Image construction for a concave mirror (Item No.: P1064000)

Curricular Relevance

Area of Expertise: Physik

Education Level: Klasse 7-10

Topic: Optik

Subtopic: Reflexion und Brechung

Experiment: Bildkonstruktion am Hohlspiegel

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Easy	10 Minutes	10 Minutes	2 Students

Additional Requirements:

- Ruler (approx. 30 cm)
- White paper (DIN A4)
- Compasses

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional Information

In this experiment the students will become acquainted with a procedure for the construction of an image of a given object by a concave mirror. Selected light beams and their characteristic paths are used.

The experiment is demanding on the students' capabilities and experimental proficiency. However, with an accurate adjustment and performance of the experiment it can result in tremendous gains in the students' insights; particularly if corresponding experimental demonstrations with the optical bench are performed complementarily.

With this experiment the character of physical experiments in general can be clearly demonstrated: by carefully selecting the experimental conditions (object, distance, object size, focal length) one obtains results with new information content.

On the one hand, physical conformities to natural laws can be derived by varying the conditions; on the other hand, an inverse, deductive method can also be applied. The formation of images with the aid of selected light beams and the subsequent experimental testing allow for a large amount of leeway for an interesting and exciting organisation of your class.

This experiment also clearly illustrates the role of mathematics (geometric construction) in acquiring knowledge of physical phenomena.

Remarks

Before performing the experiment the students should be made aware that objects in our environment can only be seen because light from a light source (e.g. the sun) is reflected by them and reaches the eye of an observer. Image formation in a concave mirror is similar to this. A real image can only then be formed when the light beams which have its origin at an object reunite in a point after reflection.

In order to construct these image points, it is sufficient to select two rays from the infinite number of light beams and to follow their path from the object point to the image point. For reasons of simplicity one selects singular light rays ("main rays"). A third one is used for verification.

Suggestions

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

Robert-Bosch-Breite 10
D - 37079 Göttingen

Tel: +49 551 604 - 0
Fax: +49 551 604 - 107

info@phywe.de
www.phywe.com

It is helpful to make thin guide lines, e.g. parallel to the optical axis, before beginning. If this is done, reproducible results can be expected.

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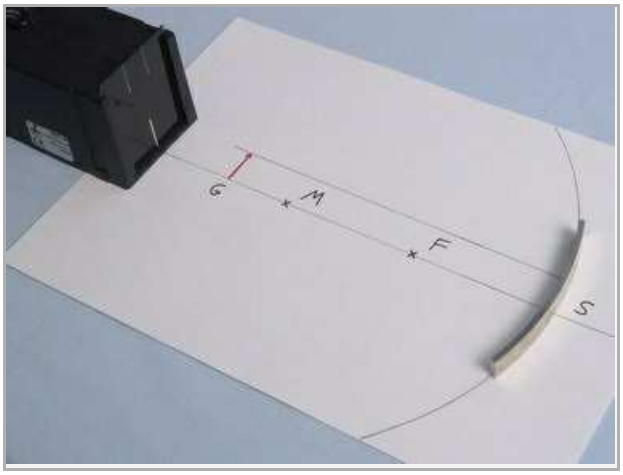
Task and equipment

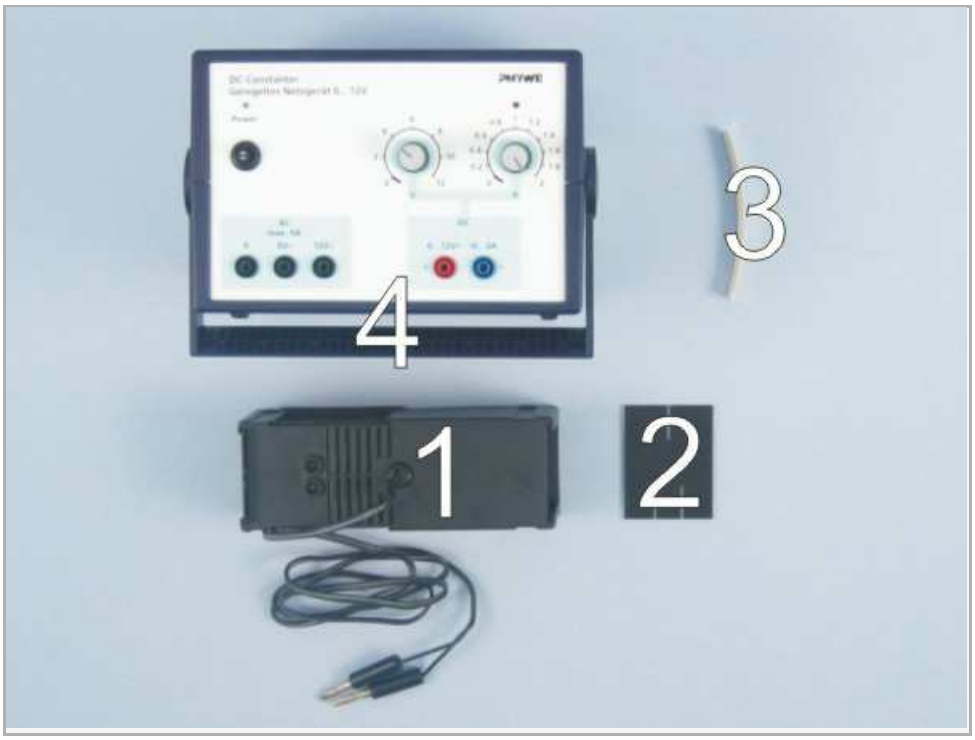
Task

Why is the reflected image in a polished spoon inverted and reduced?

In this experiment the image formation in a concave mirror is investigated with selected light beams.



Equipment



Position No.	Material	Order No.	Quantity
1	Light box, halogen 12V/20 W	09801-00	1
2	... with single-slit/double-slit aperture		1
3	Mirror, concave-convex	09812-00	1
4	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
Additional material			
	Ruler (approx. 30 cm)		1
	White paper (DIN A4)		1
	Compasses		1

Set-up and procedure

Set-up

Attention!

Ensure that the centre of the inner curvature of the concave mirror is continually on the point S and that its position does not change when the light box is moved.

Set-up

- Prepare a sheet of paper as shown in the picture; the distances FS and MF each are 7.2 cm, the circular arc around M has MS as its radius.
- Draw a 2 cm long, perpendicular arrow on the optical axis 18 cm away from the point S with a red pencil; label it with G.
- Draw a thin guide line with your pencil exactly parallel to the optical axis; it should cross the tip of the object arrow G.

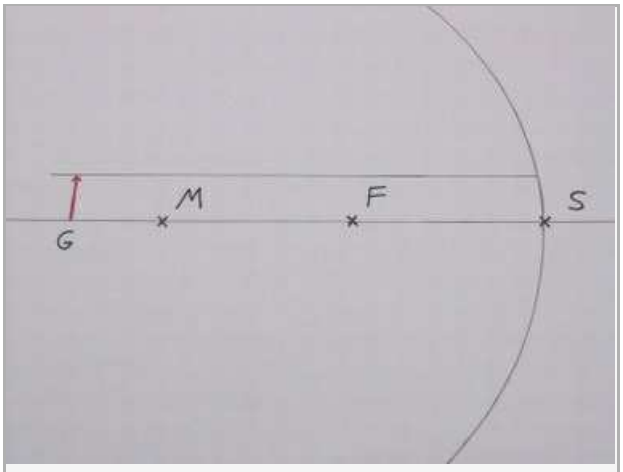


Fig. 1

- Mount the single-slit aperture on the light box's lens end; place the box and the concave mirror on the sheet of paper as shown in Fig. 2.

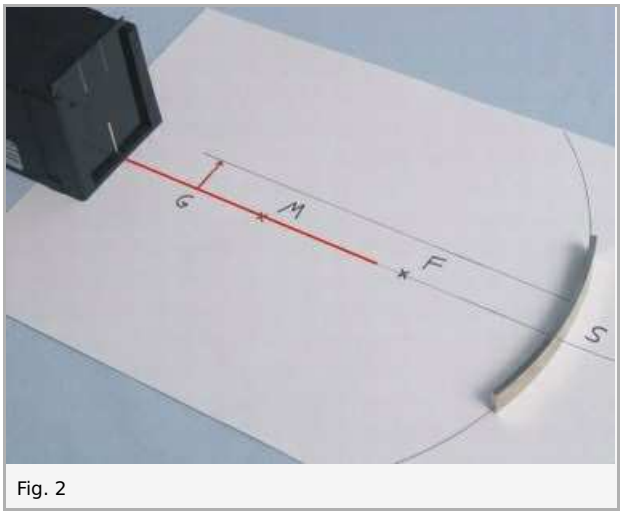


Fig. 2

Procedure

- Connect the light box to the power supply (12 V AC) and switch it on.

Fig. 3

- Check the mirror's correct positioning by letting an incident beam of light run along the optical axis.

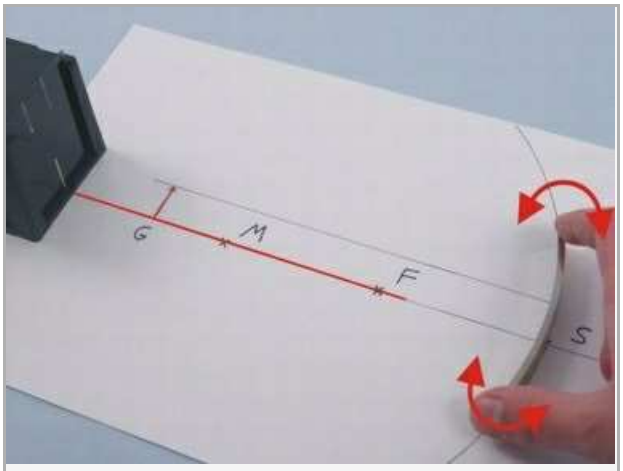


Fig. 4

- Move the light box sideways until the beam of light is exactly parallel to the optical axis along the guide line and just touches the tip of the arrow G (imaginary object).

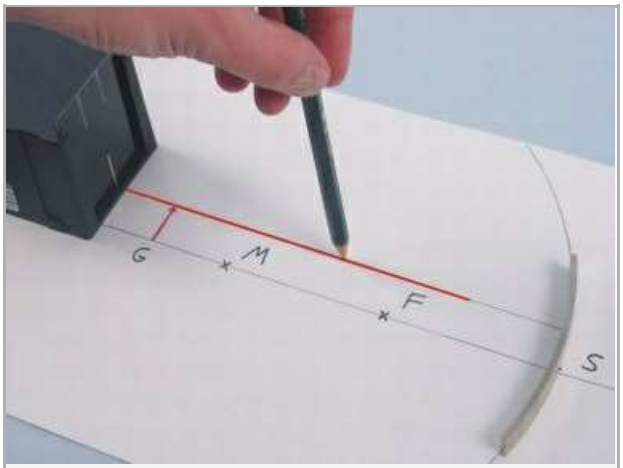


Fig. 5

- Observe the light beam reflected by the concave mirror and mark the path of the incident and reflected light beams with two crosses. Note your observations in the table in the report.
- Turn the light box until its beam passes through the G's arrowhead and the point F (focal point).

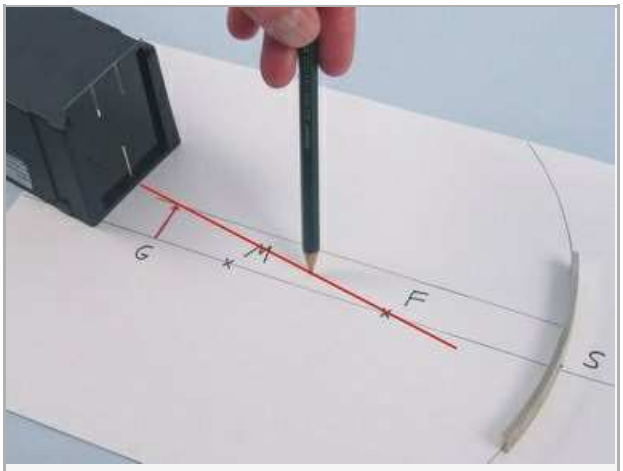


Fig. 6

- Again observe the light beam reflected by the concave mirror and mark the path of both the incident and the reflected light beams twice (use a different colour or symbol). Note your observations in the table in the report, too.
- Switch off the power supply and remove the light box and the concave mirror from the paper.
- Connect the corresponding marks so that the path of the light beams before and after reflection in the concave mirror are visible.
- How do the paths of the two reflected light beams lie in relation to each other? Note your observations.

Robert-Bosch-Breite 10
D - 37079 Göttingen
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Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Report: Image construction for a concave mirror

Result - Table 1

Note your observations.

Path of the incident light beam	Path of the reflected light beam
Parallel to the optical axis (parallel beam)	1
Through the focal point F (focal point beam)	1

Result - Observation 1

Note your observations on the relation of the two reflected light beams.

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Evaluation - Question 1

The intersection of the two reflected light beams is the image of the object's arrowhead. Draw the perpendicular from this intersection point to the optical axis; label this arrow with B.

Evaluation - Table 1

Compare this image of the arrow B with the object arrow G. What can you say about the size, position and distance from point S?

Note your results in the table below.

	Object arrow G	Image arrow B
Size	1 ±0	
Orientation to the optical axis	1	
Distance from the apex S	1	

Robert-Bosch-Breite 10
D - 37079 Göttingen

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Evaluation - Question 2

Based on the results in the table above formulate a statement which gives you the position, size and distance of the image when the object is outside the twofold distance FS from the concave mirror.

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Evaluation - Question 3

Why is the reflection in a polished spoon inverted and reduced?

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Evaluation - Question 4

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

What do you see? Give the reasons for this result.

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Evaluation - Question 5

Why is it sufficient to employ only two singular light rays from the tip of an object which is located on the optical axis to construct its image?

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D - 37079 Göttingen

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Evaluation - Supplementary problem 1

For image formation in concave mirrors the following equation is valid:
$1/f = 1/b + 1/g$
(f = 7.2 cm = focal length, b = image distance (line segment BS), g = object distance (line segment GS)).

Check your measuring results from Evaluation - Table 1 with this equation.

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