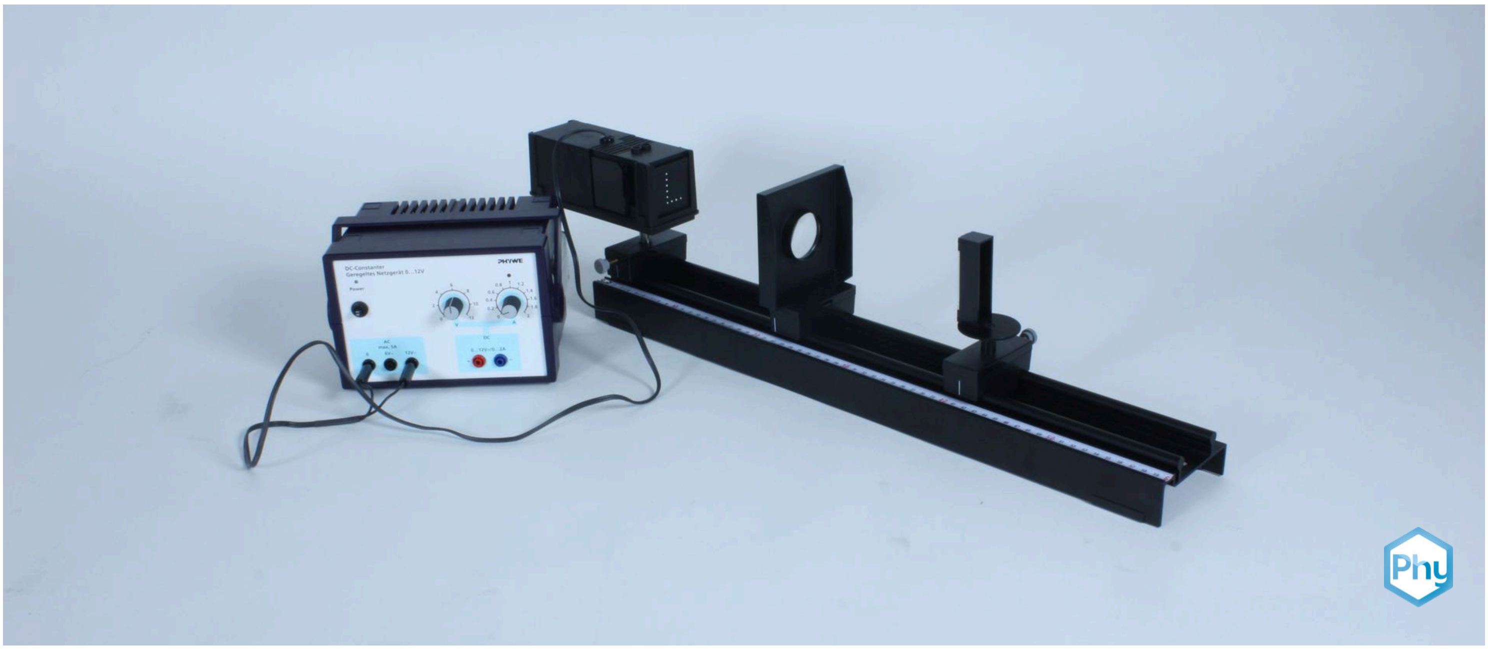
Determining the focal length of a convex lens



Physics | Light & Optics | Optical devices & lenses

Difficulty level	Group size	Preparation time	Execution time
easy	1	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/62dbc088a52f910003dffb72

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Teacher information

Application

Experimental setup

Convex lenses, also called converging lenses, can produce a magnified image. They are an important element of ray optics and are therefore widely used in optical instruments and in photographic lenses.

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Other teacher information (1/4)

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Principle

Incident light that is parallel to the optical axis is focused by the convex lens at the focal point. This can produce a magnified real image.

Learning objective

The students should observe the optical effect of a convex lens, carry out the two experiments to determine the focal length and compare the results of both variants.

Other teacher information (2/4)

Task

The pupils determine the focal length of a convex lens (converging lens) in two different ways:

1. by autocollimation.
2. by uniting parallel light at the focal point.

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Other teacher information (2/4)

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Task

The pupils determine the focal length of a convex lens (converging lens) in two different ways:

1. by autocollimation.
2. by uniting parallel light at the focal point.

Other teacher information (3/4)

Two experimental variants for determining the focal length of a convex lens are therefore proposed so that the students can discuss the advantages or disadvantages of the variants. The second variant is less accurate but closer to life than the first. If only one variant is used, we recommend determining the focal length by autocollimation.

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Other teacher information (4/4)

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Notes on set-up and procedure

- It can be assumed that the pupils have already worked several times with the two convex lenses included in the equipment set. They therefore know their focal lengths. For this reason, we have refrained from over-gluing the information about the focal lengths of the lenses on the lens holders.
- If, in the first variant, the aperture with the Perl-L, the lens plane and the mirror surface are not completely parallel, then the Perl-L and its image (on the aperture with the Perl-L) are not at the same height. This is irrelevant for the result of the experiment. If necessary, some readjustment can be made, e.g. by tilting the mirror slightly.

Safety instructions

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- The general instructions for safe experimentation in science lessons apply to this experiment.

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Student information

Motivation

Magnifying glass as an example of a convex lens

Convex lenses, also called converging lenses, can produce a magnified image. They are a central component of optics and are therefore often found in everyday devices, such as telescopes, camera lenses or even eyeglasses.

How do convex lenses work?

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Equipment

Position	Material	Item No.	Quantity
1	Optical profile-bench for student experiments, l = 600 mm	08376-00	1
2	Light box, halogen 12V/20 W	09801-00	1
3	Bottom with stem for light box	09802-20	1
4	Lens on slide mount, f=+50mm	09820-01	1
5	Lens on slide mount, f=+100mm	09820-02	1
6	Slide mount for optical bench	09822-00	2
7	Table with stem	09824-00	1
8	Screen, white, 150x150 mm	09826-00	1
9	Mirror on block, 50 mm x 20 mm	08318-00	1
10	Diaphragm holder, attachable	11604-09	1
11	Object -L-, glass bead	11609-00	1
12	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

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Experiment 1 - Set-up (1/3)

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1. Determination of the focal length by autocollimation:

- Assemble the optical bench from the two tripod rods and the variable tripod foot and place the scale on the front tripod rod.
- Place the base with stem under the light box.

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Experiment 1 - Set-up (2/3)

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- Clamp the light box in the left part of the tripod base so that the lens side faces away from the optical bench.
- Slide an opaque shade in front of the lens and the Perl-L into the shaft at the other end of the luminaire.

Experiment 1 - Set-up (3/3)

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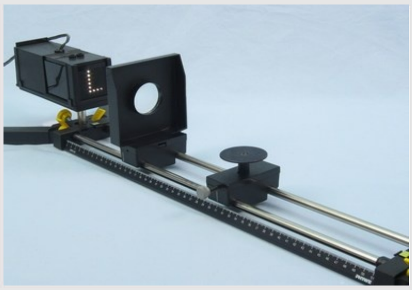
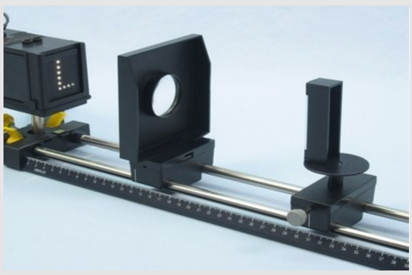
- Set the lens with $f = +100\,\mathrm{mm}$(whose focal length should be unknown) onto the optical bench and to the right of it the slide with the table.
- Place the mirror upright on the table so that it is perpendicular to the optical axis.





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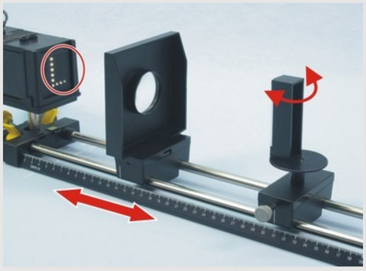
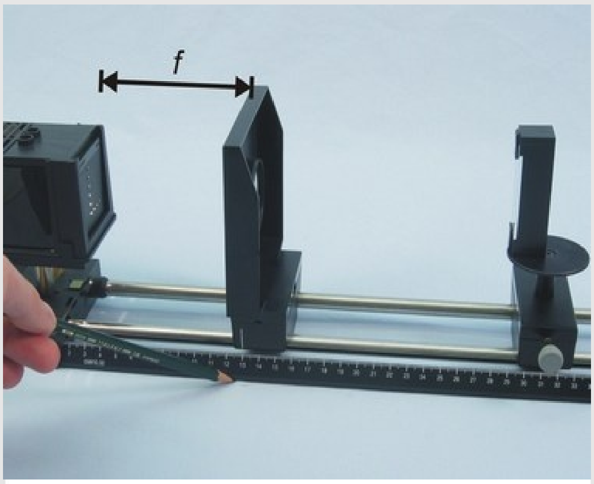
Experiment 1 - Procedure (1/2)



- Connect the lamp to the power supply unit (12 V~) and switch it on.
- Now move the lens until the image of the same size of the Perl-L appears on the aperture with the Perl-L next to the original Perl-L; focus on this image.
- Adjust slightly if the image has an unfavourable position and is difficult to see because of the much greater brightness of the original. To do this, rotate or tilt the mirror slightly in relation to the optical axis of the lens.

Experiment 1 - Procedure (2/2)



Measuring the focal length

- Measure the distance of the Perl-L (or its image) from the lens.
- This distance is equal to the focal length f of the converging lens. Write down your result in the protocol.

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Experiment 2 - Set-up

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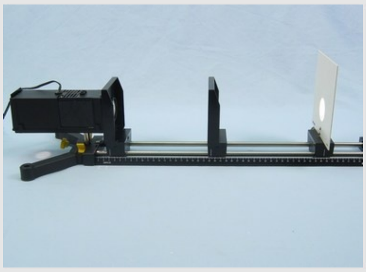

2. Determine the focal length by uniting parallel light at the focal point:

- Remove the aperture with the Perl-L, the mirror with the table as well as the lens with the $f = +100\ \mathrm{mm}$. Now adjust the lens with $f = +50\ \mathrm{mm}$ close to the luminaire and create a sharp image of the light source at the greatest possible distance from the lens (several metres).
- Set the lens with $f = +100\ \mathrm{mm}$(whose focal length should be unknown) to the right of it the screen on the optical bench.

Experiment 2 - Procedure

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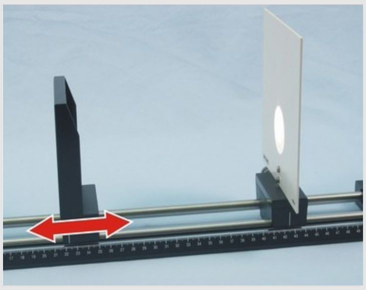

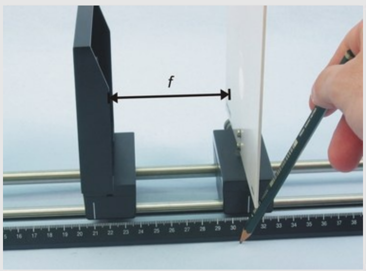

- Move the lens or the screen until the light spot on the screen is as small as possible. Attention! If the glare of the light reflected from the screen becomes too uncomfortable, briefly place the light box at **6 V~** instead of **12 V~** .
- Switch off the power supply unit.
- Measure the distance of the lens from the screen. This gives you the focal length you are looking for f . Note the value in the report.

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Report

Task 1

Enter your measurements in the gaps.

Experiment 1: The focal length is $f =$ ______ mm

Experiment 2: The focal length is $f =$ ______ mm

Check

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Task 2

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What is true if the focal length is equal to the distance of the Perl-L from the lens?

- ☐ The reflected image of the Perl-L is magnified on the aperture with the Perl-L.
- ☐ The perl-L and its equal-sized image of the mirror lie side by side on the aperture with the perl-L.
- ☐ The mirror reflects the light rays of the Perl-L's so that the rays emanating from it intersect again in the focal plane of the lens.
- ☐ The light rays emanating from the Perl-L beyond the lens run parallel.

Check

Task 3

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Which two methods of determining the focal length do you think are more accurate?

- ○ Determination of the focal length by autocollimation.
- ○ Determining the focal length by uniting parallel light at the focal point.

Check

What is the rationale?

- ○ One assumes that the optical bench is as straight as possible. This is not the case.
- ○ The second method assumes that the light beam passing through the lens is parallel. But this is only approximately the case.

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Task 4

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You are given a converging lens on a sunny day with the task of determining its focal length. There is no other lens or light available, but there is a ruler.

How can you determine the focal length? (Fill in the blanks!)

I hold the ______ in the sun in such a way that as large a beam of light as possible passes through it and approach it with a sheet of paper, for example, until the beam of light on the paper has the smallest ______. Then the ______ of the lens is on the paper. Now I measure the distance from the lens to the paper, i.e. the ______. f. This method works because the ______ falling from the sun to the earth is practically ______ due to the great distance of the sun from the earth.

Check

Task 5

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The reciprocal of the focal length f becomes refractive power D of a lens. It applies: $D = 1/f$. The unity of D is the diopter (dpt); it is given in 1/m. What is the refractive power of the lens whose focal length you have determined?

The refractive power of the lens under examination is ______. $1/\mathrm{m}$ $=$ ______ dpt.

Check

What does it mean to say that a person wears glasses with -2 dioptre?

- [ ] The focal length is $f = 5\,\mathrm{m}$.
- [ ] The lenses are concave lenses.
- [ ] The focal length is $f = 10\,\mathrm{m}$.

Check

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