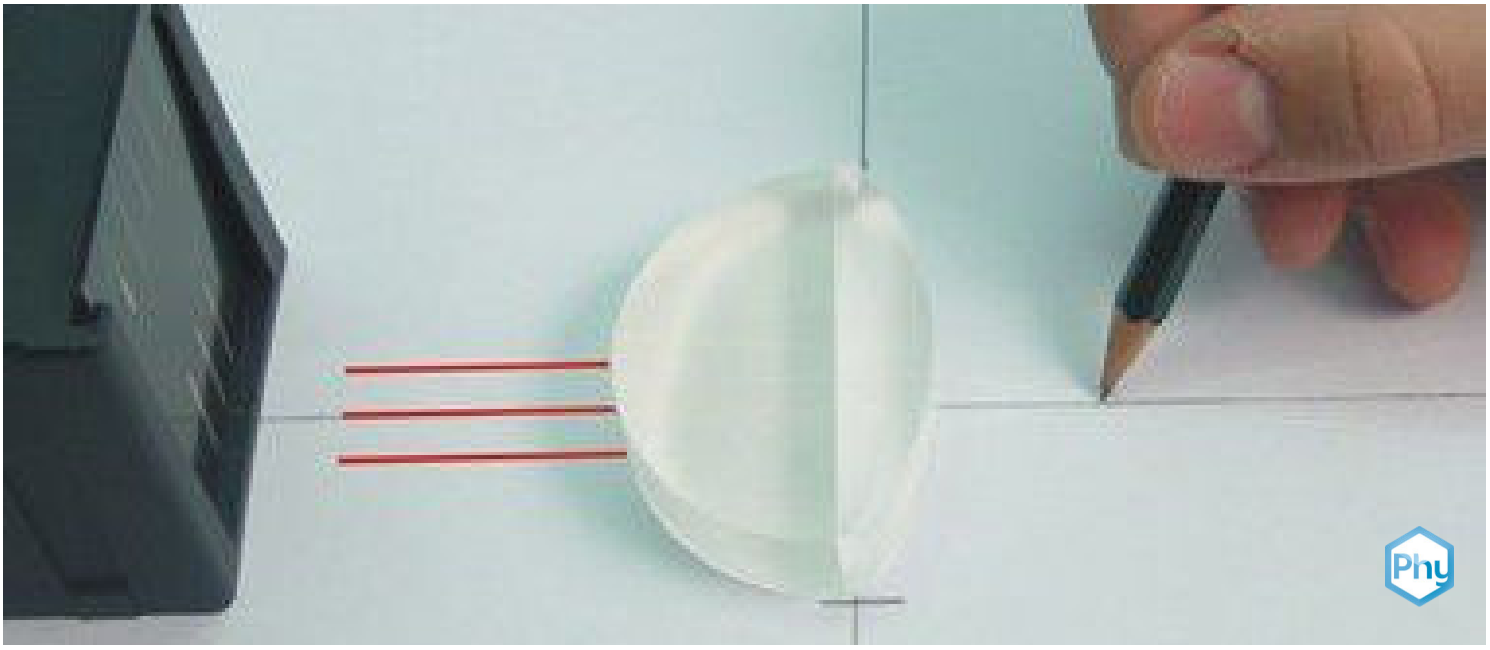
Focal length of lens combinations



The task of the experiment is to investigate the path of light through combinations of convex and concave lenses. Specifically, the focal length and resulting refractive power of the individual systems are considered.

Physics > Light & Optics > Optical devices & lenses

Difficulty level	Group size	Preparation time	Execution time
easy	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/616d5c57aeb0ac0003430b37

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Teacher information

Application

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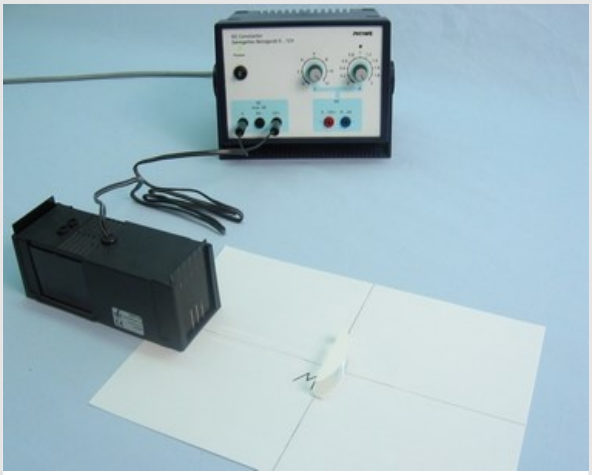

Focal length of lens combinations

Optical devices usually contain not only individual lenses, but combinations of several lenses. Such lens systems have very different properties. For example, the focal length can be varied and adapted to the application by using different combinations.

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Other teacher information (1/4)

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Previous

The ray paths of concave and convex lenses, as well as the relationship between focal length and refractive power should be known.

Principle

Depending on the combination of different lenses, specific ray paths result and thus a different refractive power is also achieved.

Other teacher information (2/4)

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Learning

In this experiment, the pupils should consolidate their knowledge of the light path through convex and concave lenses. The observation of the refracted light bundles made clear to the pupil the possibility of targeted focal length changes with the aid of lens systems. In conjunction with the experiments on lens aberrations, this creates a good basis for understanding the structure of many optical devices.

Tasks

The task of the experiment is to investigate the path of light through combinations of convex and concave lenses. Specifically, the focal length and resulting refractive power of the individual systems are considered.

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Other teacher information (3/4)

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Note

The experiment is demanding in terms of skills and experimental skills. Only with careful adjustment of the respective position of the model bodies comparable quantitative results are obtained.

Since the lenses used in the experiment can already no longer be regarded as "thin" lenses, the position of the main planes is H and H' not identical with the vertical line of the line cross. The focal length determination with the help of the distance $\overline{MF}$ is therefore imprecise. However, the described method meets the requirements for the qualitative ideas that are important in the initial instruction.

Other teacher information (4/4)

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Notes on structure and implementation

In this experiment, special attention should be paid to the exact adjustment of the position of the model bodies and the precise position of the light box (incidence of the central narrow beam of light along the optical axis) during the individual experimental steps.

Focal length determination is relatively difficult at large focal lengths due to the very flat incidence of light and the resulting ambiguous fixation of the point of intersection of the light beams on the optical axis. However, parallel incident light beams further away from the optical axis cannot be used to determine the focal length due to the spherical aberration (aperture error) that occurs. For this reason, the use of the five slit diaphragm should also be avoided.

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Safety instructions

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

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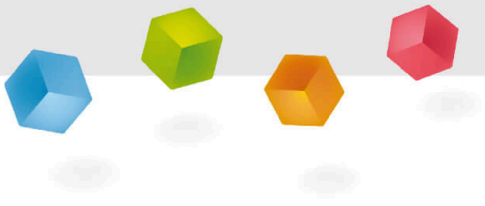

Student Information

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Motivation

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In optical components there are usually not only concave or converging lenses but combinations of different lens types. A typical example is the light microscope. A common microscope consists of two converging lenses, an objective and an eyepiece. The eyepiece functions as a magnifying glass.

Microscope as an example of a lens combination

Task

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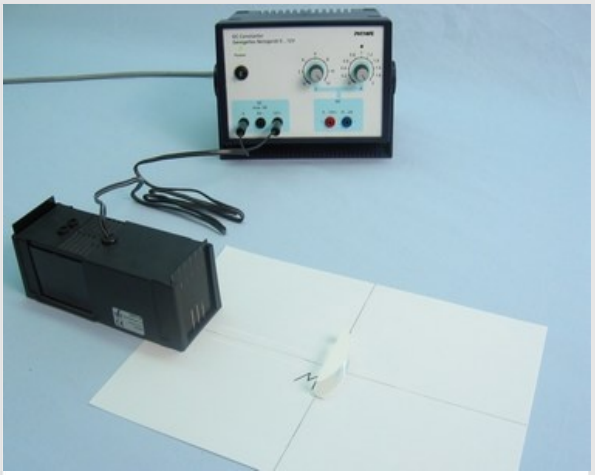

Test setup

What is the advantage of lens combinations?

- Determine the focal length of plano-convex lenses, bi-convex lenses and various lens combinations.

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Equipment

Position	Material	Item No.	Quantity
1	Light box, halogen 12V/20 W	09801-00	1
2	Block, semicircular	09810-01	1
3	Block,planoconvex lens,fl+100mm	09810-04	2
4	Block, planoconcave lens,fl-100mm	09810-05	1
5	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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Additional material

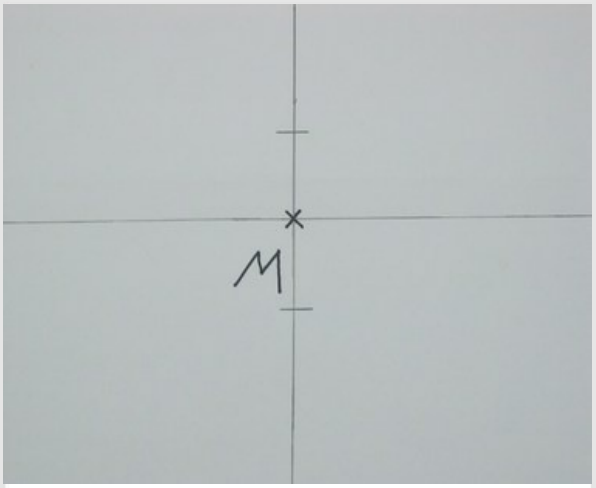
Position	Material	Quantity
1	Ruler (approx. 30cm)	1
2	White paper (DIN A4)	1

Structure (1/2)

Attention!

Make sure that the lenses are positioned with the flat surface exactly on the vertical line of the line cross and that their adjusted position does not change when moving the light box.

- Draw a right-angled cross in the middle of your sheet of paper. Let the intersection of the lines be (\M\).
- Draw at a distance of 3 cm from Mone mark each on the vertical line.



Preparation

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Structure (2/2)

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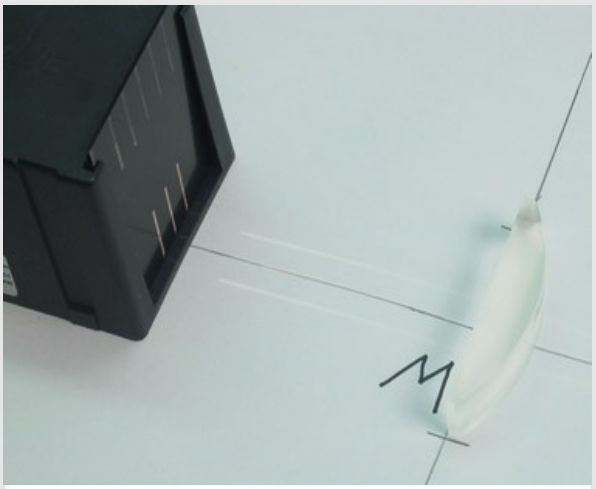
- Place the plano-convex lens (roughened side down) with the planar surface exactly at the vertical line of the line cross within the two markings.
- Insert the triple slit diaphragm into the light box on the lens side and place it about 10 cm away from the flat surface of the model body.



Preparation

Procedure (1/2)

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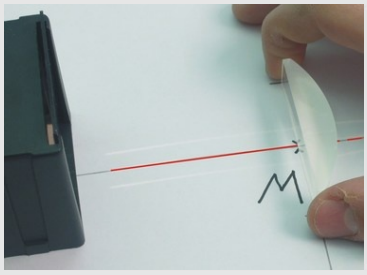
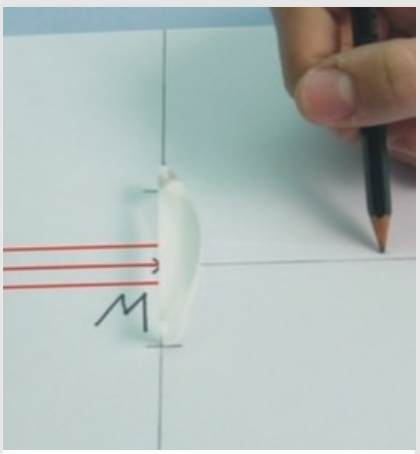


- Connect the light box to the power supply (12 V ~).
- Move the light box and the lens until the middle light beam runs exactly along the optical axis.
- Observe the path of the parallel beams of light as they pass through the lens and note your observations.
- Mark the intersection of the light beams on the optical axis and label it with F_1.



Focal point marking

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Procedure (2/2)

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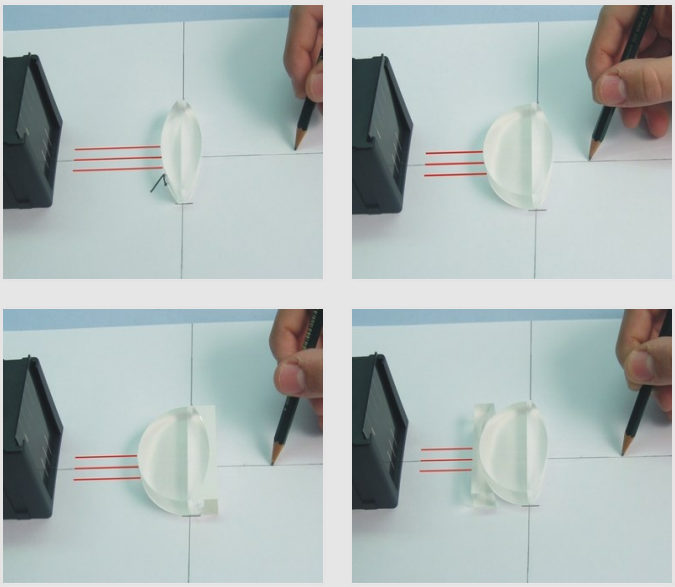
- Describe the observed light beam pattern and mark the intersection points of the light beams on the optical axis:
  - Symmetrical biconvex lens, let the intersection be F_2 (top left), Unsymmetrical biconvex lens, let the intersection be F_3 (top right).
  - Lens combination 1, let the intersection be F_4 (bottom left), lens combination 2, let the intersection be F_5 (bottom right).
- Switch off the power supply and remove the light box and the model body from the paper.



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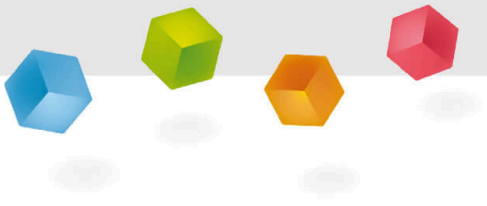

Report

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Task 1

PHYWE 10°

Determine the distance in each case f of the point M from the individual focal points.

The refractive power D is the reciprocal of the focal length f :

$D = 1/f$.

Calculate the refractive power of the lenses.

Using your results, complete the following sentence:

The refractive power of the compound symmetrical biconvex lens is much _____ than that of the single plano-convex lens. Their refractive power is about _____ as large, their focal length _____ as large.

twice | half | greater

Check

Task 2

PHYWE 10°

Does the refractive power of a lens combination depend on the order of the lenses in the light path?

- ○ No, with the different arrangement of the lenses in a lens system, the value of the refractive power remains the same.
- ○ Yes, with the different arrangement of the lenses in a lens system, a different refractive power is also achieved.

Check

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Task 3

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What is the advantage of lens combinations?

With the help of similar lenses can be in lens combinations do not change refractive power and focal length.

With the help of similar lenses, different focal lengths and refractive powers can be achieved in lens combinations.

Lenses of the same type can be used in lens combinations to achieve different focal lengths but the same refractive powers.

Lens as an example of a lens combination

Task 4

PHYWE

The values for the focal lengths of lens combinations determined according to the described procedure deviate considerably from the true values. What are the reasons for this?

- [ ] It is only due to errors in reading.
- [ ] The focal length is determined from the cross point M, although the optical center is not the same for all lenses used.
- [ ] In addition, at large focal lengths it is not possible to determine the exact point of intersection of the light beams with the optical axis due to the very flat incidence of light.

Check

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Slide	Score / Total
Slide 18: Relationship between refractive power and focal length	0/3
Slide 19: Dependence of refractive power and sequence of lenses	0/1
Slide 20: Advantages lens combinations	0/1
Slide 21: Error detection	0/2

Total 0 / 7

Solutions Repeat

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