Determination of the focal lengths of
capillary lenses

Purpose: studying the methods of determining the focal lengths of collective and dissipating fine lenses.
One of the most important elements of optical instruments is the lens. Without it, there wouldn’t be microscope, telescope, spectroscope, camera, cinema, television, etc.Lenses are transparent bodies, scarce by two surfaces. One of them of course spherical, and the other - spherical or flat Lenses refract light rays and can form optical images of objects.Material for lenses are glass, quartz, crystals, plastics, etc.
For optical properties, lenses are divided into harvesting and scattering.Collecting lenses convert falling on them a parallel beam of light rays into a beam of converging rays, and scattering - into a beam of divergent. A lens is called thin if its thickness is much smaller than the radiuses of R1 and R2 surfaces, which limit her. The straight line passing through the centers of curvature C of the refractive surfaces of the lens is called the main optical axis. Lens has a point 0, which lies on the main optical axis and is called its optical center. For biconvex and biconcave lenses, it coincides with the geometric center of their middle part. The rays pass through the optical center, are not refracted. If a beam of rays is directed to the lens parallel to the main optical axis, they or their continuation after refraction in the lens intersect at the point F, is called the focus of the lens. The distance F from the optical center to the focal point of the lens is called the focal length.Parallel rays directed at the lens at an angle to the main optical axis, after refraction they will gather at a point called the side focus. The plane drawn through the focus and the side foci perpendicular to the principal is called the focal plane.The focal length of the lens is related to the distance a from the object to the lens and the distance b from the lens to the image of formula

$$1/f = 1/b - 1/a \text{ or } f = ab/(a - b)$$

This lens formula is valid for cleaning and scattering lenses any location of the object in focus.It should be taken into account attention the rule of signs for a and b. To consider them positive if they are laid to the right of the lens, that is, along the course of the rays, and negative if they are laid to the left of the lens, that is, against the path of the rays. For the scattering lens, the signs a b the same, and the focal length is negative.

To compare the optical properties of different lenses, apply not the value of the zero focal length, but the reciprocal value
1 / f. Value Φ = 1 / f is called optical power of the lens. The application of this quantity is related to the following. than more focal length, the weaker the refractive power of the lens and the less 1 / f; The shorter the focal length, the more refractive the lens and the more 1 / f. Thus, 1 / f characterizes the refractive power of the lens.To construct an image of an object in lenses, one must construct an image of its individual points. To construct the image of a point, it is sufficient to carry out
her two rays and find their bent rays. This can be done with the help of two of the three rays:
- a ray passing through the optical center of the lens; it is not refracted;
- a beam going parallel to the main optical axis; after refraction in the lens he or his continuation passes through the focus of the lens;
- the ray or its continuation, which passes through the focus of the lens; after Lomolinya in the lens it runs parallel to its main optical axisю. Instruments and accessories: an optical bench with movable lens Reuters, a light bulb in a casing with a window, a tightened mesh (object), a cleaning and scattering lens, a screen and a scale **straightedge**.
In this work, measurements are taken on an optical bench along which Reuters can move with lenses, reredos, and the like. Before starting the measurement centers all lenses and their optical axes must be exposed (by eye) onto one line parallel to the edge of the optical bench (the optical axis of the installation). To do this, at the end of the optical benches set the lighter with frosted glass and arrow, in the subsequent measurements plays the role of the object. Next,set the screen to the center. To do this, the reuter with the screen slides the lighteritself and connects the center of the screen with the center of the object. Then the screen is moved away from the lighterand fixed to the bench.

Task1. Determination of the focal length of a thin collecting lens
The focal length of thin cleaning lenses is determined in various ways.
Method 1. Determination of the focal length by measuring distances from the object and its image to the lens.

Between the object P and the screen, place the collecting lens A (Fig. 1). Move it until you get a clear picture of the item on the screen. Determine the distance a from the object to the lens and b from the lens to the image (screen). The experiment is repeated three times at different distances between the object and the screen. Using formula (1), calculate the focal length of the lens, taking into account the rule of signs. Measure and calculate the measurements in Table 1.
The final measurement results in this and the following methods are recorded in view

$f = \langle f \rangle \pm \Delta f$ at $\alpha =$

Method 2. Determination of the focal length of the lens by the size of the object and its image. We denote the size of the object (Figure 1) by h, the size of its image through H. From the similarity of triangles it follows that these quantities are related by

$h / H = a / b$ (2)

Then from (1) and (2) we obtain that

$F = b*(h/H+h)$

Place the lens between the screen and the subject so that a clear image of the object (grid) appears on the screen and record the position of the lens and screen. to measure Using the ruler, the dimensions of the object and its image. While moving the screen, repeat the experiment three times. Calculate the focal length by formula (3). In accordance with the rule of signs H in the calculations should be considered negative. The results of measurements and calculations are written in Table. 2, which is compiled by analogy with Table. 1.

Method 3. Determination of lens focal length by the shift method

Denote the distance from the object to its image through A (Fig. 2). If this distance is greater 4 f, then there are always two positions of the lens, under which Expressive images of the subject will appear on the screen. When the lens is positioned I an enlarged image is obtained, with position II - reduced. It can be shown that both positions of the lens are symmetrical about the middle of the distance between the object and the image.

From Fig. 2 it can be seen that $a = A / 2 – l / 2$; $b = A / 2 + l / 2$. Substituting these values in formula (1) and taking into account the rule of signs, the focal length of the lens, we obtain expression.

Set the screen at a distance $A > 4$ f from the object. Between the object and the screen, place the lens and, moving it, achieve on the screen first increased, and then a reduced image subject matter. Measure the distances A and l. Repeat the experiment 3 times. The results of measurements and calculations are tabulated in Table. 3, which is compiled by analogy with Table. 1.

Task 2. Determination of the focal length of a thin scattering lens

The determination of the focal length of the scattering lens is complicated by the fact that with a real object its image is imaginary and it can not be directly measured. The problem can be solved with the aid of an auxiliary collecting lens (Fig. 3).

At the beginning of the experiment, place only the auxiliary lens L1 on the optical bench and obtain on the screen E1 a real image of the object P. Measure the distance 1 l from the lens L1 to E1. Then, between the screen E1 and the lens L1, place the scattering lens A2. The image of the object on the screen E1 disappears, but it can be obtained again by moving the screen 2 l to the position E2.

Using (1) and Fig. 3, we obtain the focal length of the scattering lens.

f=

where $l_1 - l_0 = a$; $l_2 - l_0 = b$. Experience repeat three times. The results of measurements and calculations are tabulated in Table. 4.

The final result of the measurements can be written in the form $f = \langle f \rangle \pm \Delta f$ at $\alpha =$

Control questions

1. What kind of lens is called harvesting? Scattering? Thin?
2. What is the main optical axis of the lens? Focus? A by-focus?
3. What is the rule of signs?
4. Construct an image of an object in the lens at various positions relative to the focus indicating the teacher). 5. What image of an object is called valid? Imaginary?
6. Construct an image of the object in the collecting lens when the object is between the lens and first focus.

Literature

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