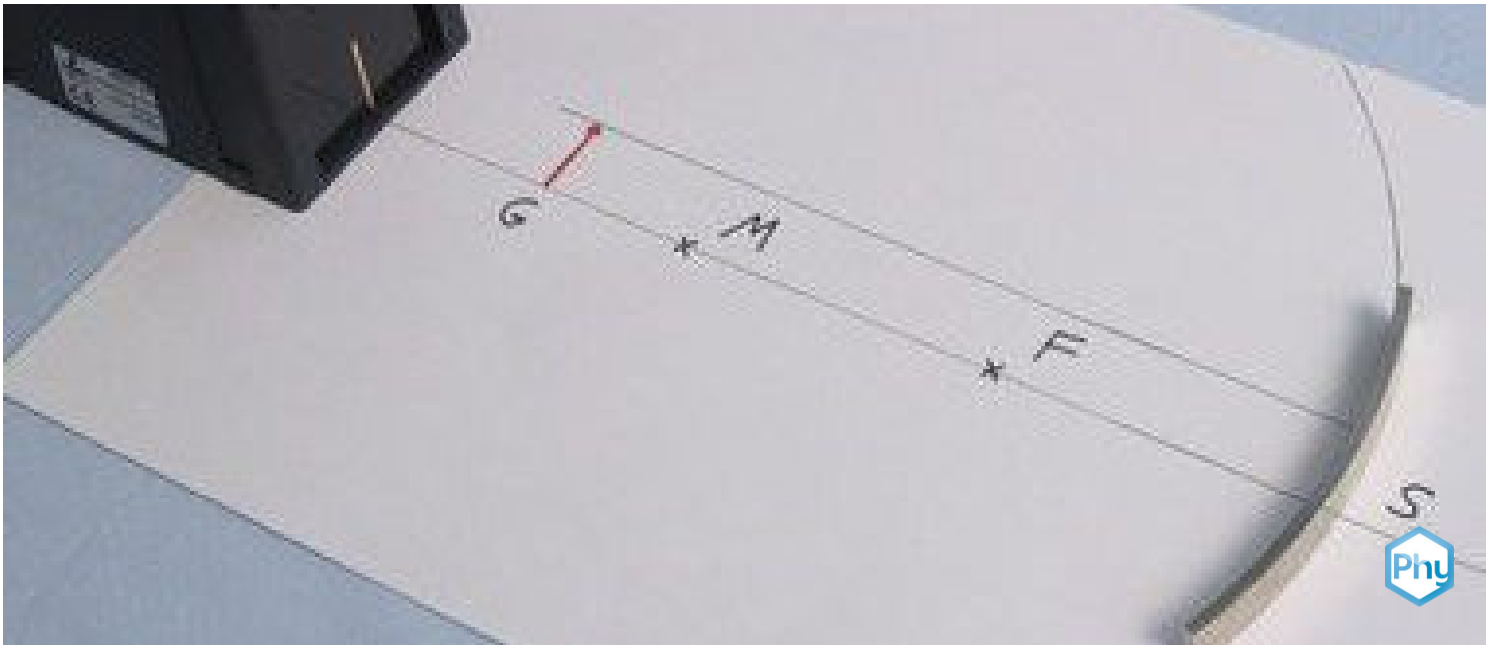
Image construction for a concave mirror



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/631b118abce9830003710de4

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Teacher information

Application

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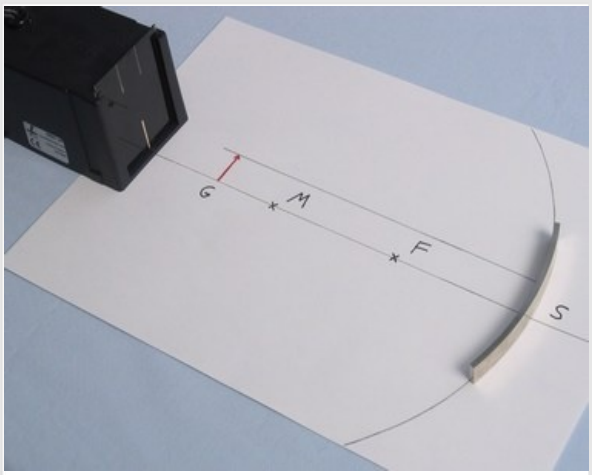

Reflection at the concave mirror

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.

Pierre Borell, a French physician, first used a concave mirror for medical examination in the 17th century. Slightly modified, they are still used today in medical diagnostics in the form of a forehead mirror,

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Other teacher information (1/6)

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Prior knowledge

The students should have previously learned the basics of the straight-line propagation of light and the application of the law of reflection. In addition, before carrying out the experiment, it should be explained why objects in our environment can be seen at all and how to construct pixels with the help of main rays.

Principle

Light beams incident on a concave mirror along the optical axis are light beams through the centre of curvature and are therefore reflected into themselves. The "foot points" of the objects "standing" on the optical axis are again imaged on the optical axis. Therefore, only one more image point is sufficient for a clear construction of the image.

Other teacher information (2/6)

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Learning objective

With this experiment, the students should learn a procedure that makes it possible to construct the image on the concave mirror with a given object. Selected light beams and their characteristic course are used for this purpose.

Tasks

Why do you see yourself inverted and diminished in a polished spoon?

In this experiment, the students are to investigate this question and examine the formation of images on a concave mirror with the help of selected light beams.

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Other teacher information (3/6)

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Additional information 1

With this experiment, the student should learn a procedure with the help of which the construction of the image on the concave mirror is possible with a given object. Selected light beams and their characteristic course are used for this purpose.

The experiment is demanding in terms of the students' abilities and experimental skills. However, with careful adjustment and precise experimental work, the experiment is associated with a very high gain in knowledge for the student, especially if corresponding demonstration experiments are carried out with the optical bench as a supplement.

Other teacher information (4/6)

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Additional information 2

With this experiment, the essence of the physical experiment can be clearly demonstrated; through the specific specification of the experimental conditions (object width, object size, focal length), one obtains a result with new information content.

By varying the conditions, physical laws can be deduced, but the reverse, deductive path is also possible. The construction of the images with the help of selected light rays and the subsequent experimental verification offer a wide range of possibilities for an interesting lesson design.

The experiment uses an example (geometric constructions) to illustrate the role of mathematics in physical knowledge.

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Other teacher information (5/6)

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Note

Before carrying out the experiment, explain to the students that objects in our environment are only seen because the light from a light source (e.g. the sun) is reflected by them and enters the eye. It is similar with the formation of an image at the concave mirror. A real image can only ever be created when the light beams emanating from an object point reunite in a point after reflection.

To construct these image points, it is therefore sufficient to select two of the infinite number of light beams and to follow their path from the object point to the image point. For the sake of simplicity, one selects individual light beams ("main beams") and a third light beam serves as a control.

Other teacher information (6/6)

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Notes on set-up and procedure

In this experiment, special attention should be paid to the exact position of the light box (e.g. parallel to the optical axis) in the individual experimental steps.

It is therefore advisable to draw a thin auxiliary line beforehand, e.g. parallel to the optical axis. Under these conditions, a high reproducibility of the results can be expected.

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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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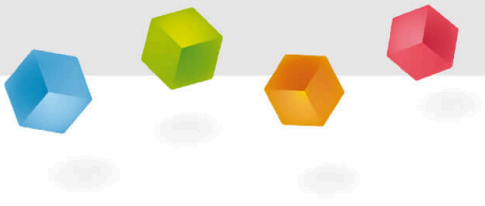

Student information

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Motivation

We encounter mirrors every day in a wide variety of designs. A special type of mirror is the so-called concave mirror. This is a mirror that is curved inwards and concentrates the reflected rays in one point, the focal point.

A typical example of a concave mirror is a spoon, as shown in the picture on the right. Have you ever looked at your reflection in a spoon, do you notice anything special about it?

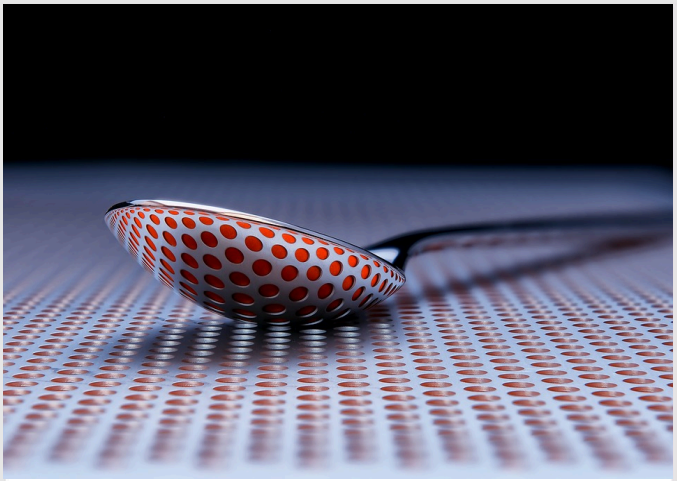
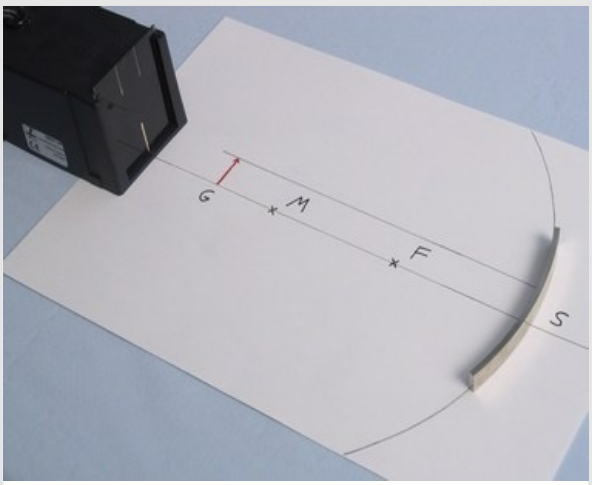


Image of a spoon on a patterned base

Task



Experimental setup

Why do you see yourself inverted and diminished in a polished spoon?

Investigate the formation of images on a concave mirror with the help of selected light beams.

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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

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Additional equipment

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

Set-up

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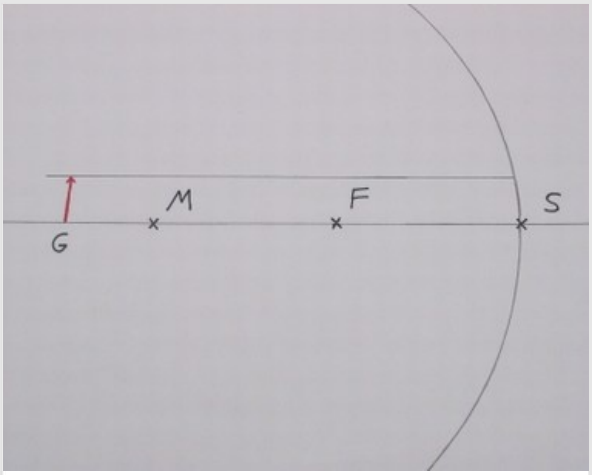

Preparation of the DIN-A4 sheet

Attention!

Make sure that the concave mirror always rests in the middle of the inner curvature on S.

- Prepare a sheet of paper as shown on the left. The distances $\overline{FS}$ and $\overline{MS}$ are 7.2 cm each, the arc of the circle around M has the radius $\overline{MS}$.
- At a distance of 18 cm from the point S, draw a vertical arrow 2 cm long on the optical axis with a red pencil and label it with G (Subject).
- Draw a thin pencil line exactly parallel to the optical axis as an auxiliary line passing through the tip of the object arrow G.

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Procedure (1/6)

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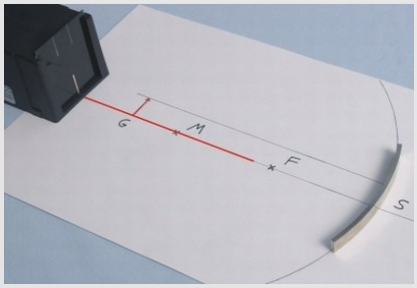
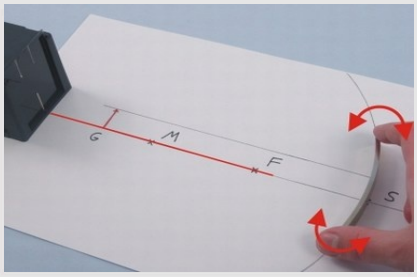
- Insert the slit diaphragm into the light box on the lens side. Place the light box and the concave mirror on the sheet of paper.



- Connect the light box to the power supply unit (12 V ~).
- Check the correct position of the concave mirror by first letting the narrow beam of light fall along the optical axis.



Procedure (2/6)

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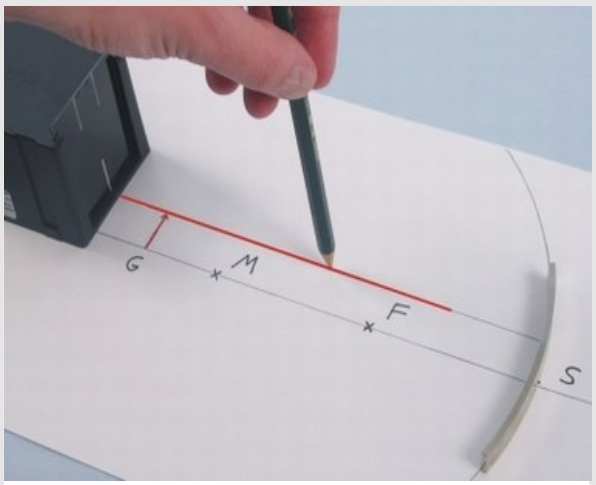

Moving the light box

- Now move the light box until the narrow light beam runs exactly parallel to the optical axis along the auxiliary line and through the tips of the arrow (imaginary object).
- Observe the light beam reflected by the concave mirror and mark the course of the incident and reflected light beam with two crosses. Write down your observations.

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Procedure (3/6)

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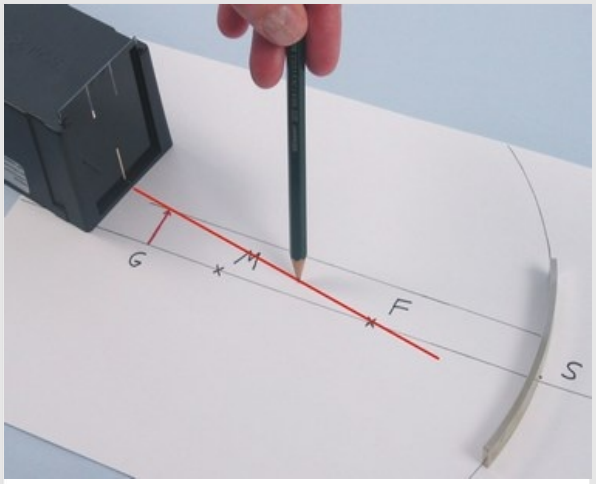

Turning the light box

- Then turn the light box until the light beam passes through the arrowhead of G and the point F (focal point).
- Again observe the light beam reflected by the concave mirror and mark the course of the incident and reflected light beam twice (use a different colour or marker). Write down your observations.

Procedure (3/6)

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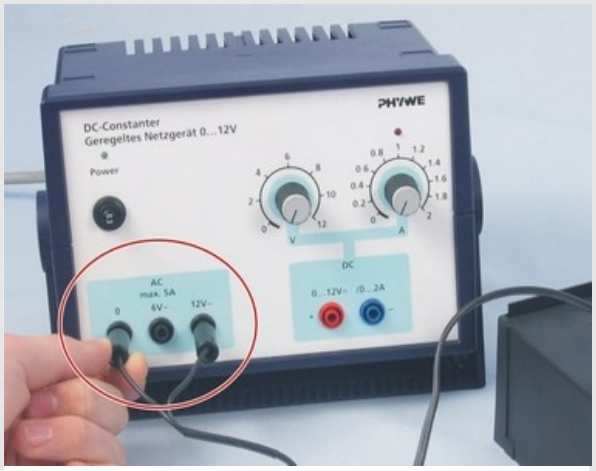

Picture of the power supply unit

- Switch off the power supply and remove the light box and the concave mirror from the paper.
- Connect the related markings so that the course of the light beams before and after reflection at the concave mirror becomes clear.
- How do the two reflected light beams relate to each other? Write down your observations.

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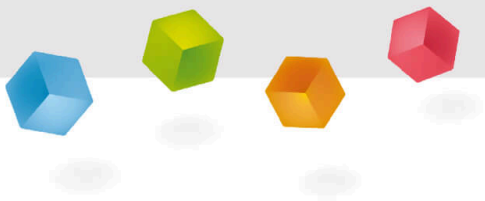

Report

Task 1

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Consider the following statement:

Both light beams intersect after reflection at a point below the optical axis.

○ True ○ False

Check

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Task 2

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Why do you see yourself inverted and diminished in a polished spoon?

A polished spoon is a small _____. The _____ and the laws governing the _____ of selected light beams thus apply to it. Since the _____ is outside the _____ focal length, the result is a _____, inverted image.

observer
concave mirror
double
reduced
course
law of reflection

Check

Task 2

PHYWE

Why do you see yourself inverted and diminished in a polished spoon?

A polished spoon is a small _____. The _____ and the laws governing the _____ of selected light beams thus apply to it. Since the _____ is outside the _____ focal length, the result is a _____, inverted image.

observer
concave mirror
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reduced
course
law of reflection

Check

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Task 3

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Draw a straight line from the tip of the object arrow G through the point M to the mirror (centre beam).

What do you see?

The _____ also passes through the _____ of the other two selected rays and thus through the _____ of the image arrow. A light beam that falls through the _____ onto the concave mirror is reflected _____ (angle of incidence = _____ = 0°). If it touches the tip of the object on its way or is emitted by it, it must also touch _____ of the image, since _____ light beams emitted from a point on the object contribute to the formation of the image.

centre ray
the tip
centre of curvature M
intersection
in itself
all
angle of reflection
tip

Task 4

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Why is it sufficient to draw two excellent rays of light from objects "standing" on the optical axis, only from the tip of the object, in order to construct the image?

Light beams incident l��ngs of the optical axis on a concave mirror are light beams through the centre of curvature and are therefore reflected parallel displaced. The "foot points" of the objects "standing" on the optical axis become the arrowheads and vice versa. Therefore, only one more image point is sufficient for a clear construction of the image.

Light beams incident on a concave mirror along the optical axis are light beams through the centre of curvature and are therefore reflected into themselves. The "foot points" of the objects "standing" on the optical axis are again imaged on the optical axis. Therefore, only one more image point is sufficient for a clear construction of the image.

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Additional task

The lens grinder equation applies to the image formation at the concave mirror:

$$\frac{1}{f} = \frac{b}{g} + \frac{1}{g} \text{ ,}$$

where $f = 7,2$ cm = focal length, b = image width = distance BS, g = object width = distance GS .

Check your measurement results in table 1 with this equation.

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