Refraction at the air-water boundary

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/631b11aabce9830003710dec

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Teacher information

Application

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Refraction at the transition from air to water

The refraction of light can be described by means of ray optics. At phase boundaries, a kink in the beam path occurs due to the refraction. The change in the refractive index leads to a change in the phase velocity and thus to a deflection of the light beam.

In the human eye, for example, light is refracted at the cornea, the eye lens and the vitreous body in such a way that a real image is created on the retina.

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Other teacher information (1/4)

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Prior knowledge

The students should have previously learned the basics of the rectilinear propagation of light.

Principle

The light is refracted during the transition from an optically thinner to an optically thicker medium (a reverse transition is also possible). If the light hits the air-water interface, part of the light is reflected in reality and a dark reflection can be seen. However, most of the light is refracted.

Other teacher information (2/4)

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Learning objective

In addition to deepening the students' experimental skills in terms of accurate and careful experimentation and setting or reading angles on the optical disc, the students learn another application of the law of refraction with the formulation of the laws that apply to this case. The investigation of the special case at an angle of incidence $\alpha = 0°$ contributes to the realisation that physical laws only apply under certain conditions.

Tasks

In this experiment, the students are to investigate the behaviour of narrow beams of light when passing from air into water and also to determine the angles of refraction β at given angles of incidence α.

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Other teacher information (3/4)

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Additional information

The second sub-experiment is more demanding in terms of the students' abilities and experimental skills. Both experiments can be seen as one unit, but an isolated execution is also possible.

Other teacher information (4/4)

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Notes on set-up and procedure

In order to obtain unambiguous and comparable measured values for the angle of refraction, it is important that the students carry out the adjustment of the cuvette and the light box very precisely.

Special care must be taken to ensure that the narrow light beam always hits the plumb bob and that moving the light box during the individual test steps does not lead to a change in the position of the cuvette.

The reflection that occurs simultaneously at the air-water interface is of secondary importance, but the student's attention should be drawn to it with regard to the (unconscious) observations of the fainter mirror images on large water surfaces.

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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

Refraction

We encounter the refraction of light every day. Without this phenomenon, we would not be able to see at all, for example, because only the refraction of light in the human eye leads to an image on the retina.

Surely you have already drunk water from a glass with a straw. Have you ever noticed that the straw, like the pencil on the left, seems to have a bend? This is also a result of the refraction of light.

Tasks

Experimental setup

Why are mirror images on large water surfaces darker than the original?

Investigate the behaviour of narrow light beams when light passes from air into water.

Measure the angle of refraction as a function of the angle of incidence when light passes from air into water.

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Equipment

Position	Material	Item No.	Quantity
1	Light box, halogen 12V/20 W	09801-00	1
2	Cuvette, double semicircular	09810-06	1
3	Optical disk	09811-00	1
4	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 material

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Position	Material	Quantity
1	Cup, approx. 100 ml	1

Set-up (1/2)

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Experimental setup

Attention!

Make sure that the narrow light beam coming from the light box always runs exactly in the direction of the centre of the optical disc in all partial experiments and that the cuvette does not change its position when the light box is moved.

- Place the optical disc in front of you on the table and place the cuvette exactly within the markings on the cross.
- The partition wall inside the cuvette must be on the vertical line.

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Set-up (2/2)

Filling the cuvette

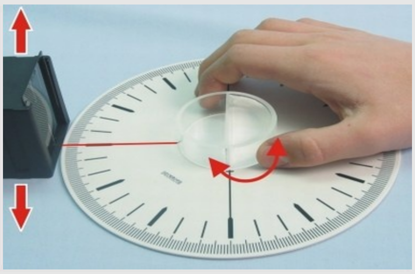
- Insert the slit diaphragm into the light box on the lens side and place it about 1 cm in front of the optical disc.
- Carefully fill the half of the cuvette facing away from the light box with approx. 20 ml of water.

Procedure (1/4)

1. The behaviour of narrow light beams at the boundary between air and water

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

- Move the light box until the narrow light beam runs exactly on the optical axis (0° line).
- If the cuvette and the light box are in the right position, the narrow beam of light continues to run along the optical axis after passing through the water.



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Procedure (2/4)

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Moving the light box

- Now move the light box until the light falls on the cuvette at an angle of incidence of 40°.
- Describe the behaviour of the narrow beam of light when it strikes the air/water interface.
- Compare the angle of incidence α with the angle between the optical axis and the refracted light beam (refraction angle β).

Procedure (3/4)

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2. Determination of the angle of refraction β as a function of the angle of incidence α

- Now align the light box in such a way that the incident light beam encloses exactly the angle of 10° with the incidence slot (0° line).
- Read the corresponding angle of refraction β and enter it in the table in the report. This is the angle between the refracted light beam and the vertical axis (optical axis).

Adjusting the angle of incidence

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Procedure (4/4)

- Repeat this process for the angles of incidence α of 0°, 20°, 30°, 45°, 60° and 75° and note the corresponding angles of refraction β.
- Switch off the power supply unit.

Adjusting the angle of incidence

Report

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Task 1

What is the angle of refraction β at an angle of incidence of α = 0° ?

- β = 0°
- β = 90°
- β = 45°
- There is no answer to that.

Task 2

Use your observations to describe how a narrow beam of light behaves when it falls obliquely on an air-water interface.

At the interface of air and water, narrow beams of light are ______. But part of the light is also ______ according to the law of reflection.

Check

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Task 3

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Why are mirror images on large water surfaces darker than the originals?

The image of a tree standing on the shore, for example, is darker than the original because no light is reflected and reaches our eye. The entire part is refracted at the interface.

- True
- False

Check

Task 4

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Compare the angle of incidence α with the corresponding value of the angle of refraction β from the previous table with each other. Which statement is true?

- When light passes from air into water, the angle of incidence is α greater than the angle of refraction β.
- When light passes from air into water, the angle of incidence is α smaller than the angle of refraction β.
- When light passes from air into water, the angle of incidence is α always as large as the angle of refraction β.

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Task 5

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What was the result of the measurement at an angle of incidence of 0°? Fill in the gaps.

With an angle of incidence of 0°, the ______ is also ______ °. Since the angle of refraction when light passes from ______ to ______ is always smaller than the ______, this could only be smaller than 0° at α = 0°. But this is not possible, so the light is not refracted at this ______.

Check

Task 6

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Is the statement true or false?

If narrow beams of light pass from air into water at an angle of incidence α greater than 0°, then the angle of refraction β is smaller than the angle of incidence.

- True
- False

Check

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Slide	Score / Total
Slide 20: Determination of the angle of refraction	0/1
Slide 21: Behaviour of a light beam at oblique incidence	0/2
Slide 22: Brightness of mirror images on large water surfaces	0/1
Slide 23: Comparison of angle of incidence and angle of reflection	0/1
Slide 24: Result at an angle of incidence of 0	0/6
Slide 25: Angle of refraction at the transition from air to water	0/1

Total 0 / 12

Solutions Repeat

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