero of the pitch scale, as shown in the figure below.



Negative zero error

Herein, the zero of the circular scale lies above the line of graduation, when the gap between P and Q is zero. In this case, the edge of the circular scale lies to the left-hand side of the zero of the main scale.



In the above figure, the edge of the circular scale lies to the left of the 0 on the main scale, when P and Q touch. So, this is a case of negative zero error. Further we can see that 97 on the circular scale coincides with the line of graduation. So, the zero error is

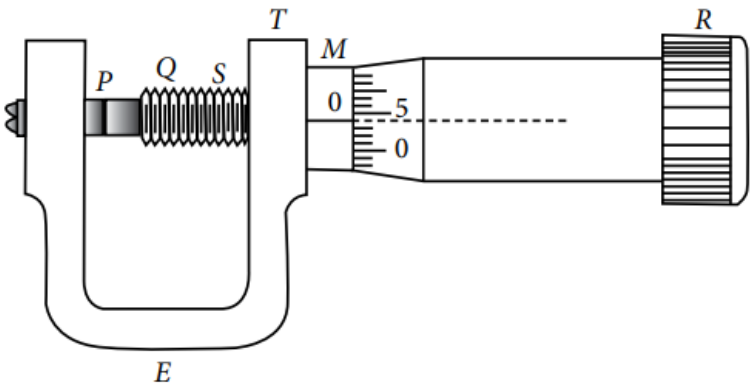
$(97 - 100) \times \text{L.C.} = (-3) \times (0.01 \text{ mm}) = -0.03 \text{ mm}.$

If the zero error is negative and the n^{th} division of the circular scale coincides with the line of graduation then,

$$Z = (n - 100) \times L.C$$

Positive zero error

Herein, the zero of the circular scale lies below the line of graduation, when the gap between P and Q is zero. In this case, the edge of the circular scale lies to the right-hand side of the zero of the main scale.



In the above figure, the edge of the circular scale lies to the right of the 0 on the main scale, when P and Q touch. So, this is a case of positive zero error. Further, we can see that 4 on the circular scale coincides with the line of graduation. So, the zero error is $(4) \times \text{L.C.} = 4 \times 0.01 \text{ mm} = +0.04 \text{ mm}$.

If the zero error is positive and the nth division of the circular scale division coincides with the line of graduation, then

$$Z = n \times L.C.$$

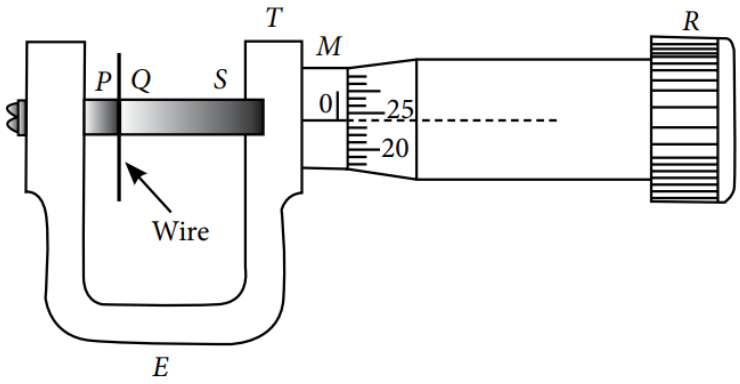
$$\text{Corrected reading} = \text{Observed reading} - \text{Zero error}$$

Back - Lash Error

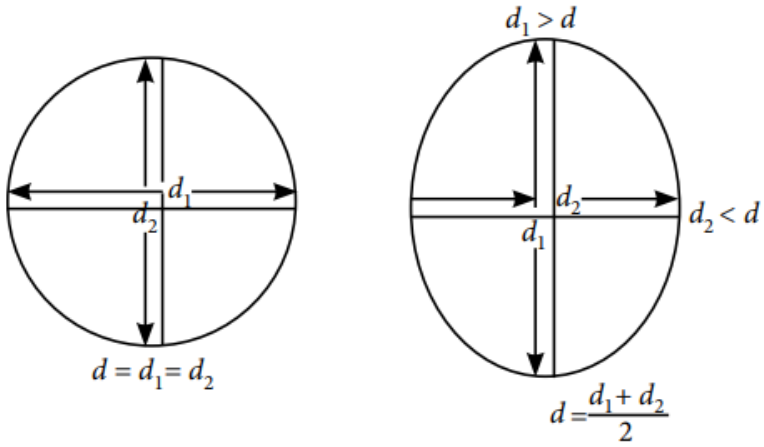
Due to wear and tear, the screw becomes loose in the nut and may not move forward when turned in the nut. In such an instrument, if the screw is adjusted by turning it in one direction and then in the opposite direction, the linear motion of the screw would not be proportional to the circular motion. This implies that for

no change in the gap length between the stud and the screw, the circular scale reading undergoes some appreciable change resulting in the back-lash error. This error cannot be calculated unlike the zero error, but can be minimized. In order to minimize, the screw must be rotated only in the same direction while making any adjustment.

Measuring the diameter of a thin wire



The wire is held as shown. Often reading is taken in two perpendicular directions for the wire, as the diameters may not be same. In case when the wire is not perfectly circular, the diameters differ along mutually perpendicular directions, we take the average of the diameters as shown below.

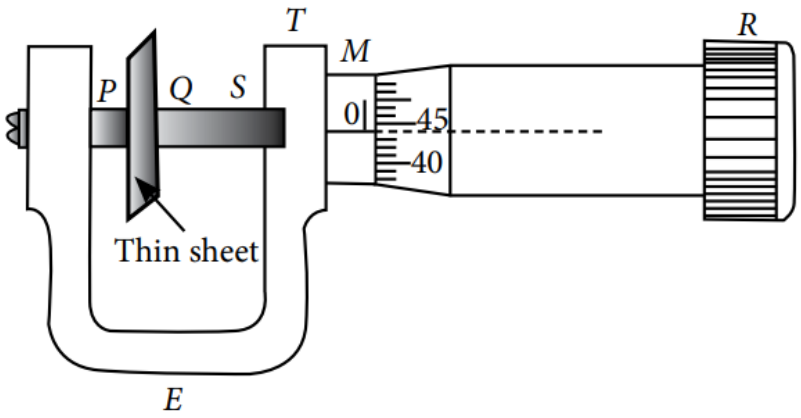


In order to take the reading, grip the wire between the stud P and spindle Q by rotating the ratchet R. Note the reading on the main scale or note the last division beyond which the edge of the circular scale lies. Also check which of the circular scale division is in line with the line of graduation. Multiply the number corresponding to this division with the line of graduation by the least count. This gives the circular scale reading. The observed reading is the sum of the main scale reading and the circular scale reading. The corrected reading is the sum of the observed reading and zero-correction. Of course, the zero correction is the negative of the zero error.

Corrected reading = Observed reading + Zero correction

Measuring the Thickness of a Sheet

The thickness of the sheet is measured at several places along the plane of the sheet as shown and an average is taken.



MCQs Corner

Experiment – 2

7. The least count of the main scale of a screw gauge is 1 mm. The minimum number of divisions on its circular scale required to measure 5 mm diameter of a wire is

(a) 50 (b) 100 (c) 200 (d) 500

8. In a screw gauge, 5 complete rotations of the screw cause it to move a linear distance of 0.25 cm. There are 100 circular scale divisions. The thickness of a wire measured by this screw gauge gives a reading of 4 main scale divisions and 30 circular scale divisions. Assuming negligible zero error, the thickness of the wire is

(a) 0.3150 cm (b) 0.2150 cm (c) 0.4300 cm (d) 0.0430 cm

9. 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 45^{th} division coincides with the main scale line and that the zero of the main scale is barely visible. What is the thickness of the sheet if the main scale reading is 0.5 mm and the 25^{th} division coincides with the main scale line ?

(a) 0.75 mm (b) 0.80 mm (c) 0.70 mm (d) 0.50 mm

10. 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.

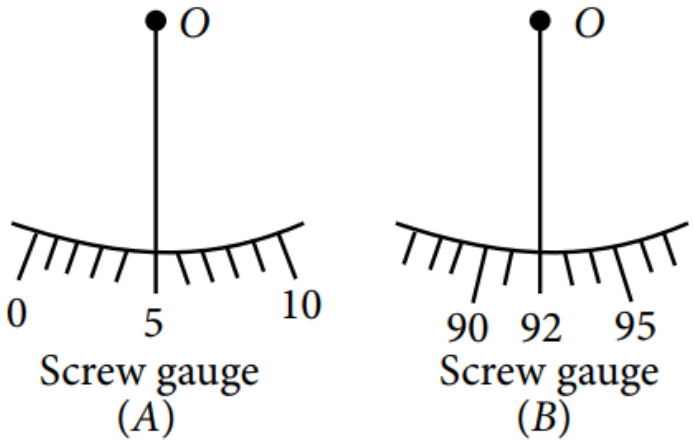
The diameter of wire from the above data is :

(a) 0.52 cm (b) 0.052 cm (c) 0.026 cm (d) 0.005 cm

11. Two full turns of the circular scale of a screw gauge cover a distance of 1 mm on its main scale. The total number of divisions on the circular scale is 50. Further, it is found that the 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 divisions in line with the main scale as 35. The diameter of the wire is

(a) 3.38 mm (b) 3.32 mm (c) 3.73 mm (d) 3.67 mm.

12. Student A and Student B used two screw gauges of equal pitch and 100 equal circular divisions to measure the radius of a given wire. The actual value of the radius of the wire is 0.322 cm. The absolute value of the difference between the final circular scale readings observed by the students, A and B will be [Figure shows position of reference 'O' when jaws of screw gauge are closed] Given pitch = 0.1 cm.



(a) 11 (b) 12 (c) 13 (d) 14

Answer Key

7. (c) 8. (b) 9. (b) 10. (b) 11. (a) 12. (c)

Hints & Explanation

7. **(c) :** Least count = 1 mm

N_d (Number of divisions) = $\frac{\text{L.C.}}{5\ \mu\text{m}} = \frac{1\ \text{mm}}{5\ \mu\text{m}} = \frac{10^3}{5} = 200$

8. **(b) :** Least count = $\frac{0.25}{5 \times 100}$ cm = 5×10^{-4} cm

Thickness of wire = $4 \times \frac{0.25}{5}$ cm + $30 \times$ L.C.

= 4×0.05 cm + $30 \times 5 \times 10^{-4}$ cm

= 0.20 cm + 0.0150 cm = 0.2150 cm

9. **(b) :** Screw gauge has negative zero error.

Least count of screw gauge

$$\text{LC} = \frac{\text{Pitch}}{\text{Number of divisions on circular scale}}$$

$$= \frac{0.5\ \text{mm}}{50} = 0.01\ \text{mm}$$

Zero error = (45 – 50) × 0.01 mm = – 0.05 mm

Thickness of sheet = Main scale reading

+ (circular scale reading × LC) – zero error

= 0.5 + (25 × 0.01) – (–0.05) = 0.50 + 0.30 = 0.80 mm

10. **(b) :** Least count of screw gauge

$$= \frac{\text{Pitch}}{\text{Number of divisions on circular scale}}$$

$$= \frac{1}{100}\ \text{mm} = 0.01\ \text{mm}$$

Diameter of wire = Main scale reading

+ circular scale reading × Least count

= 0 + 52 × 0.01 = 0.52 mm = 0.052 cm

11. **(a) :** Least count of the screw gauge

$$= \frac{0.5\ \text{mm}}{50} = 0.01\ \text{mm}$$

Main scale reading = 3 mm. Vernier scale reading = 35

∴ Observed reading = 3 + 0.35 = 3.35 zero error = –0.03

∴ actual diameter of the wire = 3.35 – (–0.03) = 3.38 mm.

12. **(c) :** For student A : Pitch = 0.1 cm,

$$\text{L.C.} = \frac{0.1}{100} = 0.001$$

Number of divisions on circular scale, $N = 100$

The reading is given by

Reading = MSR + CSR + error

$0.322 = 0.3 + \text{CSR} + 5 \times 0.001$

$\text{CSR} = 0.017$ ... (i)

For student B : $0.322 = 0.2 + \text{CSR} + 0.092$

$\text{CSR} = 0.030$

Difference = $0.030 - 0.017 = 0.013$ cm

$$\text{Division in circular scale} = \frac{0.013}{0.001} = 13$$