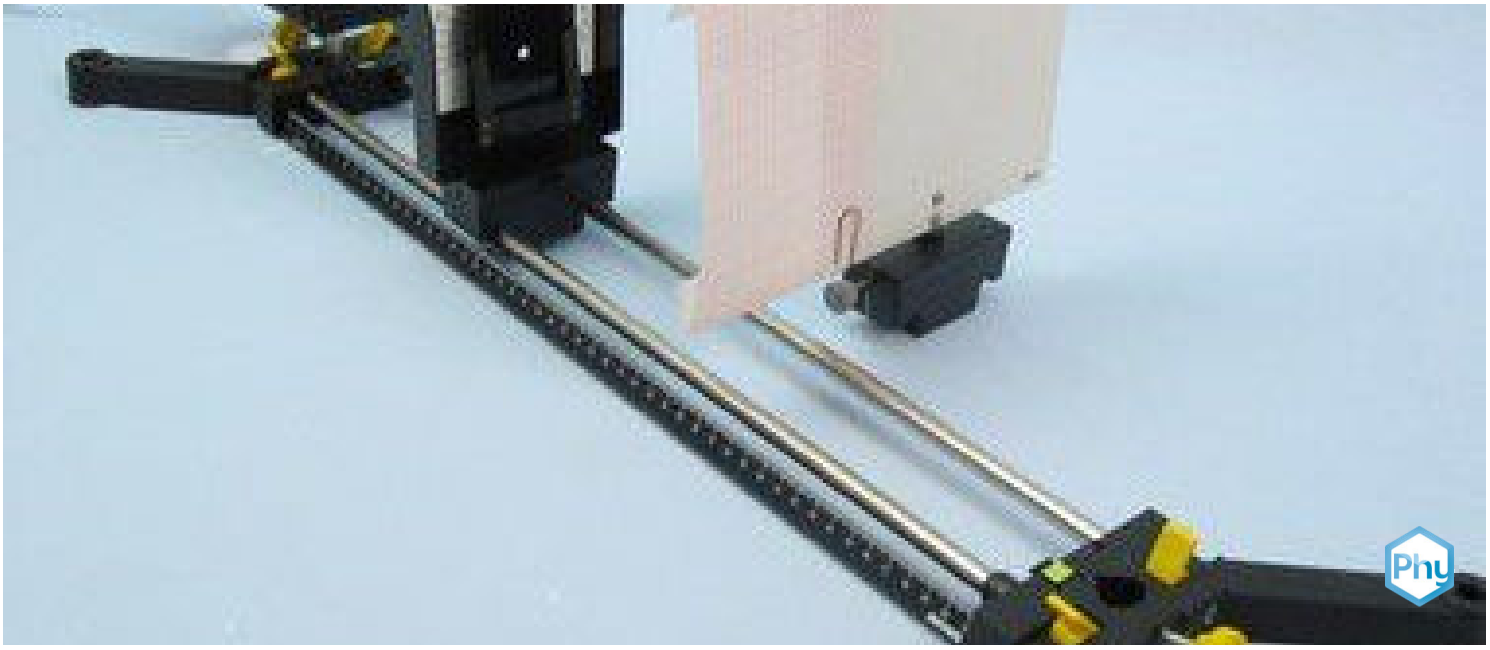
The pinhole camera



Physics > Light & Optics > Optical devices & lenses

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

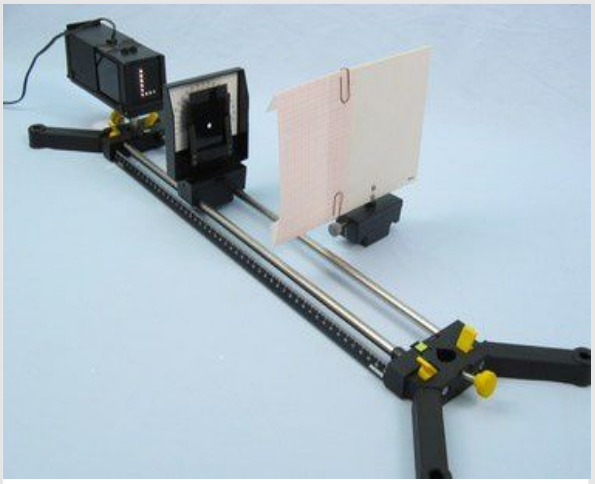
This content can also be found online at:

http://localhost:1337/c/62d6fb5b9ae57200034904f0

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

Teacher information

Application



Experimental setup

The pinhole camera is a simplified type of camera. Although pinhole cameras are no longer generally used for taking photographs, the way they work illustrates physical principles of light optics.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Other teacher information (1/4)

PHYWE

Principle

The light of an object falls through a small hole in an otherwise lightproof hollow body and is caught at a certain distance by a screen. A real and upside-down image is created on the screen, which can be stored, for example, by a light-sensitive photographic paper.

Learning objective

Students will gain an insight into the basics of light optics by differentiating between image width and object width, learning about the optical properties of an aperture and the resulting sharpness of an image.

Other teacher information (2/4)

PHYWE

Task

1. Students observe with different diaphragm diameters $d = \{1, 2, 3, 5\}\,\mathrm{mm}$ the changes of the image on the screen and describe these changes.
2. By varying the image distance b while the object distance g remains the same, students observe the changes in image size and brightness.
3. For four different positions of the diaphragm with $d = 2\,\mathrm{mm}$ and of the screen, the sizes g and b measured and entered in a table.
4. Both image size B as well as object size G are measured using a ruler and noted in the table.
5. The students calculate the quotients b/g and B/G in the table and compare them with each other. In doing so, the relation $A = b/g = B/G$ is determined, where A is the magnification.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Other teacher information (3/4)

Building a pinhole camera is quite easy, and students generally enjoy making and experimenting with a pinhole camera. It is therefore recommended that they are given a corresponding homework assignment.

The experiment with the pinhole camera model has the advantage that it allows exact investigations of the conditions that influence the image quality.

The use of the Perl-L in the pinhole camera studies is advantageous not only because the images become quite bright, but because the discrete image "points" allow one to convincingly demonstrate and discuss what image sharpness means: If the arrangement of the parts of the pinhole camera remain unchanged, and the pinhole diameters are enlarged, one can clearly see how each Perl "image" becomes larger, but the centres of the Perl images do not change their spacing.

Other teacher information (4/4)

PHYWE

Notes on set-up and procedure

The physics room must be as dark as possible so that the contrasts on the transparent screen are clear. Using transparent graph paper as a screen is therefore recommended so that the students can remember the image size better when changing the pinhole diameters and can determine it more easily while taking the measurements. If the transparent screen is a little wavy, it is recommended to staple a strip of plastic foil to the upper and lower edges and use this to stretch the paper.

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 lessons apply to this experiment.

PHYWE

Student information

PHYWE

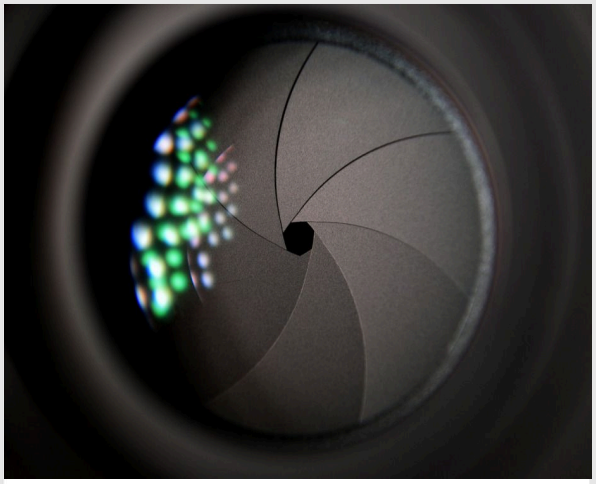
Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Motivation

PHYWE



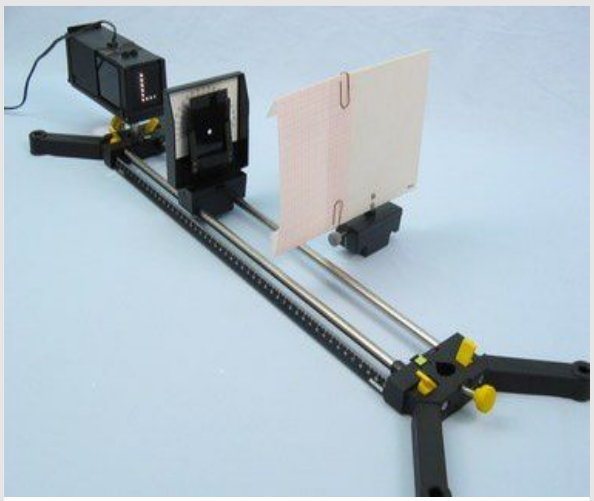
Aperture of a photographic lens

How do cameras actually work?

Admittedly, the question is not easy to answer for modern cameras. The pinhole camera, on the other hand, is a simple idea for taking pictures. Aristotle is said to have described the principle of a pinhole camera as early as the 4th century BC. You can even observe the principle in nature: Sunlight shines through the treetop onto the forest floor. Many small gaps (apertures) form between the leaves, causing circular light spots to appear on the forest floor. These light spots are images of the sun.

Tasks

PHYWE



Experimental setup

1. Observe with different aperture diameters $d = 1,\ 2,\ 3$ und $5\,\mathrm{mm}$the changes of the image on the screen and describe these changes.
2. Change the image width b while keeping the object distance g constant and observe the image size and brightness.
3. Then, calculate the quotients b/g and B/G and compare them with each other.

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	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	Slide mount for optical bench	09822-00	1
6	Mount with scale on slide mount	09823-00	1
7	Screen, white, 150x150 mm	09826-00	1
8	Diaphragm holder, attachable	11604-09	1
9	Object -L-, glass bead	11609-00	1
10	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

Set-up (1/4)

PHYWE

- 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.

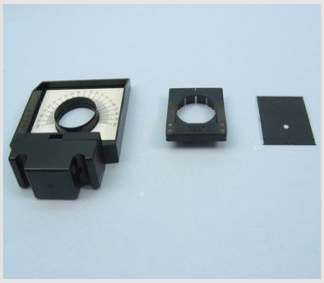



Set-up (2/4)

PHYWE

- 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 shade with the Perl-L into the shaft at the other end of the luminaire.
- Set the pinhole with d = 5 mm into the aperture holder and put it on the socket.






PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

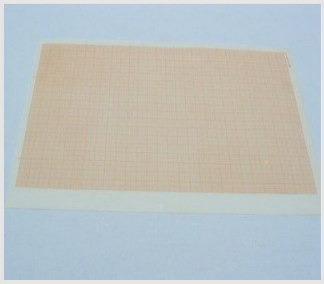
info@phywe.de
www.phywe.de

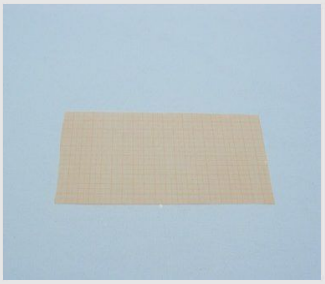
Set-up (3/4)

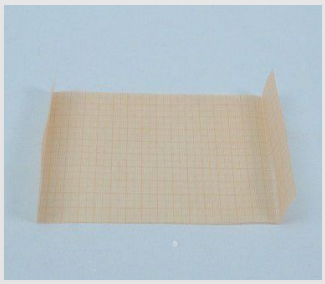
PHYWE

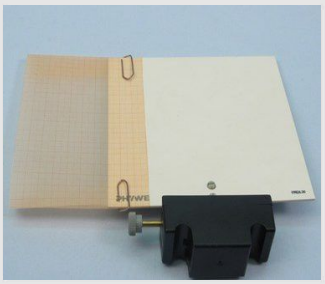
Prepare the screen:

- Take the transparent graph paper and cut out a piece measuring 100 mm x 200 mm.
- Fold the transparent graph paper on the narrow sides by approx. 25 mm and attach it to the screen with the help of the paper clips so that it protrudes over the vertical edge by approx. 70 mm.
- The protruding surface of the transparent graph paper serves as the screen in the experiment.





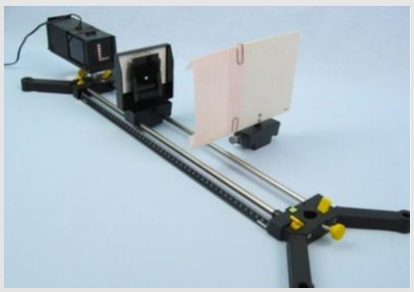


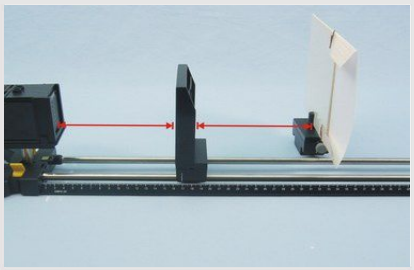


Structure (4/4)

PHYWE

- Place the pinhole in the optical bench and the screen to the right of the pinhole in front of the optical bench so that paper hangs over the optical bench.
- Make sure that the distances of the Perl-L from the aperture and the aperture from the paper screen are approximately the same.





PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

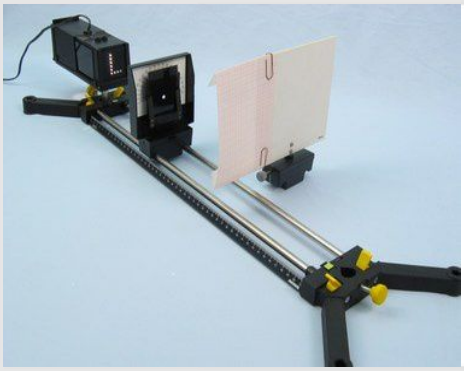
info@phywe.de
www.phywe.de

Procedure (1/5)

PHYWE

- Connect the lamp to the power supply unit (12 V~) and switch it on.
- Look at the transparent paper screen against the light coming from the Perl-L. Describe the image in the report.

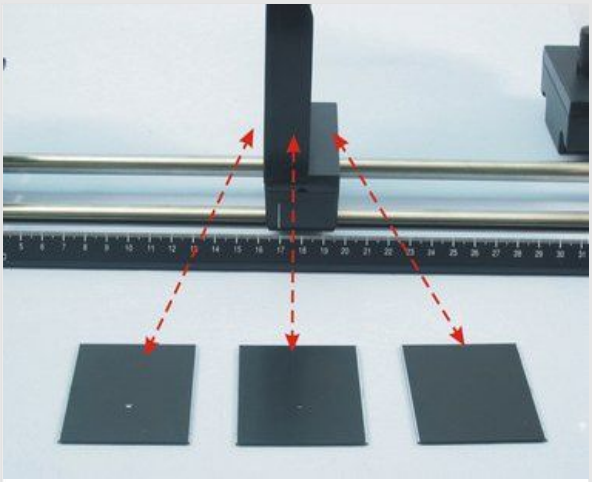
Power supply unit



Experimental setup

Procedure (2/5)

PHYWE

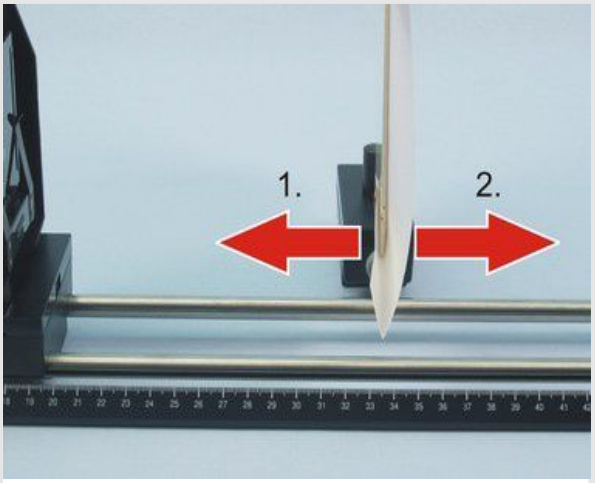


Inserting the pinholes with d=3; 2; 1 mm

- Replace the pinhole with d = 5 mm one after the other through the orifices with d = 3; 2; 1 mm.
- Observe the change of the image on the screen. (Look for possible changes in image sharpness, image size and image brightness).
- Describe your observations in the report.

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

Procedure (3/5)

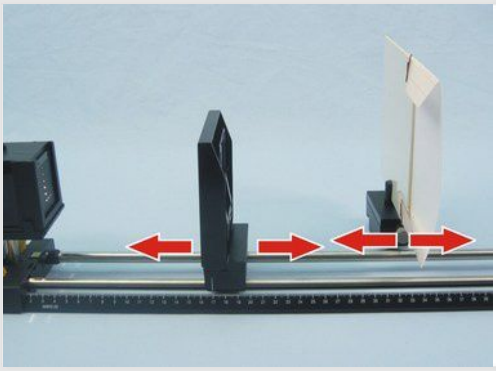


Variation of the screen

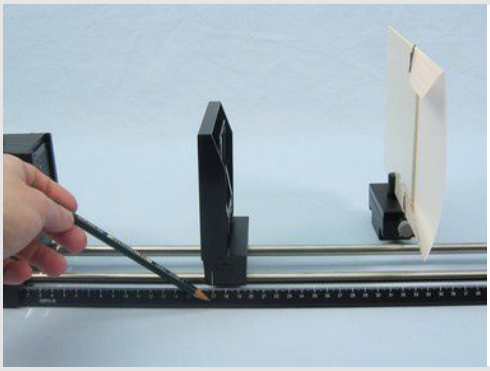
- Move the screen further to the left and then to the right, so change the image distance *b* with constant object distance *g*.
- What do you notice about the image size and brightness?

Procedure (4/5)

- Measure for four different positions of the aperture with $d = 2\,\mathrm{mm}$ and of the screen sizes g and b.



Variation of the aperture and the screen



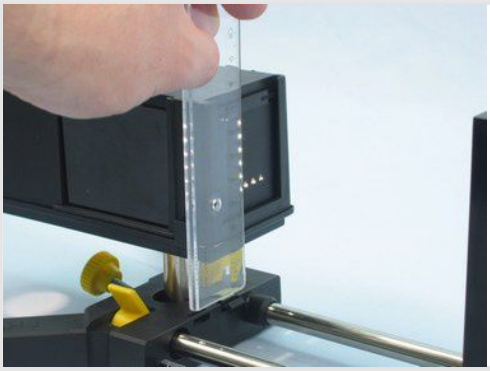
Reading the sizes

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

Procedure (5/5)

PHYWE

- Also measure the sizes G and B with the ruler.
- When measuring, determine the distances between the centers of the outer beads or their images. Enter the measured values in the log and switch off the power supply.



Reading off the sizes with the ruler

Measuring the distance between the outer beads

PHYWE

Report

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Observation 1

PHYWE

Describe the picture!

Insert the explanation in the field below

Observation 2

PHYWE

How does the image change as a result of the change in image distance?

Insert the explanation in the field below

How does changing the hole size change the image?

Insert the explanation in the field below

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Table 1

PHYWE

Enter your measurements in the table.

g [cm]	b [cm]	G [cm]	B [cm]	B/G	b/g

Task 1

PHYWE

What are the advantages of choosing the smallest possible hole diameter when building a pinhole camera? What disadvantage do you have to accept? (Fill in the blanks!)

Choosing a small [ ] has the advantage of producing a sharp [ ]. At the same time, one accepts the disadvantage that the [ ] is low.

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Task 2

PHYWE

Calculate the quotients in the table B/G and b/g to 2 decimal places. Enter their values in the last two columns and compare them line by line.

What do you find?

- ○ For all 4 positions $B = 1, 11$
- ○ The quotients are almost the same.
- ○ $b = B$ and $g = G$

Check

Task 3

PHYWE

What is the result from the previous question in mathematical form?

- ○ $B/b = G/g$
- ○ $B/G = b/g$
- ○ $B = b$ and $G = g$
- ○ $B = g$ and $G = b$

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Task 4

PHYWE

The quotient B/G means magnification A. Why do you calculate A generally with the help of the equation $A = b/g$?

- ○ This is easier because g and b are easier to measure.
- ○ You can change the sizes B and G do not measure.

Check

Task 5

PHYWE

Why does the image produced by the pinhole camera become more blurred the larger the hole in the aperture becomes? (Fill in the gaps!)

In the pinhole camera, each [ ] is not imaged as a pixel, but as a light spot.

This [ ] is larger the larger the hole in the aperture. This makes the [ ] all the blurrier, the larger the [ ] of the aperture.

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Slide	Score / Total
Slide 25: Hole diameter	0/3
Slide 26: Ratios	0/1
Slide 27: mathematical relation	0/1
Slide 28: Magnification	0/1
Slide 29: Image sharpness	0/4

Total 0 / 10

Solutions | Repeat | Export text

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