Beam path and focal length for a convex lens

Physics | Light & Optics | Reflection & refraction of light

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/5f4dcf59ce572a000382d7fe

Teacher information

Application

single-lens imaging

We all use optical devices every day. These are mobile phone cameras, cameras, microscopes, binoculars and many, many more.

They all use lenses to enable the imaging of objects. Often these are combinations of convex and concave lenses.

This experiment deals with the imaging properties of convex lenses and thus lays the foundation for understanding optical devices.

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Other teacher information (1/4)

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Prior knowledge

The students should have learned the basics of straight-line propagation of light and the concept of diffraction beforehand.

Scientific principle

In connection with the experiments on the refraction of light, this experiment is of particular importance. The knowledge of the law of refraction is consolidated and transferred to a new subject. At the same time, the student becomes acquainted with the optical lens, which is most frequently used in the construction of optical instruments.

Other teacher information (2/4)

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Learning objective

The main focus of the experiment is to observe the course of the parallel incident light bundles collected by the convex lens and to consolidate the term "focal point". In addition, the course of three selected light bundles will be investigated experimentally and the general prerequisite for understanding the image formation to be treated later will be provided.

Tasks

1. Examination of the course of light through a plano-convex lens.
2. Investigation of the course of selected light bundles incident on a plano-convex lens.

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Other teacher information (3/4)

Since the plano-convex lens used in the experiment is already no more than "thin" lens can be viewed, the optical centre (main plane H') is inside the lens. The determination of the focal length using the distance $\overline{MF'}$ is therefore not exact.

However, the described procedure meets the requirements for the qualitative ideas that are important in initial lessons.

Other teacher information (4/4)

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Instructions for construction and implementation

Special attention should be paid in this experiment to ensure that the adjustment of the experimental set-up by means of a light beam incident along the optical axis is carried out very carefully by the student in order to achieve a clear and convincing experimental result and to acquire skills for later experiments.

It should also be ensured that the flat side of the planovex lens lies exactly on the vertical line of the line cross. The adjustments made must be checked during the procedure if the lens should have slipped due to the change in position of the light box.

The previous drawing of thin auxiliary lines is recommended. The observation and subsequent supplementation of the drawn ray paths, also for the area within the lens, offers good starting points for a consolidation of both the law of refraction and the ray path at the prism.

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Safety instructions

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- Halogen lamps become warm during prolonged use
- Avoid looking directly into the light source

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Student Information

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Motivation

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Binoculars

Optical devices:

We use binoculars, mobile phone cameras or microscopes frequently, if not daily, without thinking about what is actually inside.

In optical devices these are usually combinations of different lenses with different optical properties. One of these lenses and its imaging properties will be explained in this experiment.

Tasks

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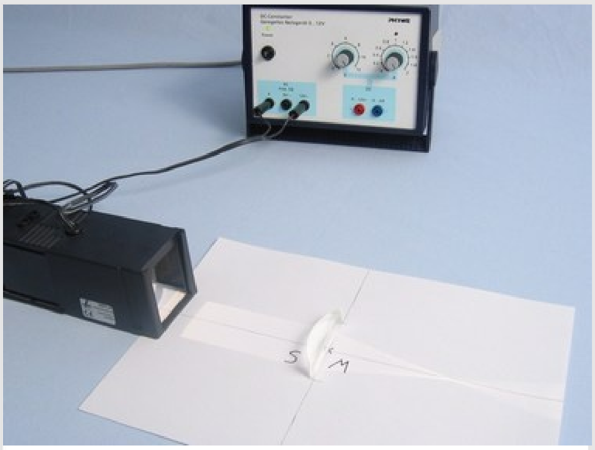

Experiment set-up

How does light pass through a lens?

1. Examine the course of light through a plano-convex lens.
2. Examine the course of selected light beams incident on a plano-convex lens.

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Equipment

Position	Material	Item No.	Quantity
1	Light box, halogen 12V/20 W	09801-00	1
2	Block,planoconvex lens,fl+100mm	09810-04	1
3	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 equipment

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

Set-up (1/2)

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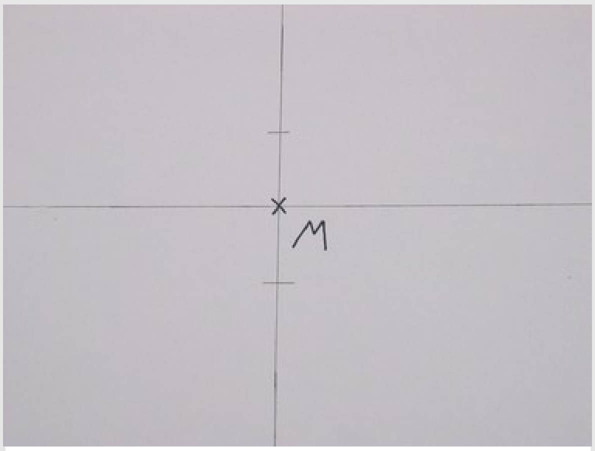

Production of the line cross

Look out!

Make sure that in all experiments with the flat surface the lens is exactly on the vertical line of the line cross and that the model body does not change its position when moving the light box.

1. course of the light through a plano-convex lens.

Draw a right-angled line cross in the middle of a sheet of paper. The point of intersection of the lines is *M*. Draw in each 3 cm distance from *M* one mark on each vertical line.

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Set-up (2/2)

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Connecting the light box

- Connect the light box to the power supply unit (12 V ~)
- Place the light box with the lens side, but without the aperture, on the edge of the sheet.
- Place the plano-convex lens with the flat surface against the vertical line of the line cross within the two marks (roughened side down).

Procedure (1/9)

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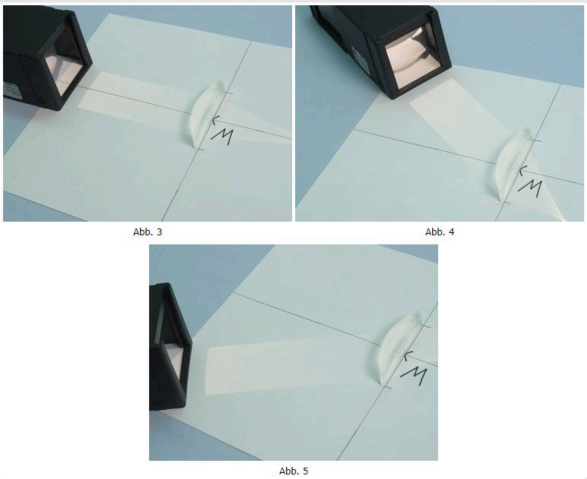

Changing the angle of light incidence

- Observe the course of the light as it passes through the lens.
- Move the light box as shown in the illustrations.
- Observe again the course of the light and note your observations in the protocol.

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Procedure (2/9)

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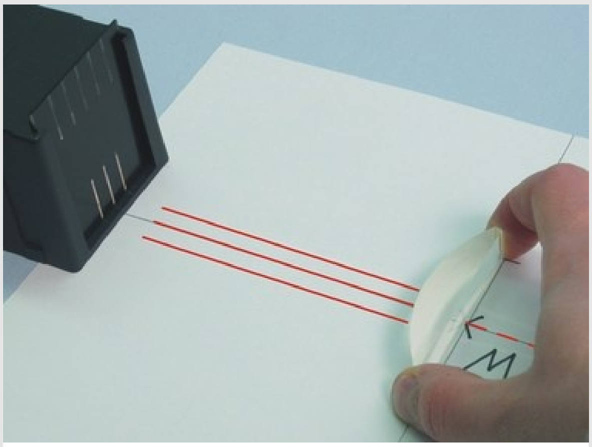

Use of the three slit diaphragm

- Insert the three-slit diaphragm into the light box on the lens side and place it about 10 cm away from the curved surface of the model body. The central light beam should be incident exactly along the optical axis.
- If it does not continue along the optical axis after passing through the lens, carefully move the lens slightly along the vertical line.

Procedure (3/9)

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Outline of the lens

- Mark the outlines of the lens with a thin pencil stroke. This results in the intersection point *S* with the optical axis.
- Describe the path of the narrow light beams as they pass through the lens, especially in the area inside the lens.
- Always mark with two crosses the course of the upper and lower light beam before and after passing through the lens.
- Mark the point of intersection of the light beams on the optical axis and designate it as *F'*.
- Connect the matching crosses so that the course of all light beams before and after passing through the lens is visible.

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Procedure (4/9)

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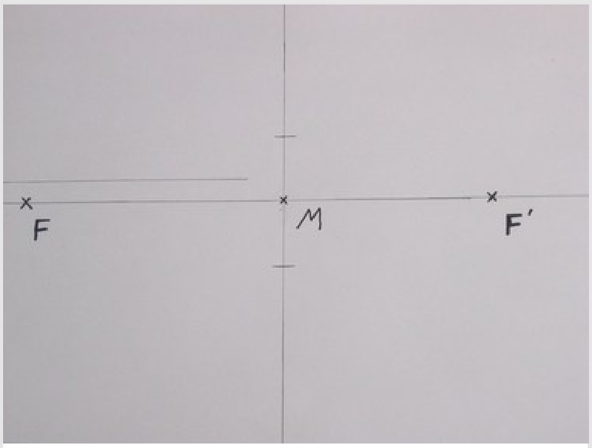

Positioning the cuvette

2. course of selected light beams.

- On a sheet of paper, prepare a line cross again with the markings as in the first part of the experiment.
- Mark at 11.3 cm distance left of *M* the point *F* and in 9.0 cm distance to the right of *M* the point *F'* on the optical axis.
- Draw a parallel as an auxiliary line 1 cm above the optical axis.

Procedure (5/9)

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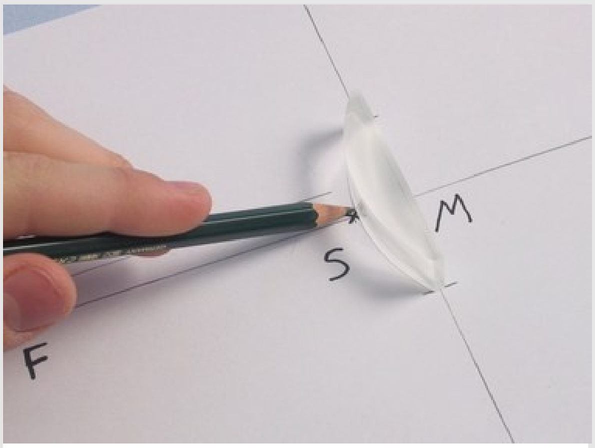

Outline of the lens

- Place the plano-convex lens (roughened side down) with the flat surface against the vertical line of the line cross within the two marks.
- Mark the outline of the lens with a thin pencil stroke and mark the intersection with the optical axis *S*.

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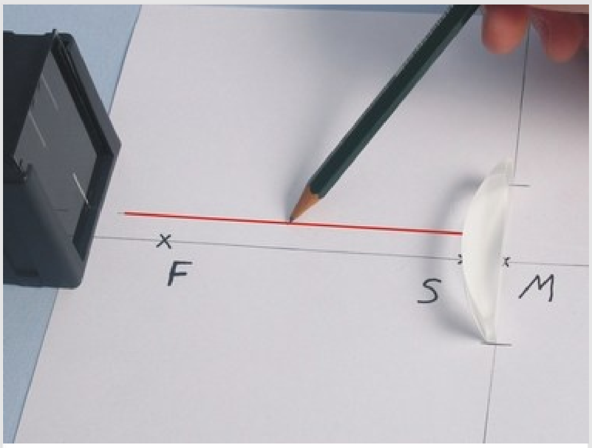
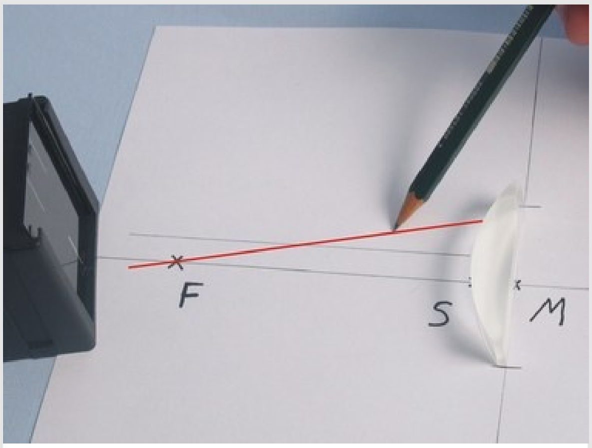
Procedure (6/9)



Use of the single-column orifice plate

- Insert the single slit diaphragm into the light box and place it at a distance of about 12 cm from the curved surface of the model body.
- Now carefully change the position of the light box until the narrow light beam is exactly parallel to the optical axis and along the guide line. Observe the refracted light beam.
- Where does this intersect the optical axis? Note the results in the protocol.
- Always mark the course of the incident and refracted light beam with two crosses.

Procedure (7/9)



Use of the single-column orifice plate

- Repeat these experiment cuts by passing the light beam through the point *F*(pay attention to the flat incidence of light).
- Write down your observations and mark again the course of the incoming and outgoing light bundles.

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Procedure (8/9)

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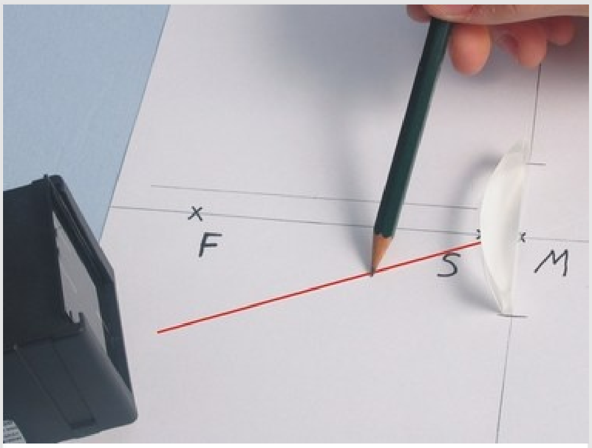

Lateral incidence of light

- Repeat your observations by moving the beam of light towards the point *M* and write them down.

Procedure (9/9)

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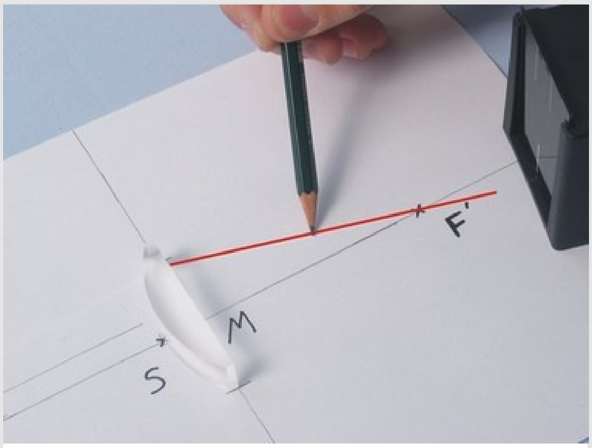

Lateral incidence of light

- Now change the position of the light box until the light falls in according to the illustration. It should be illuminated by the dot *F'* and run through the corresponding markings.
- Observe and note your results in the protocol.
- Switch off the power supply and remove the light box and model body from the paper.
- Connect the markings that belong together so that the course of the light beams is visible for all experiments.

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Report

Observation (1/3)

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Write down your observations for experimental part 1 (course of light through a plano-convex lens):

(a) observations of the light pattern without aperture

The light ______ to a convex lens ______ is ______ by a lens and converges into one point behind the lens (______ effect).

- refracted
- parallel
- incident
- collective

Check

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Observation (1/3)

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Write down your observations for experimental part 1 (course of light through a plano-convex lens):

(a) observations of the light pattern without aperture

The light ______ to a convex lens ______ is ______ by a lens and converges into one point behind the lens (______ effect).

refracted

parallel

incident

collective

Check

Observation (2/3)

PHYWE

Write down your observations for experimental part 1 (course of light through a plano-convex lens):

b) Observations of the light path with the three-slit diaphragm:

The narrow beams of light ______ to the ______ incident on a ______ are ______ twice as they pass through the glass of the lens and then pass through a common point lying on the ______.

broken

parallel

convex lens

optical axis

optical axis

Check

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Table 1

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Write down your observations for experiment part 2 in table 1.

Course of the incident light beam	Course of the emerging light beam
parallel to the optical axis (parallel beam)	
through the focal point F (focal point beam)	
through the centre M (centre beam)	

Observation (3/3)

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Write down your observations on the path of light through F.

The ______ runs exactly ______ the markings and follows the ______ to the ______.

- parallel
- along
- light beam
- optical axis

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Task 1

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Using your observations, describe how parallel light behaves when incident on a plano-convex lens.

Bundles of light ______ on a ______ parallel (to the optical axis) are ______ so that they ______ each other ______ (which lies on the ______).

- cut
- incident
- refracted
- convex lens
- at a point
- optical axis

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Task 2

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Fill in the gaps.

Measure the distance of point F (the focal point) from the center M. $\overline{MF'}$ = ______ cm

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Task 3

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Halve the distance from focal point F to the vertex S of the lens.
You get the P point. Construct an arc around P with the radius PF.
Compare this circle with the drawn outline of the plano-convex lens.
What can you infer?

The ______ has the same ______ as the ______. Therefore, P is the center of curvature of the lens.

- curvature
- convex lens
- circular arc

Note: For the plano-convex lens, when n = 1.5, f = 2r is approximated.

Check

Task 4

PHYWE

Using your observations from Table 1, formulate three sentences showing how the three selected light beams are refracted at the plano-convex lens.

After refraction at a convex lens, light bundles incident parallel to the optical axis pass through the focal point F' --> ______

Light bundles incident on a convex lens through the focal point F are ______, they continue parallel to the optical axis. --> ______

Bundles of light incident on a convex lens in the direction of the center M are ______, they continue in the previous direction. --> ______

- focal point rays
- not refracted
- center rays
- refracted
- Parallel rays

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Task 5

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Where are convex lenses used? Give 2 examples.

Examples

Additional question

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Which conclusion results from the observation of the light path through F'?

Since ______ is ______ in both directions, it follows that at ______ the reversibility of the path of light ______.

- the convex lens
- applies
- equal
- the path of light

Check

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