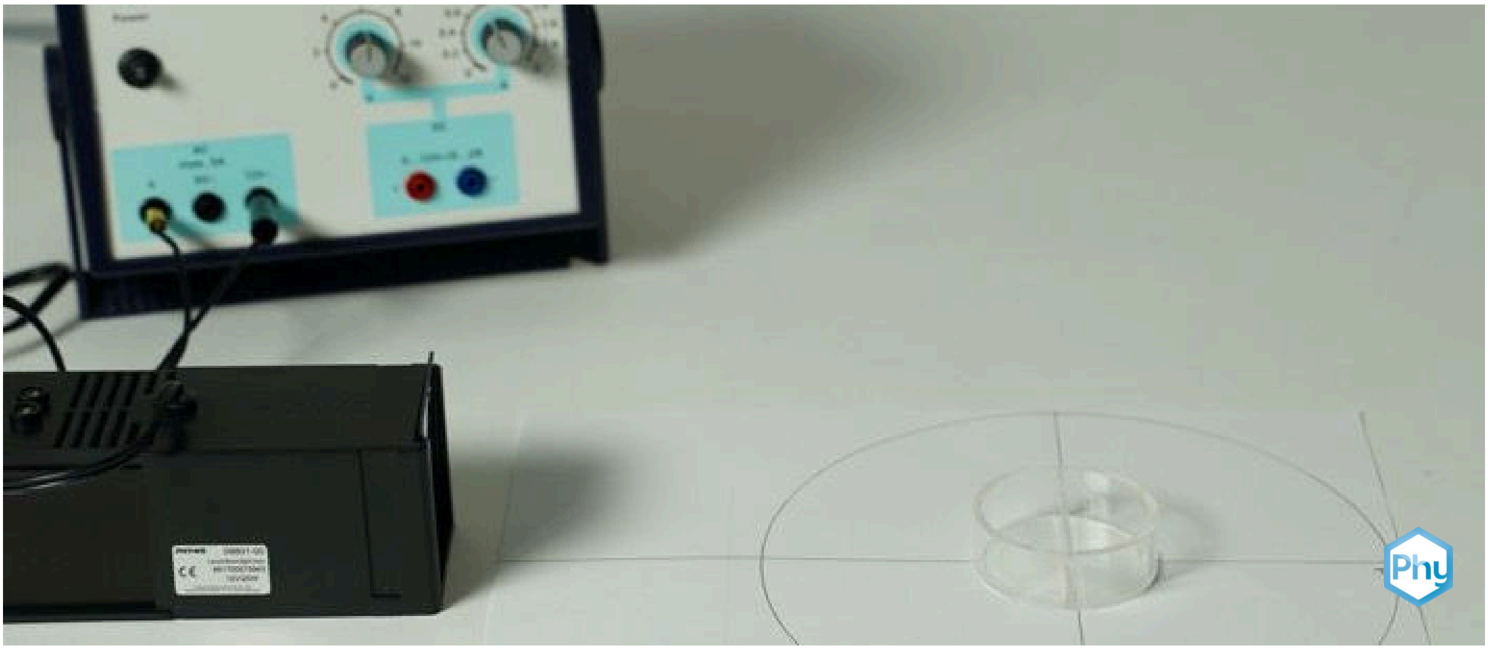
Mode of operation of the human eye (normal vision)



Physics | Light & Optics | Optical devices & lenses

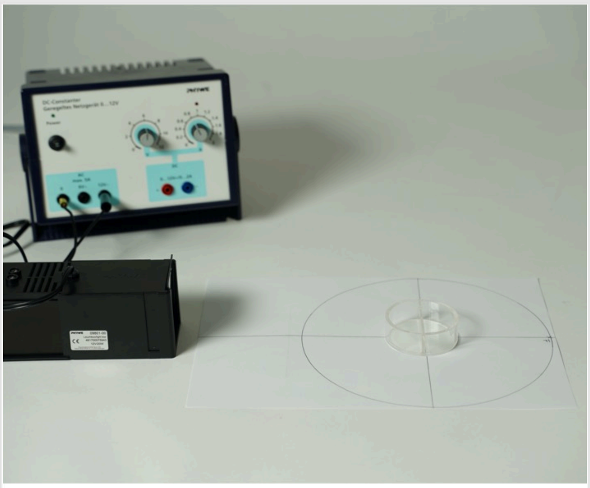
Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/5f4e6f2138db8d0003265a36

Teacher information

Application (1/2)



Experiment set-up

The experiments on the accommodation of the human eye, on defective vision and its correction are suitable to clarify the mode of action of physical laws also in living nature.

In this experiment, students are to apply their knowledge of the light path in convex lenses and of the change in focal length with lenses of different thicknesses (lens combinations) to the human eye.

Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Application (2/2)

PHYWE

In the first part of the experiment, the image on the circular arc to be considered as retina is examined under parallel incidence of light, thus simulating the position of the object in infinity. Based on the observations at light incidence slightly inclined to the optical axis, the image formation on the retina can be explained.

By changing the lens in the second partial experiment, a sharp image on the retina can be observed even with divergent incident light (simulated position of the object near the lens).

The experiment is challenging in terms of the students' abilities and experimental skills, but on the other hand, it is very demanding in terms of the motivation value for dealing with physical issues.

Other teacher information (1/3)

PHYWE

Notes on construction and implementation

If the assembly instructions (position of the arc and the cuvette, adjustment) are carefully followed, an optimum test result can be expected. The upward folded edge of the sheet of paper prevents the uninteresting observation of the course of light behind the focal point with regard to the test objective. For further improvement of the eye model, a narrow strip of paper (as retinal plane) can be glued vertically to the arc.

The inclination of the light beams with respect to the optical axis should not be more than 10°, otherwise the focal point is no longer on the circular arc.

If a plunger prober (syringe, 20 ml, made of 02591-03) is available, the process of reducing the curvature of the eye and thus the adaptation of the eye to distant objects can be simulated by aspirating the water.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Other teacher information (2/3)

Note

The advantage of the described experimental set-up compared to set-ups with the optical bench is the better approximation to real processes in the eye, which should be the subject of instruction before the experiment. The elastic change of curvature of the crystalline lens and thus the focusing of the image on the retina is caused in the human eye by the ciliary muscle (ring muscle). The mean radius of curvature varies between 10.4 mm when the ciliary muscle is not contracted and 5.7 mm when it is fully adjusted for objects close to the eye.

Other teacher information (3/3)

Learning objective

The students should gain knowledge about the light path in convex lenses and be able to apply the change in focal length with lenses of different thickness (lens combinations) to the human eye.

Tasks

Investigate the course of light in the human eye with the help of a model:

1. adjustment of the eye (accommodation) to a distant object

2. adjusting the eye to a close object.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Safety instructions

PHYWE

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

PHYWE

Student Information

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Motivation

PHYWE

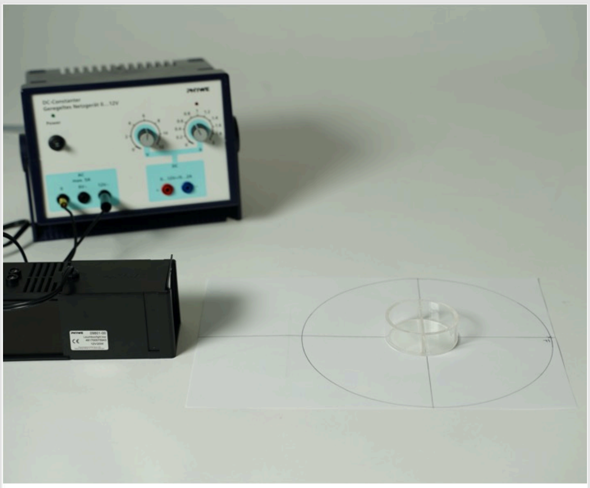
Eye

How can we watch near and far?

Things become visible to us because rays of light emanate from them. They fall through the lens into the interior of the eye onto the retina. To see clearly, all rays of light must hit the retina exactly. With the ciliary muscle we can change the shape of our lens so that we can see both near and far objects clearly. In distance vision, the lens is flat; the closer the fixed object, the rounder the lens becomes. This is the mechanism between the curvature of the lens and the incidence of light that we will look at in this experiment.

Tasks

PHYWE



Experiment set-up

Investigate the course of light in the human eye with the help of a model:

1. adjustment of the eye (accommodation) to a distant object

2. Setting the eye on a near object.

Additional is required:

- White paper
- Circle
- Ruler (approx. 30cm)
- Beaker, approx. 100ml

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Equipment

Position	Material	Item No.	Quantity
1	Light box, halogen 12V/20 W	09801-00	1
2	Cuvette, double semicircular	09810-06	1
3	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Assembly - Attention!

PHYWE

Make sure that the trapezoidal model body does not change its position when moving the light box.

Set-up (1/2)

PHYWE

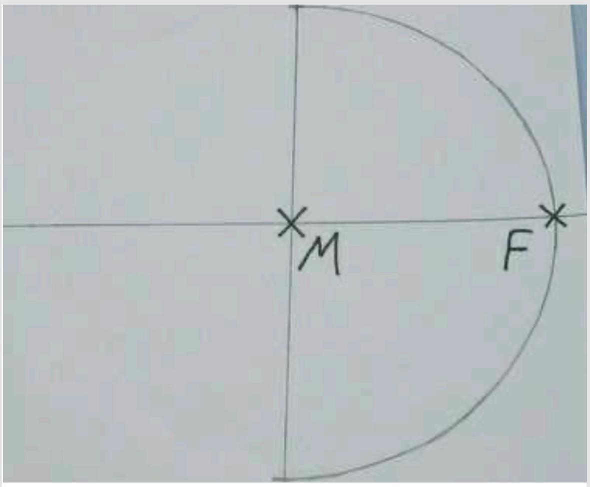


Figure 1

Attention: Make sure that the cuvette does not change its position when moving the light box.

Prepare your sheet of paper as shown in Figure 1.

Draw a right-angled line cross (intersection M) at 8.5 cm from the right edge and one mark on each vertical line at a distance of 3 cm from M.

Draw a semicircle around M with a radius of 7.5 cm. The point of intersection with the optical axis is F. The semicircle represents the retina in your eye model.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Set-up (2/2)

PHYWE

Fig. 2: Fold the sheet of paper 1 cm from the right edge upwards as a screen. Place the cell exactly within the marks on the line cross.

The partition wall inside the cuvette must be at right angles to the optical axis, i.e. on the vertical line. The cuvette represents the lens of the eye in your model.

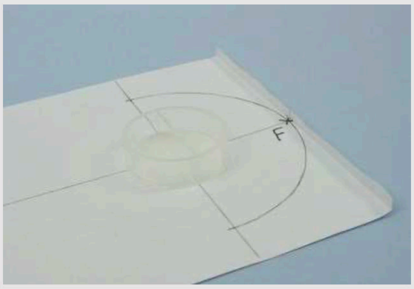
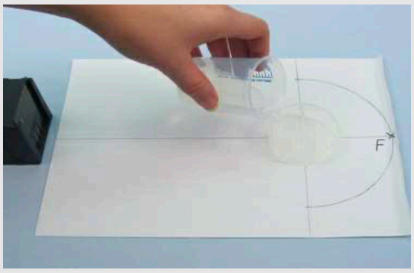


Fig. 3: Insert the three-slit diaphragm into the light box on the lens side and place the light box at about 1 cm from the left edge of the sheet. carefully fill the half of the cuvette facing the light box with about 20 ml water.



Procedure (1/5)

PHYWE

1. adjusting the eye to distant objects

Fig. 4: Connect the light box to the power supply unit (12 V ~)

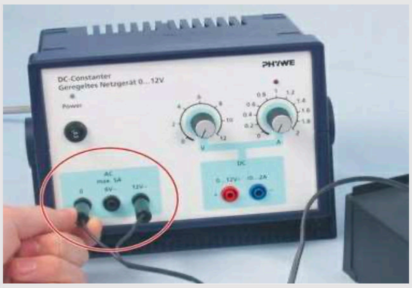
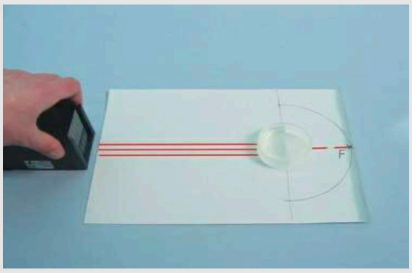


Fig. 5: Move the light box until the middle light beam runs exactly along the optical axis and unbroken through the cuvette. If this is not the case, carefully move the cuvette slightly along the vertical line.



PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Procedure (2/5)

PHYWE

Fig. 6: Using a thin pencil, carefully mark the contours of the cuvette without moving it.

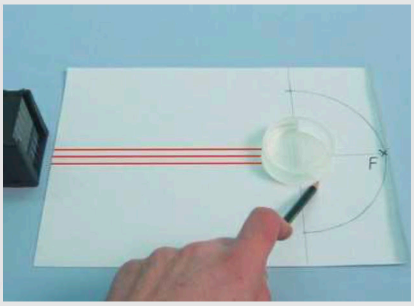
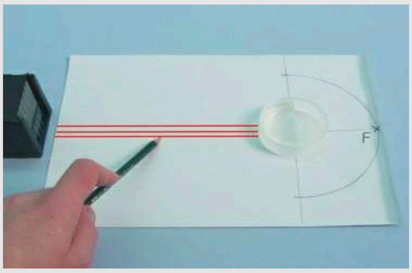


Fig. 7: Observe the course of the light as it passes through the cuvette and hits the screen. Write down your observations in the table in the protocol.

Always mark the incoming and refracted light beams with two crosses.



Procedure (3/5)

PHYWE

Fig. 7: Now move the light box until the light is incident on the cuvette at a slight angle to the optical axis, but the central light beam must continue to run exactly in the direction of the line cross (point M). Observe again the course of the light, in particular the position of the focal point in relation to point F. Write down your observations.

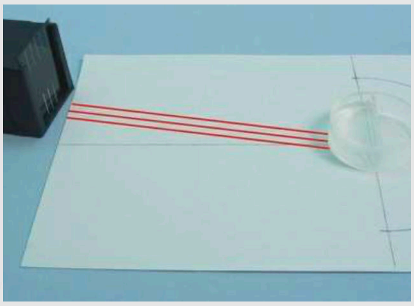
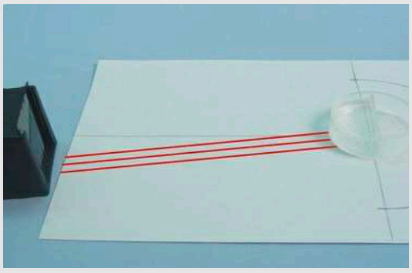


Fig. 8: Repeat these observations for the slightly upward inclined position of the light box. Write down your observations in the table.



PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Procedure (4/5)

PHYWE

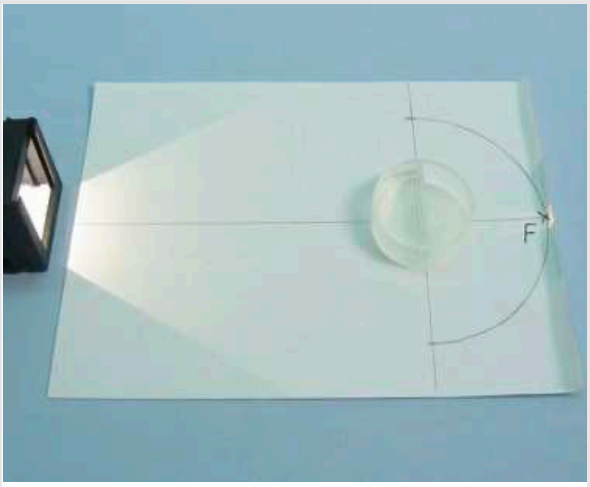


Figure 9

2. adjusting the eye to close objects.

Fig. 9: Rotate the light box 180° and remove the aperture so that divergent light is now falling on the cuvette. The position of the light box is identical to the position in the first partial experiment.

Observe the course of the light behind the cuvette, especially when it hits the screen. Note your observations in the protocol.

Procedure (5/5)

PHYWE

Fig. 10: Now carefully fill the other half of the cuvette with approx. 20 ml water.

Observe the change in the course of the light and note your observations in the table.

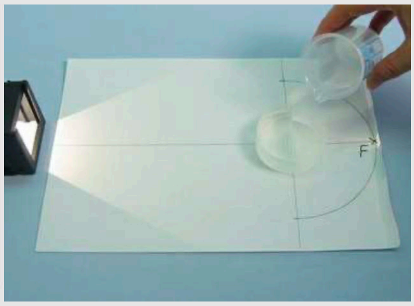
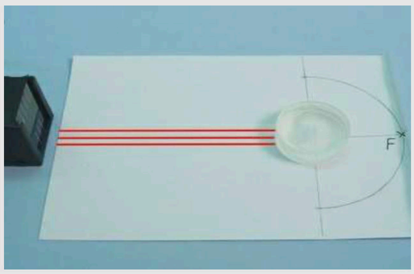


Fig. 11: Rotate the light box again by 180° so that now parallel light (with a three-slit diaphragm) falls again in the direction of the optical axis onto the completely filled cuvette.

Observe the course of the light, especially the position of the focal point and the image on the screen. Write down your observations.



PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Report

Table (1/2)

Write down your observations in the table.

Test conditions	Observations
parallel light along the optical axis	
parallel light, light box in position 2	
parallel light, light box in position 3	

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Table (2/2)

Write down your observations in the table.

Test conditions	Observations
divergent light	
Filling water into the second cuvette half	
parallel light along the optical axis, on the fully filled cuvette	

Evaluation - Question 1

Connect the matching crosses on your sheet of paper so that the course of the light beams is visible outside the cuvette and, after appropriate connection, also inside. Compare the course of parallel light passing through the half-sided water-filled cuvette with the light path through convex glass lenses.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Evaluation - Question 2

PHYWE

Compare your observations on the course of parallel light when it hits a cuvette half filled with water in the table. What is the common ground?

Evaluation - Question 3

PHYWE

Almost parallel light is emitted from objects far away from the eye. Formulate a statement about the course of light in the human eye when objects are far away.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Evaluation - Question 4

PHYWE

What changes when the cuvette illuminated with divergent light is completely filled with water?

Evaluation - Question 5

PHYWE

Divergent light enters the eye from objects close to the eye. How does the human eye adapt to the distance of these objects?

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Evaluation - Question 6

PHYWE

What conclusion can be drawn from the result of the last partial experiment (parallel light falls on the fully filled cuvette) when the eye is closed again from the model?

Evaluation - additional task

PHYWE

What is the assumption about the position of the image on the retina when you look at the results of the experiments where the light fell on the cuvette obliquely from above or below?

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 1

PHYWE

Drag the terms into the correct gaps in the text.

Through ____ things become safe for us. These must then pass through the ____ and hit the ____ so that we can see clearly. With the ____, we can change the shape of our lens so that we can see both near and far objects clearly.

- light beams
- ciliary muscle
- lens
- retina

Check

Task 2

PHYWE

To see in the distance, the lens in the eye must have the following shape:

- flat
- round

Check

Landscape

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 3

PHYWE

A common cause of myopia occurs when light is not focused directly on the retina. This is caused by:

- A curvature in the retina.
- One eyeball too short.
- An eyeball that's too long.

Check

Vision test for myopia

Slide	Score / Total
Slide 30: Seeing through the light	0/4
Slide 31: Looking into the distance	0/1
Slide 32: Myopia	0/1

Total amount 0 / 6

Solutions Repeat Exporting text

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de