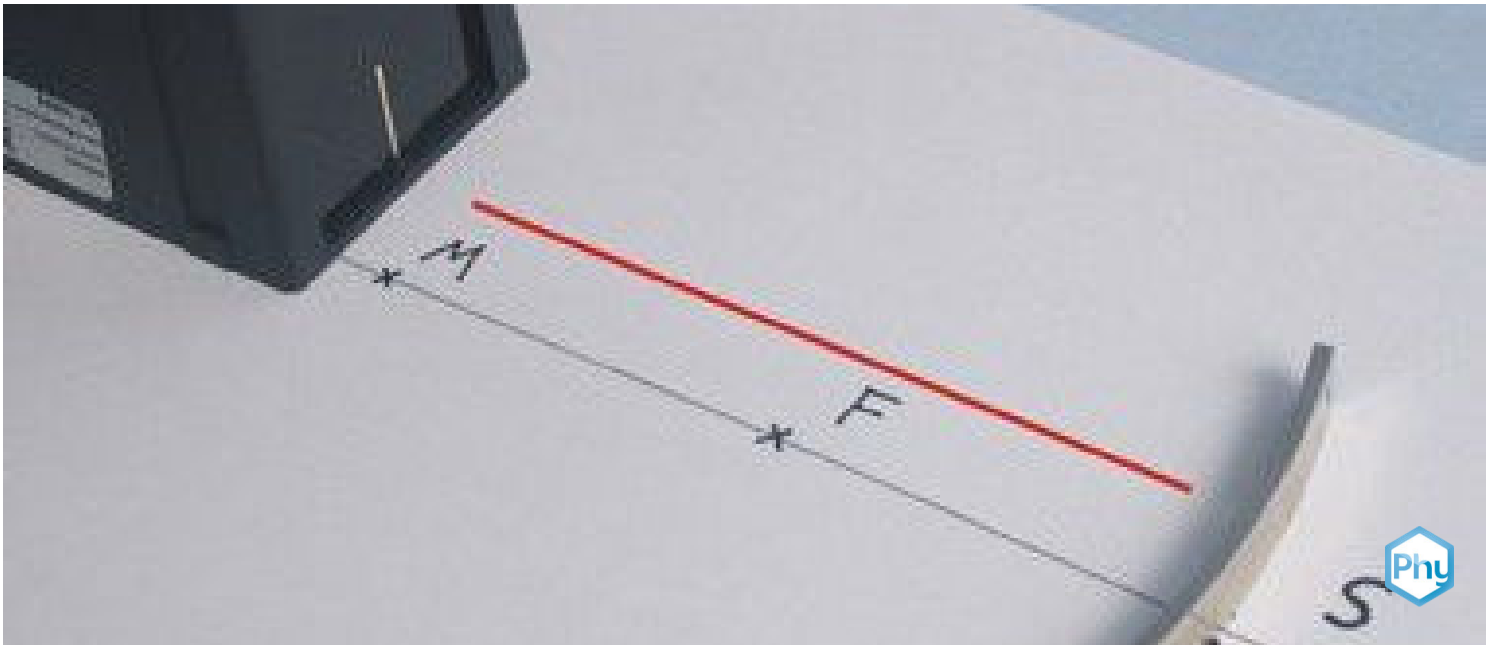
Reflection by a concave mirror



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:

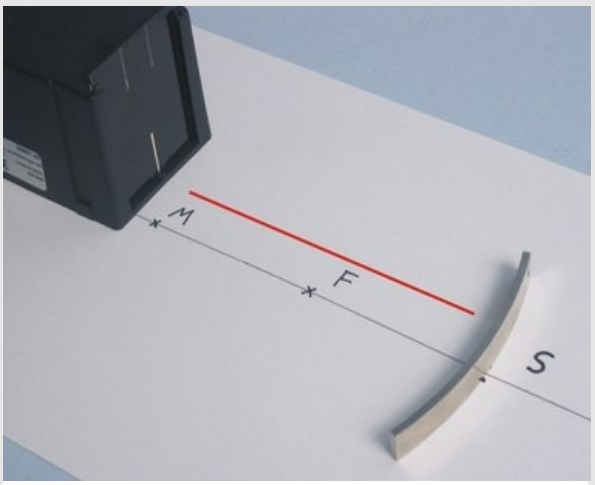
http://localhost:1337/c/631a3a4abce9830003710442

PHYWE

Teacher information

Application

PHYWE



Reflection at the concave mirror

A concave mirror is a mirror that is curved concavely (inwards).

For example, a concave mirror, which concentrates the light rays in its focal point, is used to harness solar energy.

Another interesting application is the use of a parabolic mirror, a concave mirror in the form of a paraboloid of revolution. These are used in astronomical radio telescopes and optical reflecting telescopes, among other things.

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

Other teacher information (1/5)

PHYWE

Prior knowledge

The students should have previously learned the basics of the straight-line propagation of light. In addition, they should know the law of reflection and ideally have carried out the experiment "Images in a plane mirror".

Principle

Concave mirrors have a characteristic beam path. Light rays incident parallel to the optical axis become focal rays after reflection. Centre rays remain centre rays and focal rays become parallel rays.

Other teacher information (2/5)

PHYWE

Learning objective

This experiment is of particular importance in the series of experiments on the reflection of light. The knowledge about the law of reflection and about reflection on a plane mirror is consolidated and transferred to a new situation.

Tasks

The focus of the first part of the experiment is on observing the course of the parallel incident light beams reflected by the concave mirror and, in this context, getting to know the term "focal point".

In the second part of the experiment, the course of three selected light beams is investigated experimentally, thus providing the general prerequisite for understanding the formation of the image to be discussed later.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Other teacher information (3/5)

PHYWE

Notes on set-up and procedure 1

The second part of the experiment is more demanding in terms of the students' abilities and experimental skills. Both experiments can be seen as a unit, but an seperate execution is also possible and advisable in the interest of a conscientious execution and the development of experimental skills.

However, it is also advisable to work separately and together (each learning group examines the course of a different selected light beam; at the end of the experiment, the results are summarised).

Other teacher information (4/5)

PHYWE

Notes on set-up and procedure 2

In this experiment, special attention should be paid to the fact that the adjustment of the mirror with the help of the light beams coming from the light box is carried out very carefully by the student in order to achieve a clear and convincing experimental result.

There are two possible ways to do this. One method uses the incidence and reflection of a narrow beam of light along the optical axis. Another method uses the imaging of the focal point on the optical axis with five light beams generated by the five-slit diaphragm and reflected at the concave mirror to check the correct position of the mirror

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Other teacher information (5/5)

PHYWE

Notes on set-up and procedure 3

Care should also be taken to ensure that the centre of the inner curvature of the mirror is always at point S of the optical axis.

The settings made may have to be checked again during the test if the mirror has slipped due to the change in position of the light box in the second part of the test. It makes sense to use different colours or different markings to identify the individual light paths in order to enable an error-free evaluation. It is also advisable to draw thin auxiliary lines beforehand. This facilitates e.g. a parallel incidence of light to the optical axis.

Safety instructions

PHYWE

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

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

PHYWE

Student information

Motivation

PHYWE

We encounter mirrors every day in a wide variety of designs. A special type of mirror is the so-called concave mirror. These are inwardly curved mirrors that concentrate the reflected rays in one point, the so-called focal point.

Concave mirrors are used in radio telescopes, for example, as shown on the right. They can be used to receive radio frequencies from space.

Image of two radio telescopes

PHYWE

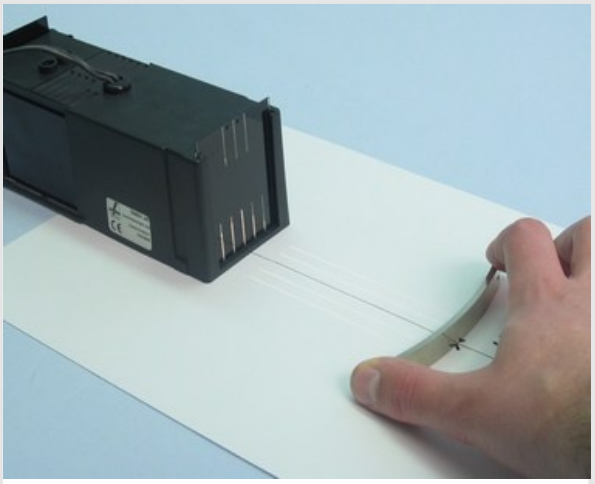
Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Tasks

PHYWE



Experimental setup

How is the light reflected at the concave mirror?

Investigate how light is reflected from a concave mirror.

Investigate the course of selected light beams reflected by a concave mirror.

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	Mirror, concave-convex	09812-00	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

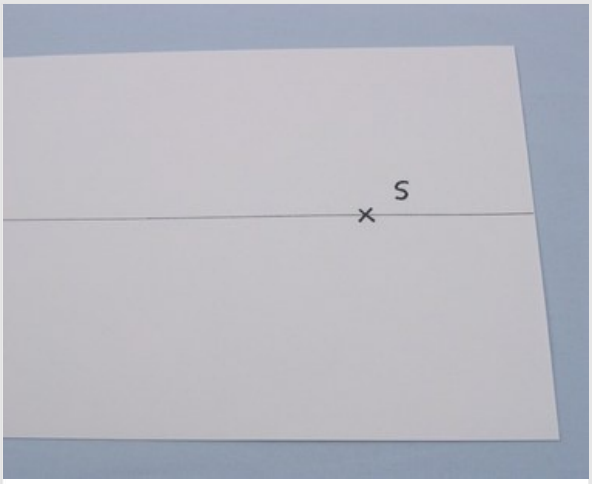
Additional material

PHYWE

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

Set-up

PHYWE



Preparation of the DIN-A4 sheet

Attention!

Make sure that the concave mirror always rests in the middle of the inner curvature on S and does not change its position when the light box is moved.

Experiment part 1: Reflection at the concave mirror

- Prepare a sheet of paper as shown on the left. The line on the paper is the optical axis and the point S is the apex.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

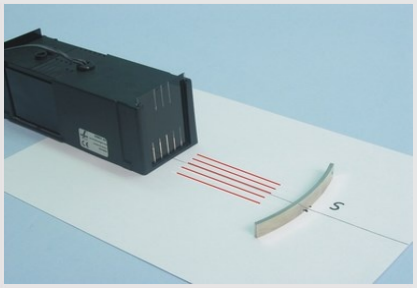
Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Procedure (1/6)

PHYWE

- Insert the five-slit diaphragm into the light box on the lens side and adjust the concave mirror and the light box as shown on the right.

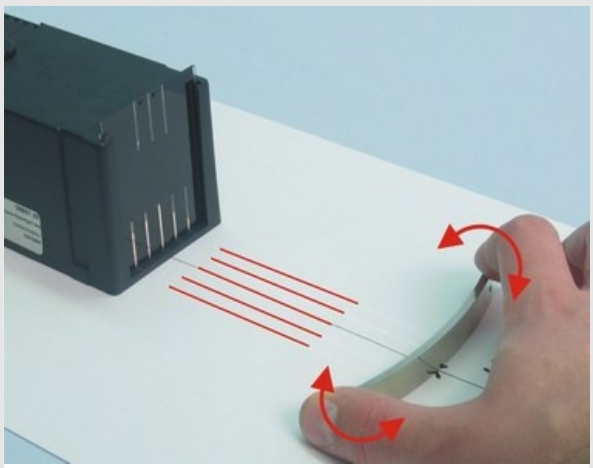


- Connect the light box to the power supply unit (12 V ~).

- Move the light box until the middle of the five narrow light beams runs along the optical axis. Carefully rotate the concave mirror around the point S and observe the course of the incident and reflected light beams. Write down your observations.

Procedure (2/6)

PHYWE



Rotating the concave mirror

- Now rotate the concave mirror around the point S until the middle of the five incident light beams is reflected into itself on the optical axis.
- What can you observe? Write down your observations.
- Mark the point of intersection of the reflected light beams on the optical axis and call it F.
- Carefully transfer the inner outline of the concave mirror onto the sheet of paper.

PHYWE

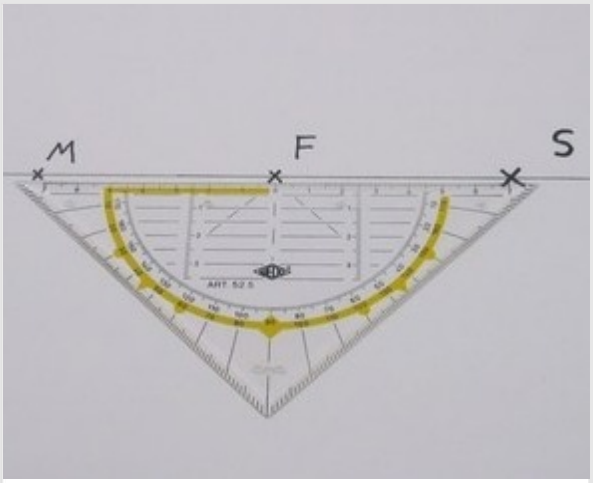
Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Procedure (3/6)

PHYWE

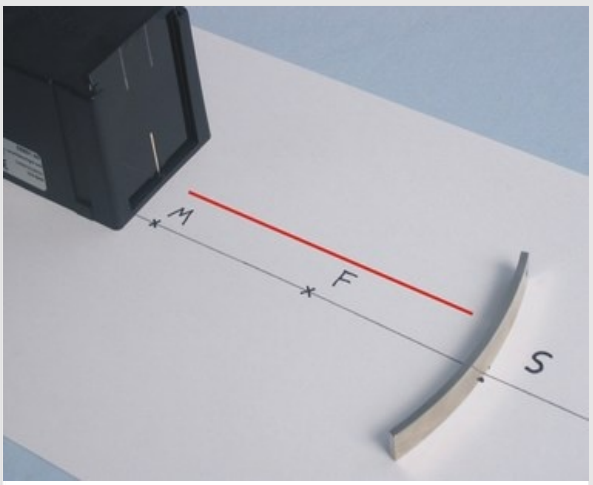


Doubling the distance $\overline{FS}$

- Switch off the power supply and remove the light box and the concave mirror from the sheet of paper.
- Double the distance with the compass $\overline{FS}$ as shown in the picture on the left. You get as a further intersection point the point M on the optical axis.

Procedure (4/6)

PHYWE



Set-up experimental part 2

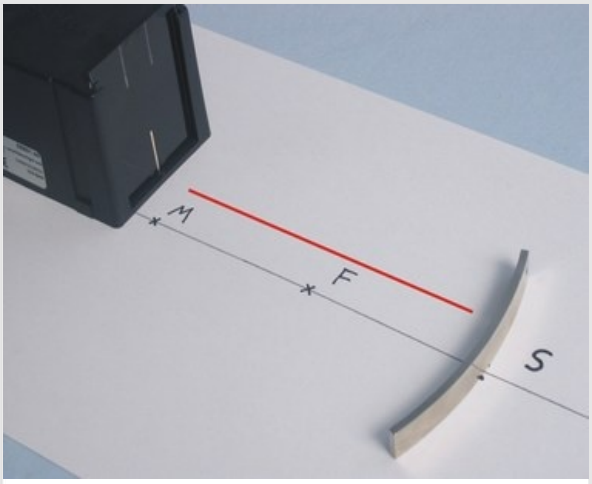
Experiment part 2: Course of selected light beams after reflection

- Place the concave mirror with the side curved inwards on the point S. Now insert the slit diaphragm into the light box on the lens side. Place the light box approx. 17 cm in front of the concave mirror and switch on the power supply unit (12 V ~).
- Check the adjustment of the concave mirror. The narrow light beam should run along the optical axis.

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

Procedure (5/6)

PHYWE



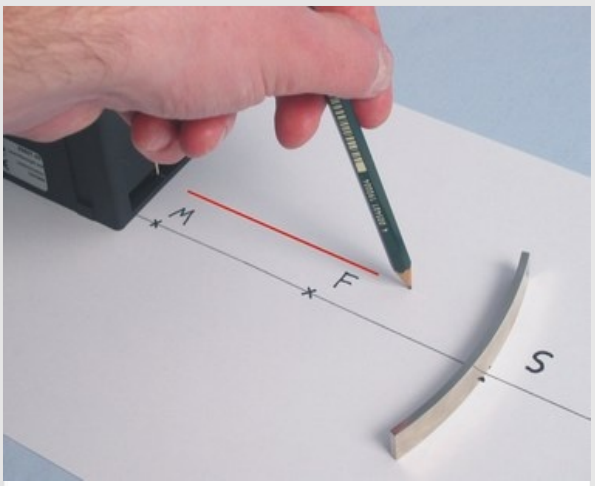
Set-up experimental part 2

- Move the light box until the narrow light beam is parallel to the optical axis at a distance of 1 cm.
- Observe the reflected light beam. Where does it intersect the optical axis? Write down your observations.
- Mark the course of the incident and reflected light beams with two crosses each.

Procedure (6/6)

PHYWE

- Let the light beam pass through the point M (centre point) and then through the point F (focal point) fall on the concave mirror. Observe the course of the reflected light beam and write down your observations in the report. Mark the course of the incident and reflected light beam at two points (use different colours or symbols).
- Switch off the power supply and remove the light box and the concave mirror from the sheet of paper.
- Connect the markings for each light beam with each other so that the course of the three selected light beams before and after reflection at the concave mirror becomes visible.



Markings of the light beams

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

PHYWE

Report

Task 1

PHYWE

How are light beams incident parallel to the optical axis reflected at the concave mirror?

The light beams incident on a concave mirror parallel to the optical axis are thus reflected,

- that one cannot determine a certain course after reflection.
- that they subsequently run parallel to the optical axis.
- that they meet at one point (the focal point) F) which lies on the optical axis.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Task 2

PHYWE

Construct an arc around M with the radius $\overline{MS}$ which is the optical axis at the point S.
Compare this arc with the drawn outline of the concave mirror. What can you conclude?

The concave mirror has the same curvature as the circular arc. It follows that M is the centre of curvature of the concave mirror.

The Holh mirror has a greater curvature than the circular arc. It follows that the centre of curvature lies to the right of M .

The Holh mirror has a smaller curvature than the circular arc. It follows that the centre of curvature lies to the left of M.

Task 3

PHYWE

What is the relationship between the focal length f of the concave mirror (distance $\overline{FS}$) and the distance from M to the apex S?

The distance $\overline{MS}$ is twice as large as the focal length $\overline{FS}$.

○ True ○ False

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

How are light beams reflected at the concave mirror?

Light beams incident parallel to the optical axis pass through the focal point after reflection at the concave mirror F(___ → ___). Through the (centre of curvature) M light beams incident on the concave mirror are reflected into themselves (___ → ___). Through the focal point F light beams incident on the concave mirror are reflected in such a way that they run parallel to the optical axis: (___ → ___).

focal rays
centre rays
centre rays
parallel rays
parallel rays
focal rays

Check

Task 5

PHYWE

Why is a centre point through the M reflected onto the concave mirror?

Through the (centre of curvature) M light beams incident on the concave mirror are reflected into themselves because in this case the angle of incidence is 45°. Thus, according to the law of reflection, the angle of reflection is also 45°.

○ True ○ False

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 22: Reflection of parallel rays at the concave mirror	0/1
Slide 23: Determination of the centre of curvature of a concave mirror	0/1
Slide 24: Determination of the focal length	0/1
Slide 25: Reflection of light beams at the concave mirror	0/6
Slide 26: Reflection of centre rays at the concave mirror	0/1

Total 0 / 10

Solutions Repeat

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