Determining the focal length of a convex lens

Task and equipment

Information for teachers

Additional Information

Two experimental variants for the determination of the focal length of a convex lens are suggested, so that at least once the students can discuss the advantages and disadvantages of each. The second variation is less accurate but easier to understand than the first. If the teacher decides to have the students carry out only one variant, then the determination of the focal length by autocollimation is to be preferred.

Suggestion

It is assumed that the students have already worked with the two convex lenses in several experiments. Thus they know their focal lengths. For this reason we did not ask the teacher to cover the focal length information on the lens holder and thus avoid the students knowing this data at the beginning of the experiment.
In variant 1 it could happen that the glass-bead -L-, the lens plane and the mirror surface are not exactly parallel. In this case the glass-bead -L- and its image (on the cover next to the glass-bead -L-) are not located on the same level. Generally is this unimportant for the experimental results. If necessary, this can be corrected, for example, by tilting the mirror slightly.

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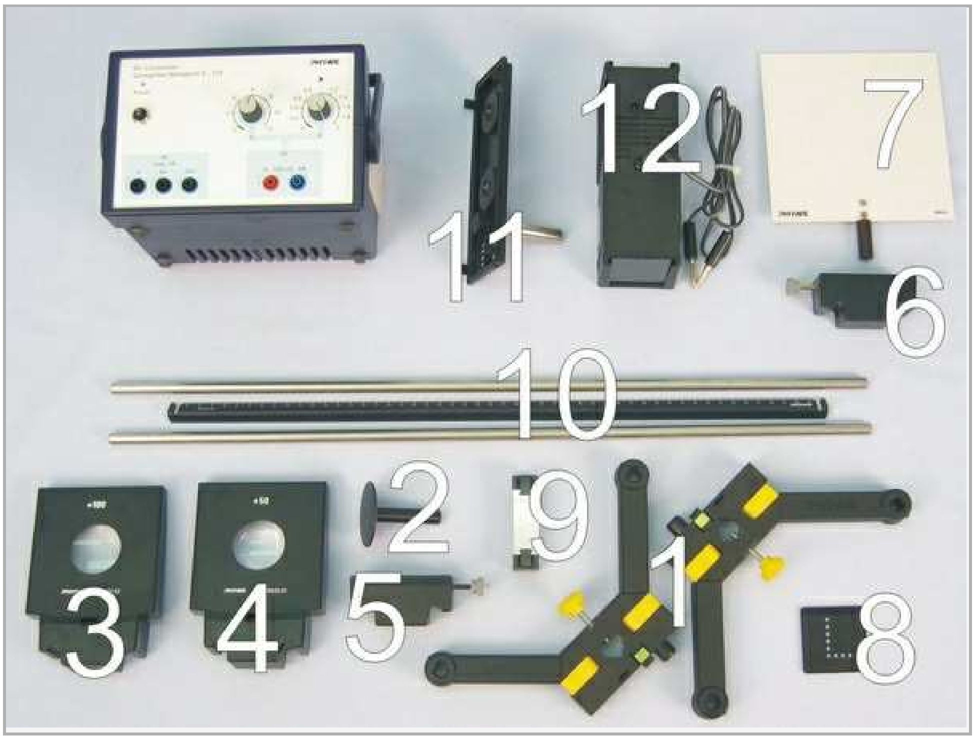
Task

How is the focal length of a convex lens determined?

Determine the focal length of a convex lens (convergent lens) with two different methods:
1. by autocollimation
2. by uniting parallel light at the focal point.

Equipment



Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Table with stem	09824-00	1
3	Lens on slide mount, f=+100mm	09820-02	1
4	Lens on slide mount, f=+50mm	09820-01	1
5/6	Slide mount for optical bench	09822-00	1
7	Screen, white, 150x150mm	09826-00	1
8	Object -L-, glass bead	11609-00	1
9	Mirror on block, 50 mm x 20 mm	08318-00	1
10	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
10	Meter scale for optical bench	09800-00	1
11	Bottom with stem for light box	09802-10	1
12	Light box, halogen 12V/20 W	09801-00	1
	Diaphragm holder, attachable	11604-09	1
	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

Set-up and procedure

1. Determination of the focal length with autocollimation

Using the two support rods and the variable support base assemble the optical bench and place the scale for the optical bench against the front support rod.

Fig. 1

Fig. 2

Place the bottom with stem under the light box.

Fig. 3

Fig. 4

Clamp it in the left part of the support base so that the lens end points away from the optical bench.

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Fig. 5

Insert an opaque cover in front of the lens and the cover with the glass-bead -L- into the slot at the other side of the light box.

Fig. 6

Place the lens with *f* = +100 mm (whose focal length should be unknown) onto the optical bench and put the slide mount with the optical stage just to the right of it. Place the mirror on the edge of the table so that it is perpendicular to the optical axis.

Fig. 7

Fig. 8

Connect the light box to the power supply (12 V AC) and switch it on.

Fig. 9

Now move the lens until an equally large image of the glass-bead-L appears next to the original; focus this image.
Readjust the setup if the image has an unsuitable position and is difficult to see because of the much greater brightness of the original. Turn or tilt the mirror slightly in relation to the lens's optical axis to do this.

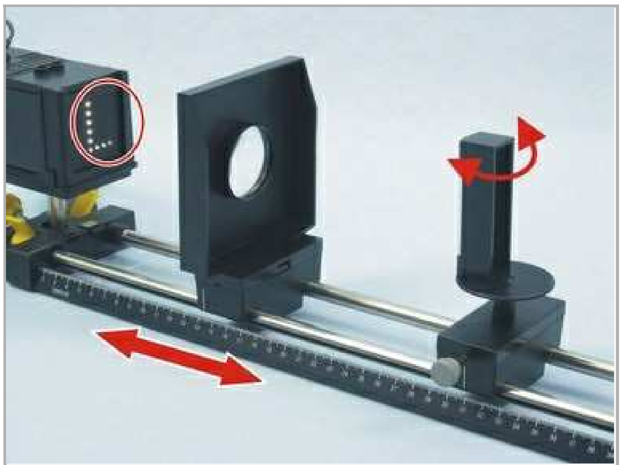


Fig. 10

Measure the distance of the glass-bead-L (or its image) from the lens.
This distance is equal to the focal length of the convergent lens. Note your result in the report.

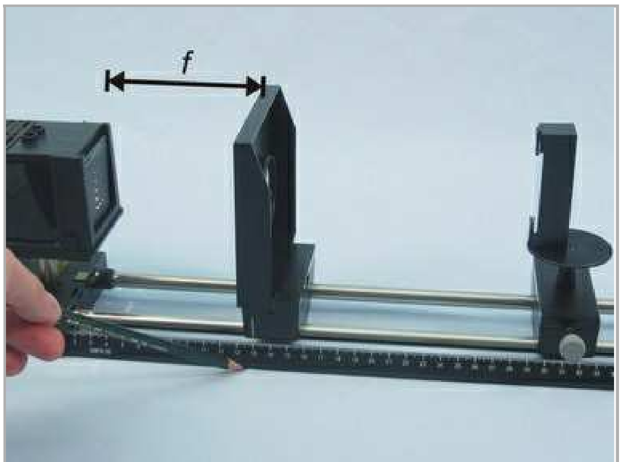


Fig. 11

2. Determination of the focal length by uniting parallel light at a focal point.

Remove the cover with the glass-bead-L, the mirror with the optical stage and the lens with f = +100 mm and place the lens with f = +50 mm close to the light and project a focused image of the light source as far way as possible (several metres) from the lens onto the room's wall.

Fig. 12

Put the lens with *f* = +100 mm (whose focal length should be unknown) onto the optical bench and place the screen to the right of it.

Fig. 13

Move the lens or the screen until the patch of light on the screen is as small as possible. If the glare of light reflected by the screen becomes too unpleasant, change the voltage to the light box from **12 V AC** to **6 V AC**.

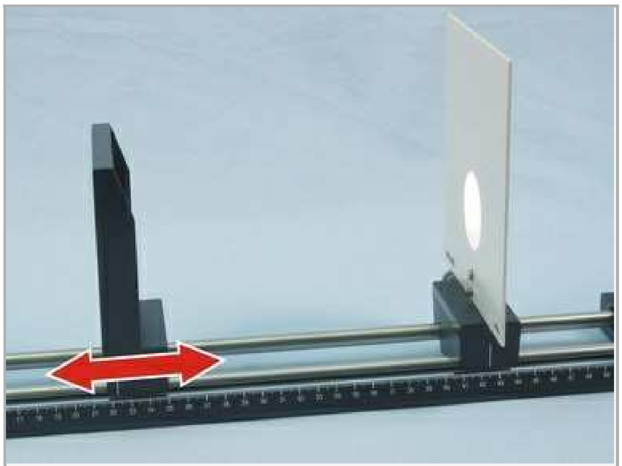


Fig. 14

Switch off the power supply.
Measure the distance of the lens from the screen. You have thus found the desired focal length *f*.

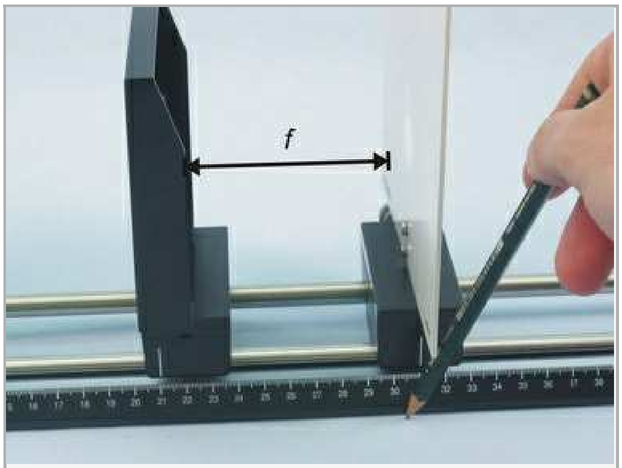


Fig. 15

Report: Determining the focal length of a convex lens

Result – Observations

1st Experiment: The focal length f = ...mm

2nd Experiment: The focal length f = ...mm

Evaluation – Question 1

Explain the principle of experiment 1:
Why is the focal length equal to the distance of the glass beads from the lens?

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Evaluation – Question 2

In your opinion, which of the two methods of determining the focal length is more accurate?
Give reasons for your opinion.

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Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Evaluation – Question 3

On a sunny day you are given a converging lens and asked to determine its focal length. You have no further lens and no light, but you do have a ruler.

How can you determine its focal length?

Explain why your method works.

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Evaluation – Question 4

The reciprocal of the focal length f is called the refractive power D of a lens: $D = 1/f$. The unit of D is the dioptre (dpt); it is given in 1/m.

What is the refractive power of the lens whose focal length you have determined?

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Evaluation – Question 5

What is meant when someone says that a person is wearing a pair of glasses with -2 diopters?

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