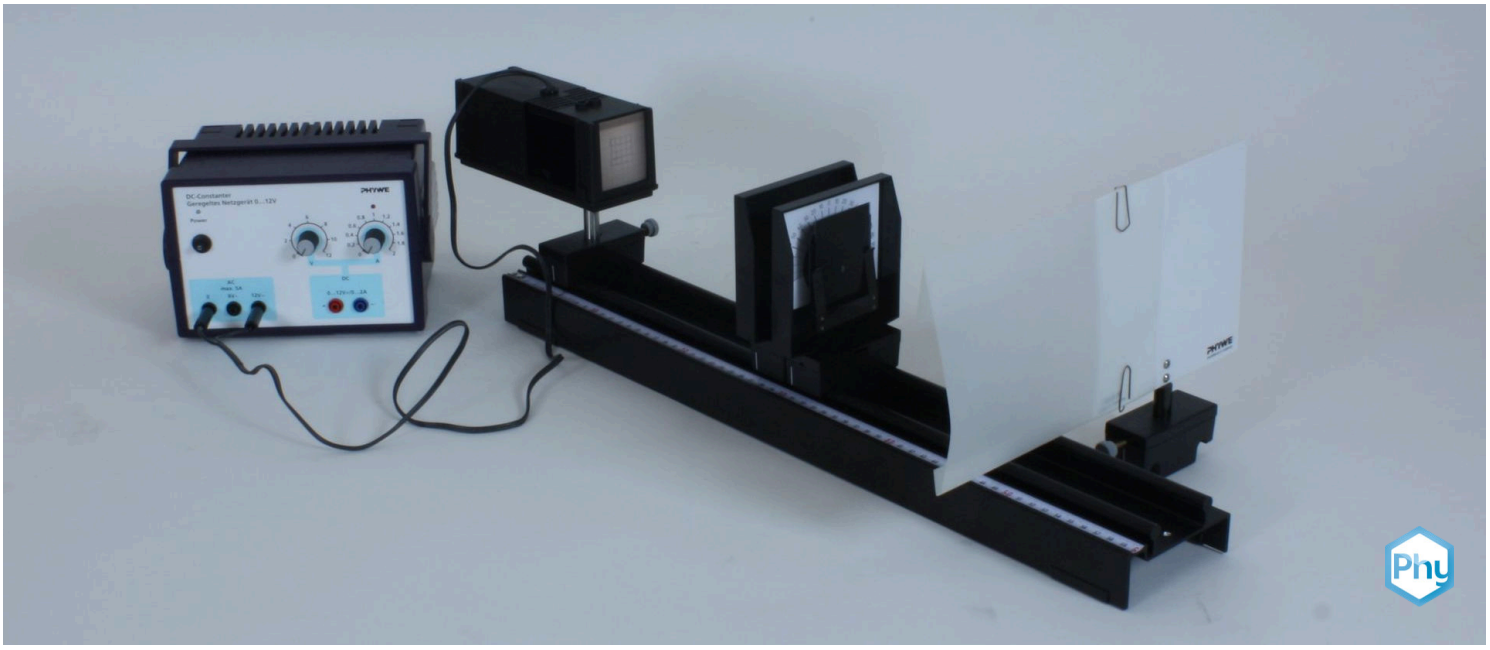
Pincushion an barrel distortion



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/62dd0a3794c15900039bae01

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Teacher information

Application

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Experimental setup

An iris is an optical device that allows you to control the brightness and sharpness of an image by limiting the aperture. When using an iris, distortion (geometric aberration) can occur. An image is distorted in a pincushion shape if the magnification increases towards the edges of the image. If the magnification decreases, the image will be barrel-distorted. The latter happens, for example, with glasses for short-sighted people.

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Other teacher information (1/4)

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Principle

Distortion is caused by the narrowing of the bundle of rays at an aperture. There is a local change in the magnification, as rays that are far from the axis are magnified more/less than rays that lie on the optical axis.

Learning objective

Students should observe and explain the optical effect of distortion.

Other teacher information (2/4)

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Task

- Students should investigate whether and how an image produced by a convex lens changes when a pinhole is placed at different points in the optical path to limit the light beam.
- Different pinhole sizes are to be used for this.

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Other teacher information (3/4)

For the experiment, it is suggested the convex lens is equipped with $f = +100\,\mathrm{mm}$so that the object width and the image width become sufficiently large to allow enough space between the luminaire and the lens or the lens and the shade to work with the pinhole.

Other teacher information (4/4)

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Notes on set-up and procedure

- The experiment requires concentrated, close observation from the student, as the changes in the image may not be as clear as desired.
- If the picture is not well lit, the students have to readjust it. For example, the pinhole can be moved a little horizontally.

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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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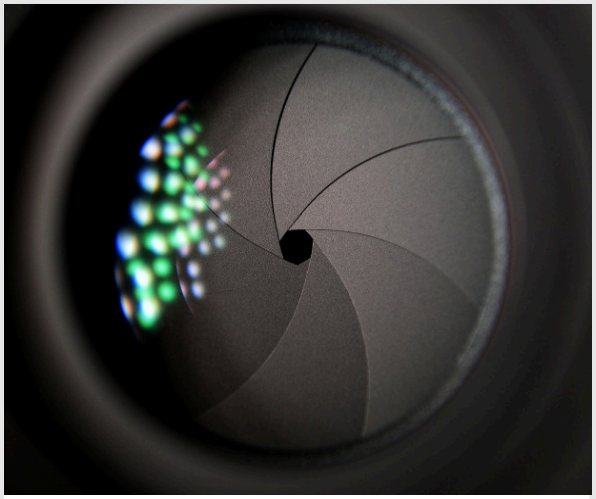

Aperture of a camera lens

An iris is an optical device that allows you to control the brightness and sharpness of an image by limiting the aperture. It is therefore an important component for camera lenses. When using an iris, pincushion or barrel distortion can occur. The latter happens, for example, with glasses for short-sighted people.

How does this distortion occur?

Tasks

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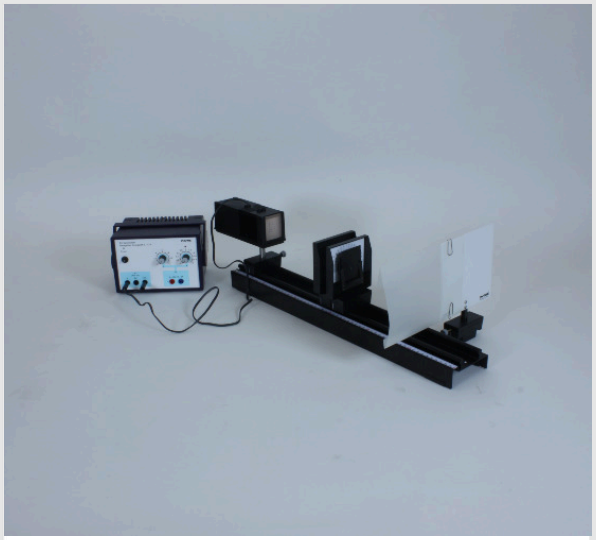

Experimental setup

- Investigate whether and how an image produced by a convex lens changes when a pinhole is placed at different points in the optical path to limit the light beam.
- For this, you should use different pinhole sizes.

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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	Diaphragms, d 1, 2, 3, 5 mm	09815-00	1
5	Lens on slide mount, f=+100mm	09820-02	1
6	Slide mount for optical bench	09822-00	1
7	Mount with scale on slide mount	09823-00	1
8	Screen, white, 150x150 mm	09826-00	1
9	Diaphragm holder, attachable	11604-09	1
10	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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Set-up (1/4)

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- 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.




Set-up (2/4)

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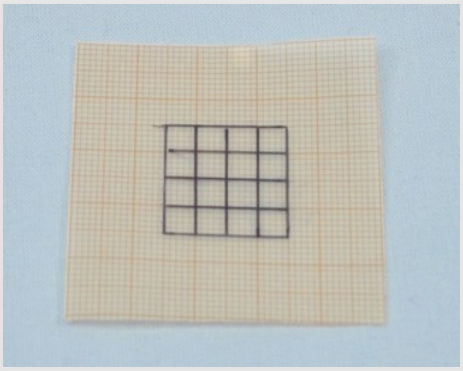
- Clamp the light box in the left part of the tripod base so that the lens side faces away from the optical bench.
- Slide an opaque screen in front of the lens and a prepared piece of graph paper into the shaft at the other end of the light.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Set-up (3/4)

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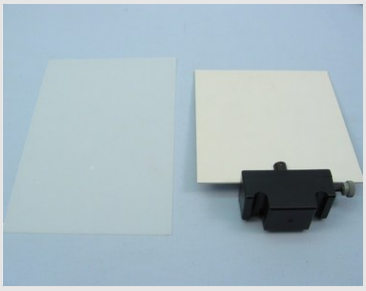

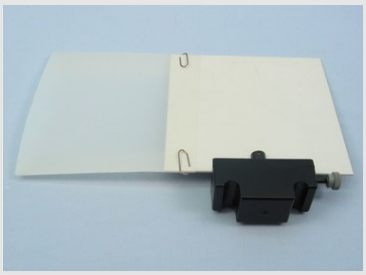

- Place the tracing paper on the screen so that about half of it extends over a vertical edge of the screen.
- Fold it around the top and bottom edges of the screen and attach it tightly with paper clips.

Structure (4/4)

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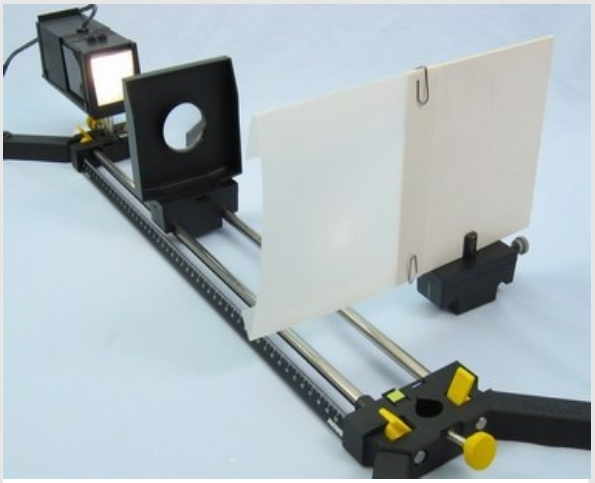

Experimental setup

- Set the lens with $f = +100\,\mathrm{mm}$ in the middle of the optical bench (object width approx. 20 cm) and place the screen on the slide to the right of it behind the optical bench so that the transparent paper hangs above it.

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Procedure (1/3)

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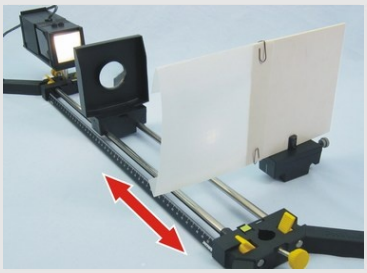

- Connect the lamp to the power supply unit (12 V~) and switch it on.
- Move the screen until you have an approximately equal image of the squares drawn on the graph paper.

Procedure (2/3)

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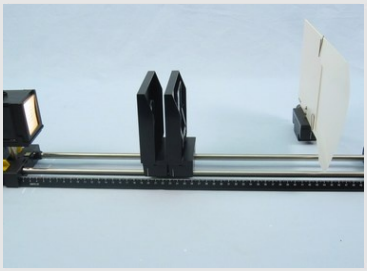

- Insert the pinhole with $d = 5\,\mathrm{mm}$ into the aperture holder, place the aperture holder on the mount with scale and place it close to the lens between the lens and the shade.

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Procedure (3/3)

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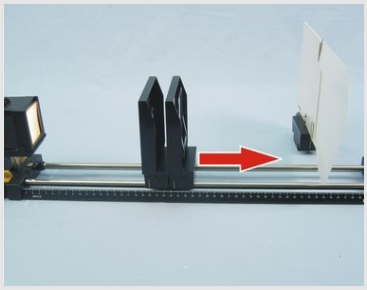

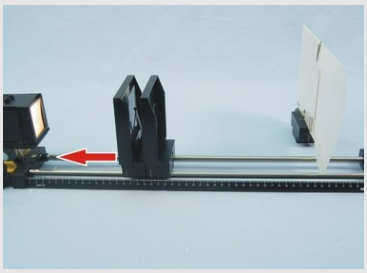

- Look towards the light path on the tracing paper and move the frame with the pinhole towards the screen. Describe the change in the image in the report.
- Now place the frame close to the lens between the object (graph paper) and the lens. Move the frame with the pinhole towards the object.
- Describe the change in the image.
- Carry out the experiment again using the pinhole with $d = 3\,\mathrm{mm}$ and check your observations so far.
- Switch off the power supply unit.

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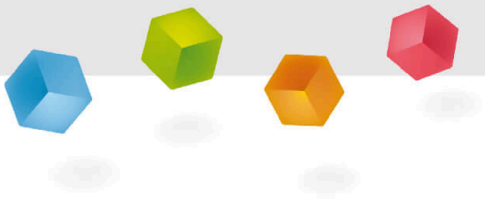

Report

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Task 1

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What do you observe when you try to move the pinhole towards the image (case a)?

- ○ The sides of the squares keep their shape.
- ○ The sides of the squares curve outwards.
- ○ The sides of the squares curve inwards.

Check

What do you observe when you try to move the pinhole towards the object (case b)?

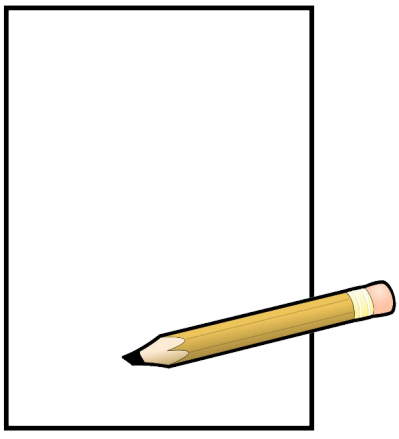
- ○ The sides of the squares curve outwards.
- ○ The sides of the squares curve inwards.
- ○ The sides of the squares keep their shape.

Check

Task 2

PHYWE

Make sketches of the images that appear on the screen in case a and b!



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Task 3

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Why do you use apertures in optical devices?

- [ ] To obtain a specific colour correction.
- [ ] To change the brightness of the image.
- [ ] To avoid lens aberrations by limiting the light beam.
- [ ] To change the size of the image.

Check

Various camera lenses

Task 4

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Where should the diaphragm be placed to avoid pincushion or barrel distortion of the image?

- ○ The diaphragm must be placed close to the lens (or lens system).
- ○ The aperture must be placed far away from the lens (or lens system).
- ○ The aperture must be placed at a distance of half the focal length of the lens away from the lens (or lens system).

Check

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Slide	Score / Total
Slide 20: Multiple tasks	0/2
Slide 22: Properties of an orifice plate	0/2
Slide 23: Arrangement of the aperture	0/1

Total 0 / 5

Solutions Repeat

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