Optics

Geometrical optics
Laws of imaging

LD Physics Leaflets

P5.1.2.1

Determining the focal lengths at collecting and dispersing lenses using collimated light

Objects of the experiment

- Determination of the focal length of a convergent lens.
- Determination of the focal length of a divergent lens.

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.

The focal length of a convergent lens is defined as the distance between the lens and the focal point. The focal point is where the refracted light rays converge after emerging from the lens.

The focal length of a concave lens is defined as the distance between the lens and the virtual point of intersection of the backward projected light rays emerging from the lens for parallel incident light.

In this experiment the virtual point is found by graphical determination of the intersection of the light beam which is incident on a sheet of paper at a glancing angle.

Apparatus

1 Incandescent lamp 6 V / 30 W	450 51
1 Lamp housing with cable	450 60
1 Aspherical condenser with diaphragm holder	460 20
1 Transformer 6 V / 12 V	521 210
1 Lens in frame f = +50 mm	460 02
1 Lens in frame f = +100 mm	460 03
1 Lens in frame f = +200 mm	460 04
1 Lens in frame f = -100 mm	460 06
1 Translucent screen	441 53
1 Small optical bench	460 43
1 Stand base, V-shaped, 20 cm	300 02
3 Leybold multiclamp	301 01
1 Steel tape measure, l = 2 m/78"	311 77

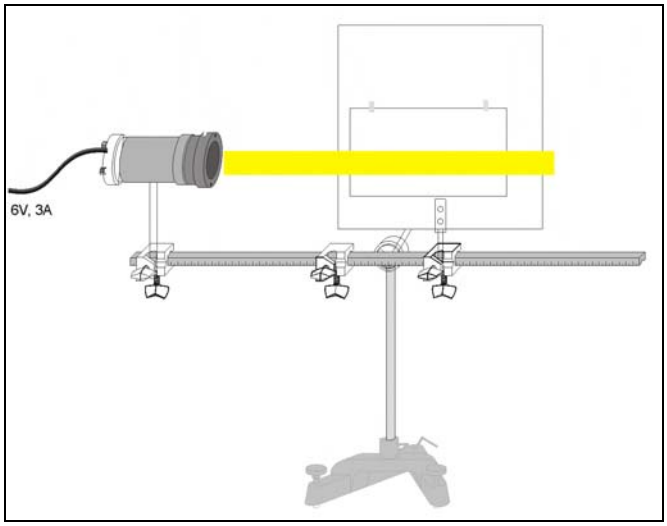

Fig. 1: Schematic diagram of the basic experimental setup.

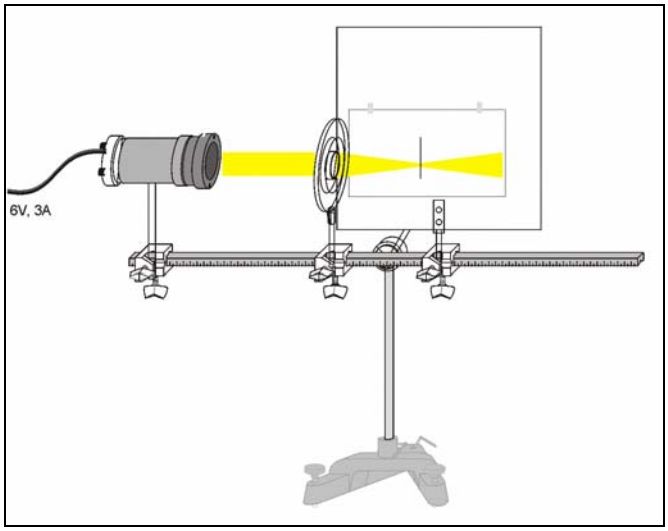

Fig. 2: Schematic diagram of experimental setup for measuring the focal length of lenses.

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Setup

- Set up the lamp with the aspherical condenser and the translucent screen on optical bench as depicted in Fig. 1. Initially, no lens is inserted in the setup.
- To generate a parallel light beam along the optical axis shift the .
- Mount a sheet of white paper with adhesive tape on the translucent screen and adjust the translucent screen on the optical bench in such a manner that the light beam can illuminate it at a glancing angle. If necessary, readjust the lamp by the three adjusting screws at the rear of the lamp housing.

Carrying out the experiment

The experiment should be performed in a darkened room.

a) Determination of the focal length of convergent lenses

- First demonstrate the parallelism of the light beam.
- Position the lens f = +50 mm in front of the screen in the free clamp.
- Mark the point of intersection of the refracted light beam emerging from the lens to the point of intersection (Fig. 2).
- Repeat the experiment with other convergent lenses and measure the focal length for each lens with the steel tape measure.

b) Determination of the focal length of a divergent lens

- Fold a sheet of white paper A4 to an A5 paper format. Attach the folded sheet with adhesive tape to the translucent screen in such a manner that the fold coincides with the screen edge facing the lens (Fig. 3).
- Adjust the translucent screen in such a manner that the light beam can illuminate it at a glancing angle.
- First demonstrate the parallelism of the light beam. If necessary, readjust the lamp by the three adjusting screws at the rear of the lamp housing.
- Position the lens f = -100 mm in front of the screen in the free clamp.
- Mark the shape of the light beam behind the lens on the white paper (Fig. 3).
- Remove the white paper, unfold it and determine the intersection of the projection of the delimiting lines of the light beam.
- Measure along the center line the distance f between the fold and the point of intersection of the light beam.

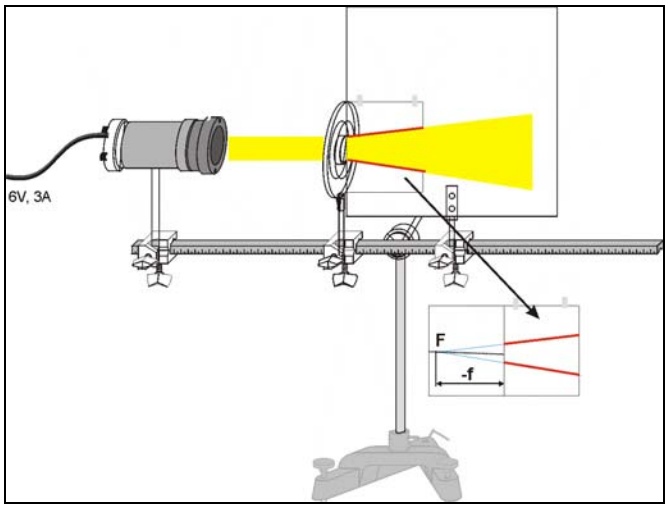

Fig. 3: Schematic diagram of experimental setup for measuring the focal length of a divergent lens.

Measuring example

Table. 1: Comparison of the measured and given focal length of convergent lenses

Focal length f / mm given	50	100	200
Focal length f / mm measured	46	98	189

Table. 2: Comparison of the measured and given focal length of a divergent lens

Focal length f / mm given	-100
Focal length f / mm measured	-105

Evaluation and results

a) convergent lenses

An incidenting parallel light beam propagating along the optical axis is refracted towards the optical axis by convergent lenses (convex lenses).

The distance between the point of intersection (or point of convergence) and the lens is defined as the focal length f of a convergent lens.

The point of intersection is referred to as the focal point F.

b) divergent lens

An incidenting parallel light beam propagating along the optical axis is refracted away from the optical axis by divergent lenses (concave lenses).

For an parallel light beam propagating along the optical axis the backward production of the emerging divergent light beam gives the virtual focus point F of a concave lens.

The distance between the virtual focus F and the lens is defined as the negative focal length f.

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