



EXPERIMENT

Aim

To determine radius of curvature of a given spherical surface by a spherometer.

MATERIAL REQUIRED

Spherometer, a convex mirror, a scale of 15 cm, a plane glass strip, a sharp pencil, eraser.

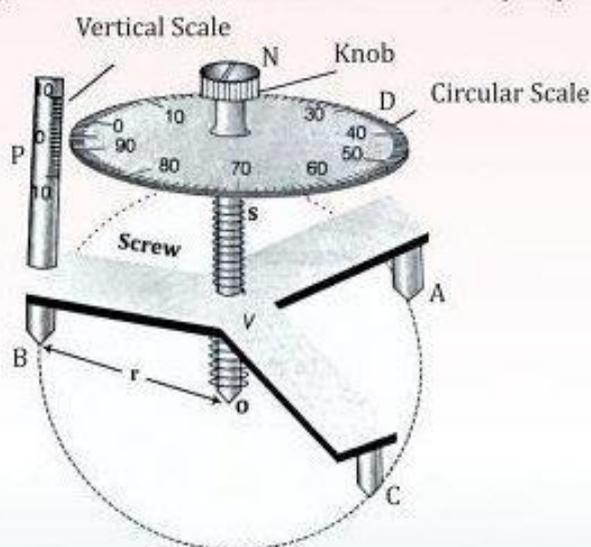
DIAGRAM

DESCRIPTION OF SPHEROMETER

A spherometer is an instrument for the precise measurement of the radius of a sphere and thickness. This instrument is primarily used by opticians to measure the curvature of the surface of the lens.

CONSTRUCTION OF SPHEROMETER

A spherometer consists of a triangular metallic frame F . It has three legs A , B , and C which form three corners of an equilateral triangle ABC , and it lies on the periphery of a base circle of known radius r . The plane which contains the pointed end of the three legs is called the reference plane or ground plane. It also has central leg OS . This central leg OS is provided in such a way that its lower tip, i.e., point O lies just on the center of the equilateral triangle ABC . At the center of the frame F , a threaded hole V (nut) is given through which the central leg OS can be raised or lowered. A circular disc having a circular scale is attached to the upper end of the central leg. This scale is divided into 100 or 200 equal parts.



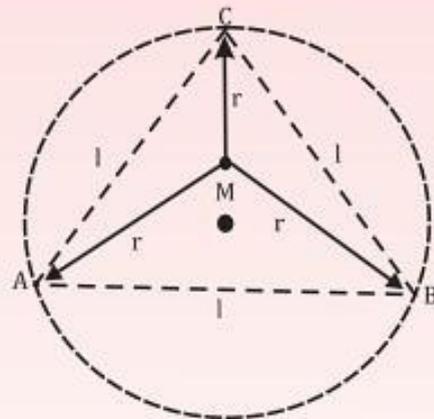
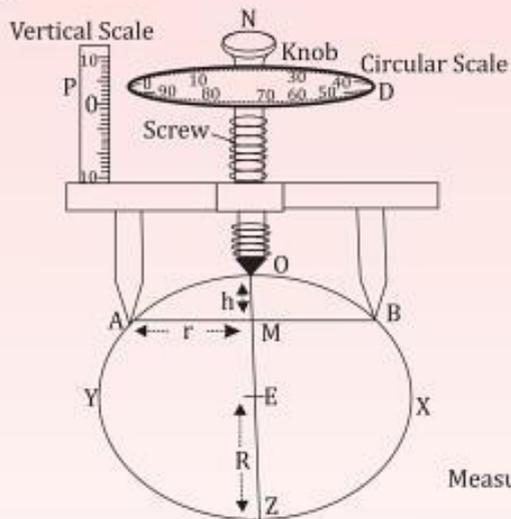
spherometer

At the other end of the frame, a scale called main scale or pitch scale P is attached vertically parallel to the central leg. This scale is used to read the vertical distance which the screw S moves through the hole V . This scale is attached in such a way that it does not touch the disc D despite being very close to it.

THEORY

Radius of Curvature of a Spherical Surface

Let us consider that the radius of curvature of a lens is to be measured. The spherometer is placed on the convex surface of this lens in such a way that all three legs and screws of the spherometer touch the convex surface. The two legs touch the surface at points A and B and the third leg cannot be shown in the figure. The tip of the screw on the spherical surface at point O lies above the plane of the three legs at height h . Suppose that convex surface whose radius of curvature is to be measured in XY as shown in figure. Here it must be noted that point M as shown in the figure is not only the mid-point of line AB but also the center of the equilateral triangle ABC. The distance OM is called Sagitta. From the property of the circle, we know that if the two chords of the circle intersect at a point, then the areas of rectangles formed by these chords will be equal.



Measuring the radius of curvature with the help of a spherometer

$$\therefore OM \cdot MZ = AM \cdot MB \quad \dots\dots\dots (1)$$

But,

$$AM = MB \text{ and } MZ = OZ - OM$$

Thus, from equation (1), we get:

$$(AM)^2 = OM (OZ - OM)$$

Let, $AM = r =$ radius of the base circle of the spherometer.

$EZ = R =$ radius of curvature of the given spherical surface

or,

$$r^2 = h (2R - h)$$

Thus,

$$R = \frac{r^2}{2h} + \frac{h}{2}$$

Let l be the distance between any two legs of the spherometer, then from the geometry:

$$r = \frac{l}{\sqrt{3}}$$

Therefore,

Radius of curvature,

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



TERMS RELATED TO EXPERIMENT

PITCH

The linear distance travelled by the screw in one complete rotation of its head is called pitch.

$$\text{Pitch (P)} = \frac{\text{Distance moved by the plane of the disc along the vertical scale}}{\text{Number of complete rotations given to the circular scale}}$$

LEAST COUNT

The least measurement that is done by the spherometer accurately is called least count.

$$\text{Least Count (LC)} = \frac{\text{Pitch(P)}}{\text{Total number of divisions on circular scale(n)}}$$

ZERO ERROR

If the three fixed legs and the central screw are touching the plane surface and the zero mark on the disc is in line with the zero mark on the main scale, then the spherometer possesses no zero error, otherwise, the spherometer has zero error. The zero error can be occurred in any of the two manners discussed as follows:

POSITIVE ZERO ERROR: If on the circular scale, zero mark lies a little above the zero mark of the main scale, it is called positive zero error.

$$\text{Positive zero error} = n \times \text{LC}$$

Where,

n = number of divisions of circular scale coinciding with the vertical scale

LC = least count

NEGATIVE ZERO ERROR: If on the circular scale, zero mark lies a little below the zero mark of the main scale or vertical scale, it is called negative zero error.

$$\text{Negative zero error} = -(n - n') \times \text{LC}$$

where,

n = number of divisions on the circular scale.

n' = number of divisions coinciding with the vertical scale.

$$\text{Positive zero error} = n \times \text{LC}$$

$$\text{Negative zero error} = -(n - n') \times \text{LC}$$

PROCEDURE

Initial Observations

1. First, take a spherometer and examine it properly, so that its legs and vertical scale are not shaky and screw at the center is not loose.
2. Note the value of one division on pitch scale of the given spherometer.
3. Note the number of divisions on a circular scale.
4. After that, calculate the least count and pitch of the spherometer.

Setting Up the Three Legs and Screw of the Spherometer

5. Place the spherometer on a glass slab and move the central screws till its tip just touches the surface of the glass slab.
6. During the motion of the central screw, count the total number of rotations till it touches the glass slab.

Plane Surface (Sheet of Paper) Reading

7. Place the spherometer on a sheet of paper and press it lightly and take the impressions of the tips of its three legs. Join the three impressions to make an equilateral triangle ABC and measure all the sides of ABC. Calculate the mean distance l between two legs of the spherometer.

NOTE: The term l_2 is used in determining the radius of curvature R. So, one should take care of measuring the length.

8. Read the main scale reading i.e., equals to $m \times LC$ (main scale)
(m = number of complete main scale division below the edge of circular scale)
9. Read the circular scale reading i.e., equals to $c \times LC$.
(c = number of divisions in circular scale which coincides with the edge of main scale)
10. Now, calculate the total reading. i.e. main scale reading + circular scale reading
 $\Rightarrow m \times (LC \text{ of main scale}) + c \times (LC \text{ of spherometer})$

Curved Surface (or Convex Mirror) Reading

11. Now, take the convex mirror and set it on the horizontal surface, so that its convex surface is in the upward direction.
12. Put the spherometer on the convex surface, so its legs rest on it.
13. Now, move the central screw till it touches the surface of the convex part. It is to be ensured that the screw touches the given spherical surface gently. One can observe its image formed due to reflection from the surface beneath it.
14. Again, note the reading of the circular scale, main scale, and note whether the zero of the circular scale has moved down or up the zero of the main scale.
15. The difference between two sets of observations with the proper sign, i.e. (curved surface – plane surface) gives the value of h called Sagitta.
16. Repeat steps 7 to 15 and calculate the mean value of h .

OBSERVATIONS

Pitch of the Spherometer Screw

1. Value of smallest division on the vertical scale = ____ mm.
2. Distance (q) moved by the screw for complete rotations (p) of the circular disc = ____ mm.
3. Pitch of the screw $\left(\frac{q}{p}\right)$ = ____ mm.

Least Count of Spherometer

4. Total number of divisions on the circular scale (N) = ____ mm
5. Least count (LC) of the spherometer = $\frac{\text{Pitch of the spherometer screw}}{\text{Number of divisions on the circular scale}} = \frac{\text{Pitch of the screw}}{N} = \text{____ cm}$
6. Distance between the two legs of the spherometer in triangle ABC, marked by legs of the spherometer:
AB = ____ cm
BC = ____ cm
AC = ____ cm

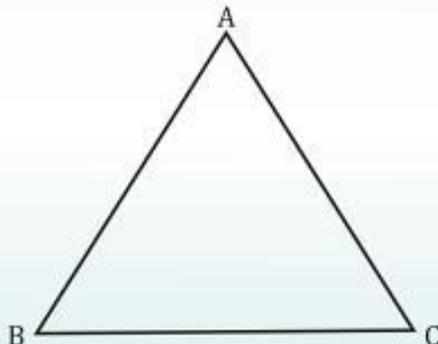


Fig. Distance between the two legs of the Spherometer

TABLE FOR MEASUREMENT OF SAGITTA (h)

S. No.	MSR x	CSR y	CSR Z=y × LC (cm)	Curved surface total reading, h ₁ =x+z (cm)	MSR x' (cm)	CSD y'	CSR z'=y'×LC	Plane surface total reading, h ₂ =x'+z' (cm)	Mean corrected reading, h =h ₁ +h ₂
1.									
2.									
3.									
4.									

CALCULATION

1. Mean distance (l) between two legs of spherometer,

$$\frac{AB + BC + CA}{3} = \text{_____ cm}$$

Where, AB, BC and CA are measured distances of equilateral triangle.

2. Mean corrected value of Sagitta,

$$(h) = \frac{h_1+h_2+h_3+h_4}{4} = \text{_____ cm}$$

3. Radius of curvature,

$$(R) = \frac{l^2}{6h} + \frac{h}{2} = \text{_____ cm}$$

RESULT

The radius of curvature of given mirror = _____ cm.

PRECAUTIONS

1. Before starting the experiment, you must examine the spherometer properly.
2. The screw of the spherometer should move freely without friction.
3. The screw should be moved in one direction thereby the backlash error can be avoided.
4. Legs of the spherometer must touch the spherical surface.
5. Screw present at the centre must touch the curved or plane surface.
6. You must note the curved surface and plane surface readings carefully with the proper sign.

SOURCES OF ERROR

1. Screw may have friction.
2. Graduations may not be uniform on scale.
3. There may be instrumental and human errors.
4. The main scale may not be exactly vertical.
5. Spherometer may have backlash error.

VIVA VOCE

Q1. Mention the purpose of using the spherometer.

Ans. The purpose of using the spherometer is to measure the reading of curvature of the spherical surface.

Q2. Define the term pitch of the spherometer.

Ans. Pitch of the spherometer can be defined as the distance between the consecutive strings of the screw taken parallel to the distance moved by the screw in one complete rotation of the circular scale.

Q3. Mention the formula through which you can calculate the least count of the spherometer.

Ans. The formula through which the least count of the spherometer can be calculated is given as the Least count of the spherometer,

$$LC = \frac{\text{Pitch}(P)}{\text{Total number of divisions on the circular}}$$

Q4. State the conditions to decrease the least count of a spherometer.

Ans. The followings are the conditions to decrease the least count of a spherometer.

(i) By decreasing the pitch.

(ii) By increasing the number of divisions on the circular scale.

Q5. What do you think, what can be a reason of using the good spherometer made of gun metal?

Ans. To reduce the wearing and touring, the good spherometers are made up of gun metals.

Q6. What is the formula for the determination of radius of curvature with the help of a spherometer?

Ans. The formula for the determination of radius of curvature is: $R = \frac{l^2}{6h} + \frac{h}{2}$ where h is sagitta and l the length of the sides of an equilateral triangle formed by the tips of the legs of the spherometer.

Q7. In which way, the accuracy of a spherometer can be increased?

Ans. As we know, the least count of an instrument is always inversely proportional to its accuracy. So, lesser the least count of spherometer, greater will be its accuracy. Besides this, accuracy of the spherometer can be increased by increasing the number of divisions on circular scale and by decreasing the pitch.

Q8. Which is the most necessary precaution that is to be followed while performing this experiment?

Or how the backlash error can be avoided?

Ans. While performing this experiment, we should rotate the circular scale in one direction in one go only, to avoid backlash error.

