# Unit-02   Basic Measurement II

## Objective：

Use spherometer to measure the curvature radius of a spherical surface.

## Apparatus：

Spherometer, traditional spherometer, plate glass, convex glass

## Principle：

### A.   The Construction

The structure of a spherometer is shown as Fig.1. **A** is a tripod with three arms **B**, **C**, and **D**, and that also with equivalent length. The included angle of each two arms is 120°. **E** is the main-meter, one tick is 1 mm. And there are 100 ticks on the periphery of sub-meter **F**. Probe **H** shifts 1 mm when sub-meter is screwed one round, which means the length per tick is 0.01 mm. We can get the height of probe from the main-meter and sub-meter.
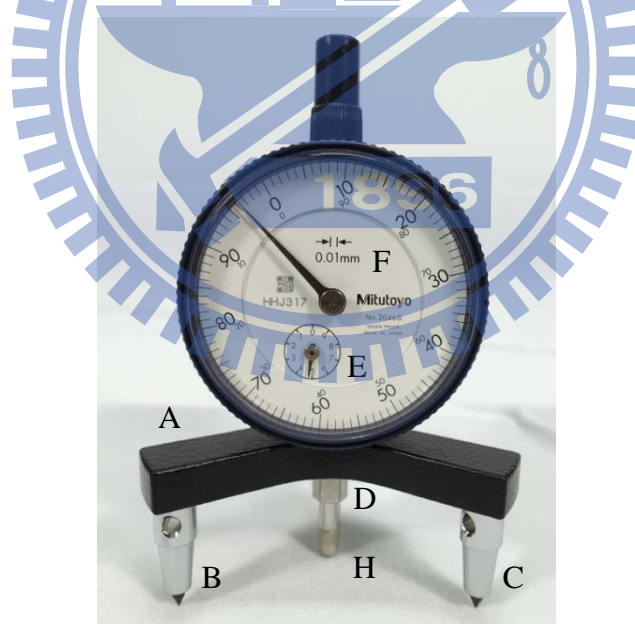


Figure 1. The structure of a spherometer

### B.   Measurement of the Curvature Radius

As shown in Fig.2, the distance between each arm of the tripod is $S$, hence **B**, **C** and **D** form an equilateral triangle. We can make a circumscribed circle of radius $r$.
The extended line of probe **H** is sure to pass the center of the sphere **O'**. We assume that the line **O'H** intersects place **BCD** at **O**. Let curvature radius is $R$, if we measure the height is $a$ by probe **H**, and then we could calculate curvature radius $R$ by Pythagorean proposition.

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

$$R^2 = (R - a)^2 + r^2$$
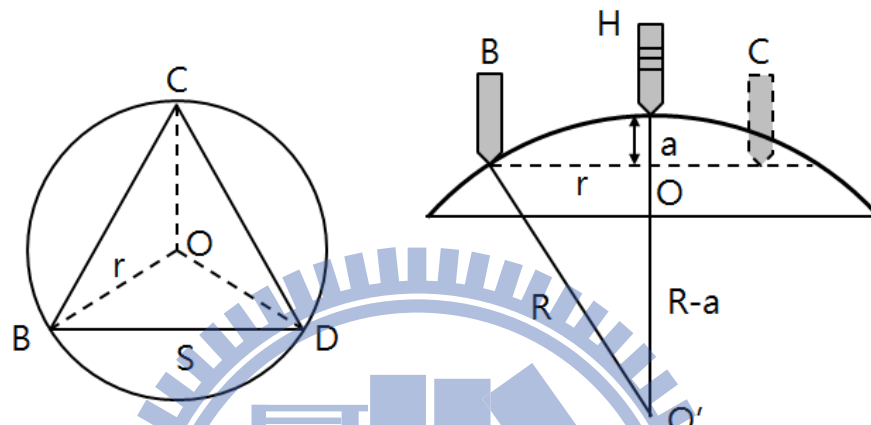
$$R = \frac{S^2}{6a} + \frac{a}{2}$$


Figure 2. Vertical view and Side view of a spherometer

## Remarks：

1. When you put spherometer on the glossy grass plate, please gently lay down.

## Procedure：

1. Adjust the fixed tips to make it into triangle.
2. Push down 3 tips B, C, D on the paper.
3. Remove the spherometer and and draw a triangle.
4. Use vernier caliper to measure the length between two fixed tips.
5. Put the spherometer on the plate glass, and making the tips of **BCDH** contact the plate glass. Recording the value $a_0$.
6. Put the spherometer on the convex glass, and making the tips of **BCDH** contact the convex glass. Recording the value $a_1$.
7. The difference between $a_0$ and $a_1$ is $a$, that is the height of **H** from plane **BCD**.

$$a = |a_1 - a_0|$$

8. Get the average value and standard deviation of the mean.

9. Calculate the curvature radius $R$. (should consider the error transfer)

[Note] Curvature Radius $R = \overline{R} \pm \sigma_R$

$$\overline{R} = \frac{\overline{S}^2}{6\overline{a}} + \frac{\overline{a}}{2}$$

$$\sigma_R = \sqrt{\sigma_S^2 \left( \frac{\overline{S}}{3\overline{a}} \right)^2 + \sigma_a^2 \left( -\frac{\overline{S}^2}{6\overline{a}^2} + \frac{1}{2} \right)^2}$$

10. Used traditional spherometer to do this experiment.


## Questions：

1. The construction of traditional spherometer and spherometer are the same? Please explain.
2. Can we use spherometer to measure the radius of convex len? Please explain.