1. MEASUREMENT OF THE RADIUS OF CURVATURE OF A SPHERICAL LENS

OBJECTIVES

1. Measure the radius of curvature of the concave or convex lens
2. Determine the error of measurement
3. Analyze the errors in measurement

THEORETICAL PART

In studying image formation with lenses offers a method of measuring radius r. Measurements can be made with various methods. One of the measurements of radius of lens is the measurement by the spherometer. The spherometer is shown in fig.1
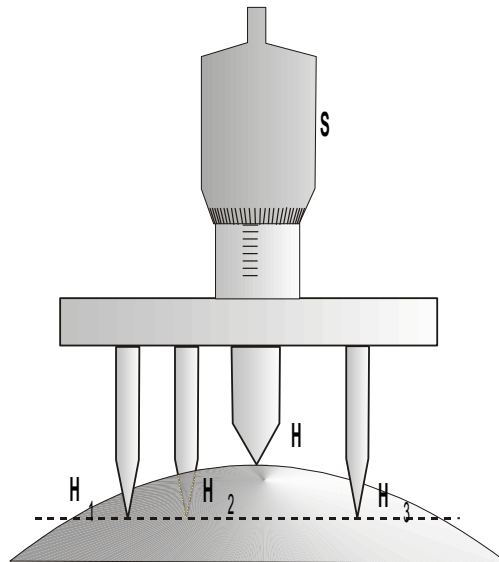

Fig. 1

The spherometer consists of a tripod with micrometric screw at the center. The tips of the three legs define the plane on the surface of the lens. The micrometric screw can be lowered (or raised above) the plane of the legs.

Let a is the average distance between the tips of the tripod legs and h is the high measured from the plane through the ends resting on the lens surface. The situation is shown in fig.2
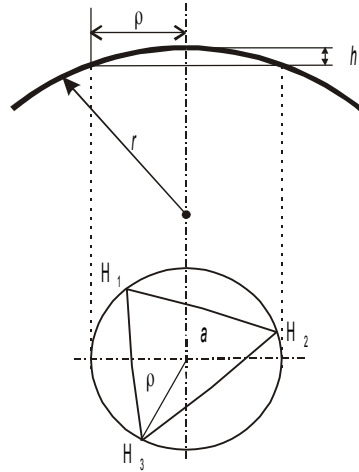
Fig.2

We shall derive the expression for determination the radius of lens by the spherometer. Using Pythagoras' theorem we have

$$\rho^2 + (r - h)^2 = r^2 \tag{1}$$

Rearranging this equation gives

$$r = \frac{\rho^2}{2h} + \frac{h}{2} \tag{2}$$

where r is the radius of curvature of the lens and ρ is the radius circumscribed around the tips of the legs of spherometer.

$$\rho = \frac{a}{\sqrt{2}} \tag{3}$$

Inserting eq.3 into eq.2 gives

$$r = \frac{a^2}{6h} + \frac{h}{2} \tag{4}$$

THE METHOD-PRACTICAL PART

From eq.4 we can see that the method of measurement of the radius of lenses by the spherometer is very simply. This method resides in the measurement of the distance a between the tips of the tripod legs and the high h of the point of the screw resting on the lens surface.

MEASUREMENT

APPARATUS: spherometer, lenses, plane surface, meter- stick

Measure the distance a between the tips of the tripod legs a several times. Measure the high h a few times on the various places on the surface of the spherometer. Measure the zero position of the spherometer on the plane surface a few times. Record all data into recommended data sheets: Tab1, Tab.2.

CALCULATION

Calculate the average value of "zeroed" position equals

$$\bar{h}_0 = \frac{\sum\limits_{i=1}^{n} h_{oi}}{n} \tag{5}$$

and average value of the high h is given by expression

$$\bar{h}_1 = \frac{\sum\limits_{i=1}^{n} h_{1i}}{n} \tag{6}$$

where: n is the number of measurement of h_0 and h_1

Then the average high of the tips plane given by the three legs of micrometer is

$$\bar{h} = \bar{h}_1 - \bar{h}_0 \tag{7}$$

Then the average value of a is defined as

$$\bar{a} = \frac{\sum\limits_{i=1}^{n} a_i}{n} \tag{8}$$

Using eq.4 calculate of the radius of the measured lens r as

$$\bar{r} = \frac{\bar{a}^2}{6\bar{h}} + \frac{\bar{h}}{2} \tag{9}$$

Compute the statistical error of the mean of r as

$$u_{\bar{r}} = \sqrt{\left(\frac{\bar{a}}{3\bar{h}} u_{\bar{a}}\right)^2 + \left[\left(-\frac{\bar{a}^2}{6\bar{h}^2} + \frac{1}{2}\right) u_{\bar{h}}\right]^2} \tag{10}$$

where
$$u_{\bar{a}} = \sqrt{\frac{\sum\limits_{i=1}^{n} (\Delta a_i)^2}{n(n-1)}} \tag{11}$$

$$u_{\bar{h}} = \sqrt{\frac{\sum\limits_{i=1}^{n} (\Delta h_i)^2}{n(n-1)}} \tag{12}$$

Give a complete analysis of the sources of errors in the experiment

i	h_{0i} ( )	Δh_{0i} ( )	$(\Delta h_{0i})^2$ ( )	h_{1i} ( )	Δh_{1i} ( )	$(\Delta h_{1i})^2$ ( )
1.						
...						
10.						
Sum						
$\bar{h}_0$, $\bar{h}_1$ ( )						

Tab. 1

i	a_i ( )	Δa_i ( )	$(\Delta a_i)^2$ ( )
1.			
9.			
Sum			
$\overline{a}$ (　)			

Tab.2