Verifying the imaging laws with a collecting lens

Objects of the experiment

- Experimental verification of the lens equation.
- Experimental verification of the imaging law.

Principles

The focal length of lenses can be determined by a variety of means. The basis for the different procedures are the laws of imaging.

An image of an object is formed on a translucent screen by a convex lens of focal length f. The lens equation

$$\frac{1}{f} = \frac{1}{g} + \frac{1}{b} \qquad \text{(I)}$$

Is verified by altering the object distance g and measuring the image distance b.

The relationship between the object size G and the image size B and the object distance g and image distance b is derived.

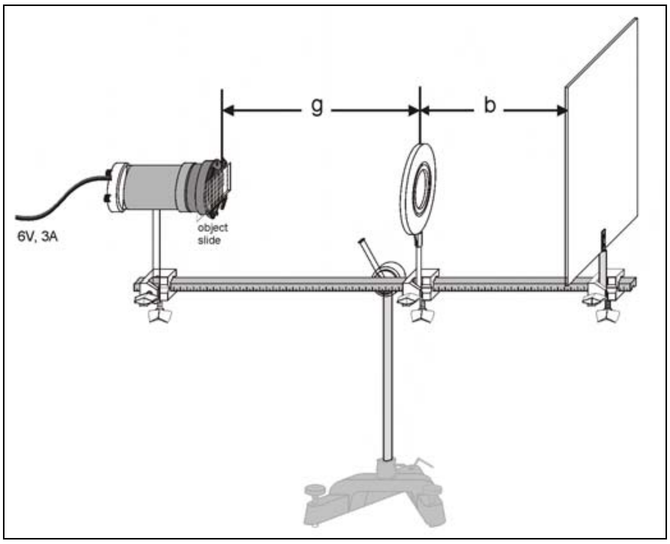

Fig. 1: Schematic diagram of the basic experimental setup.

Apparatus

1 Lamp, 6 V/30 W	450 51
1 Lamp housing	450 60
1 Aspherical condenser	460 20
1 Transformer	521 210
1 Lens f = +50 mm	460 02
1 Lens f = +100 mm	460 03
1 Set of two transparencies	461 66
1 Translucent screen	441 53
1 Small optical bench	460 43
1 Stand base, V-shape, 20 cm	300 02
3 Leybold multiclamp	301 01
1 Steel tape measure, 2 m	311 77

Setup

- Set up the lamp with the aspherical condenser and the translucent screen on optical bench as depicted in Fig. 1.
- Set up the translucent screen at the opposite end of the optical bench.
- Position a lens with a clamp between the lamp and the translucent screen.

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Carrying out the experiment

The experiment should be performed in a darkened room.

- Measure the object size on the transparency and insert it in the diaphragm holder of the lamp.
- Position the lens f = +100 mm 25 cm apart from the lamp.
- Form a sharp image on the screen (shift the lens slightly)
- Measure the object distance g (distance between lens and object) and the image distance b (distance between lens and image on screen).
- Measure the image size B.
- Repeat the experiment with object distances smaller, equal to or greater than twice the focal length.

Repeat the experiment for the lens f = +50 mm.

Measuring example

Table. 1: Comparison of the measured and given focal length of convergent lens f = + 100 mm (1/f = 0.01 mm^{-1}).

b / mm	163	220	125	200
g / mm	250	195	500	200
$\frac{1}{g}$ / mm^{-1}	0.004	0.005	0.002	0.005
$\frac{1}{b}$ / mm^{-1}	0,006	0.005	0.002	0.005
$\frac{1}{g}+\frac{1}{b}=\frac{1}{f}$ / mm^{-1}	0.0010	0.010	0.010	0.010
B / mm	3.5	4.5	21	5
G / mm	5	5	5	5
$\frac{b}{g}$	0.7	0.9	4.0	1.0
$\frac{B}{G}$	0.7	0.9	4.2	1.0

Evaluation and results

1. Experimental verification of the lens equation

From Table 1 follows that the image distance decreases with an increasing object distance.

The image distance b is equal to the object distance g when g equals 2 f.

The sum of the reciprocals of the object and image distance does not change when the distance between the object and the image is changed. The sum of the reciprocal image and object distance is equal to the reciprocal of the focal length:

$$\frac{1}{f}=\frac{1}{g}+\frac{1}{b}$$

2. Experimental verification of the imaging law

The object of size G before the collecting lens is imaged on the screen. The relationship between the image size B and the object size G is given by the imaging law

$$\frac{B}{G}=\frac{b}{g}$$

the linear magnification β is: $\beta=\frac{B}{G}$

Supplementary information

Equation (I) can be used to determine the focal length f of a collecting lens. For further methods see experiments P5.1.2.1 to P5.1.2.3.