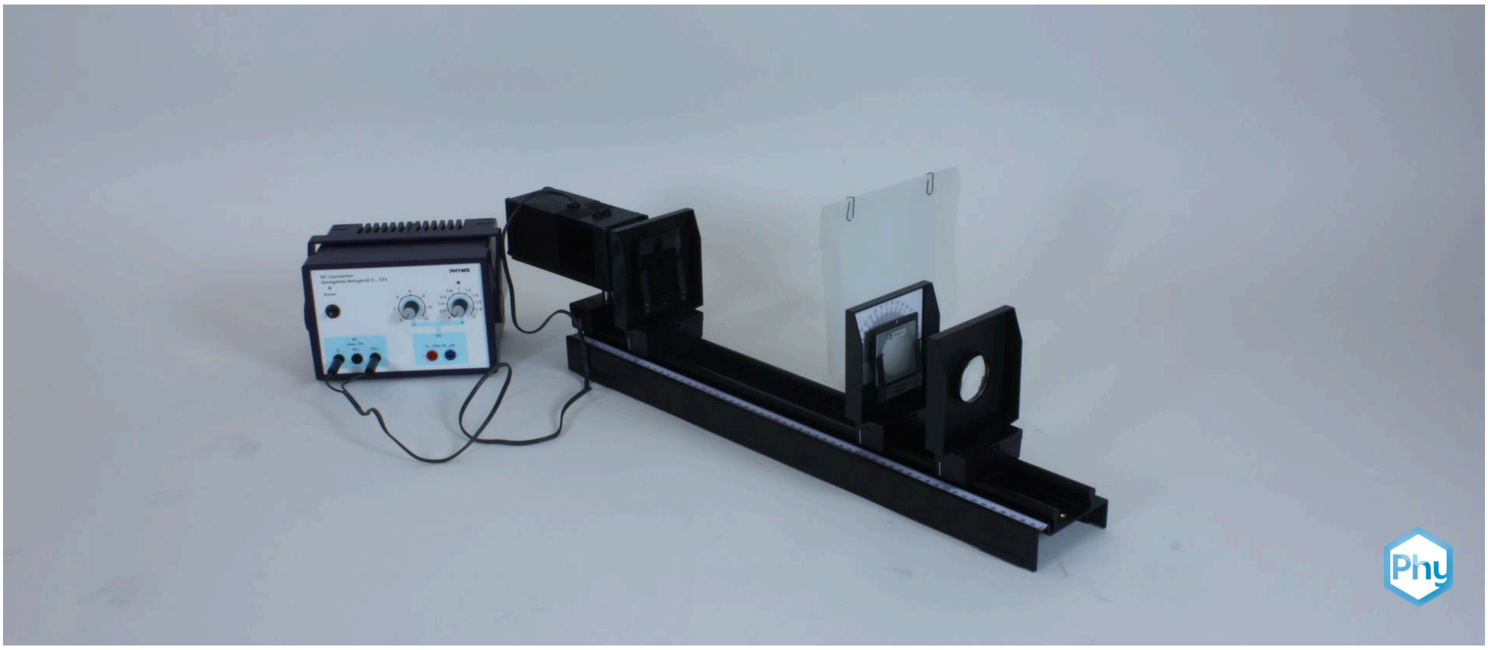
Rotation of the polarisation plane with a sugar solution



Physics | Light & Optics | Wave properties of light

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/62e4fbfe6bbfbe0003f3557f

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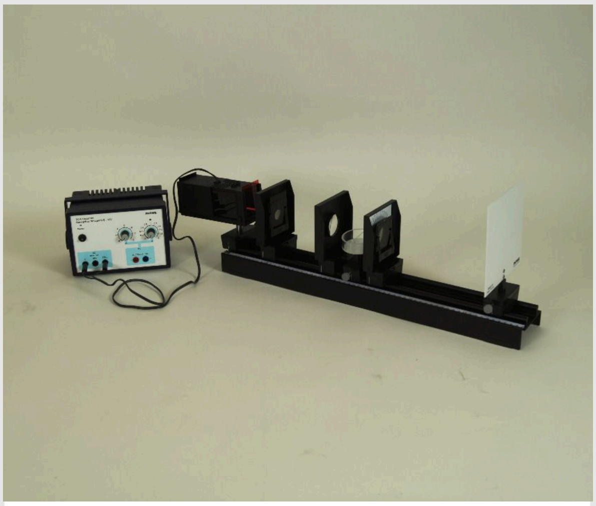
Teacher information

Application



Experimental setup

A saccharimeter can determine the sugar content of an aqueous solution with the help of several polarisation filters (polarisers). Polarisers filter electromagnetic waves that have a certain polarisation. You can use polarisers to generate linearly polarised light, filter out interfering light sources that arise, for example, from unwanted reflections when taking photographs, or also determine the polarisation of a beam of light to be examined.

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Other teacher information (1/4)

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Principle

The function of a polarising filter is based on the absorption of one component of the light, while the other component is almost exclusively transmitted. The absorption depends on the direction of polarisation relative to the optical axis, i.e. one can determine the polarisation by rotating the filter. A sugar solution placed in the beam path is an optically active substance and can change the polarisation of the light.

Learning objective

Students should observe the change in polarisation of light by an optically active substance (sugar solution) and understand how a polariser/analyzer works.

Other teacher information (2/4)

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Task

The students are asked to build a saccharimeter model and use it to investigate how polarised light behaves when it is sent through a sugar solution.

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Other teacher information (3/4)

- This experiment places high demands on the students. Not only does the saccharimeter model have to be carefully constructed, but the measurements also require care and are made more difficult by the necessary complete darkness of the physics room.
- It is a good idea to divide the work into two groups. For example, the class can be divided into two groups that carry out the measurements at single and double layer thickness. Afterwards, the results are exchanged and recorded.

Other teacher information (4/4)

Notes on set-up and procedure

To save time, the teacher should prepare a concentrated sugar solution in advance and give the students the necessary amount in the cups at the beginning of the experiment. The less concentrated sugar solution can also be prepared or made in front of the students.

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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

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Polarisation filter

A saccharimeter can determine the sugar content of an aqueous solution with the help of several polarisation filters. The polarisation filters (polarisers) play a decisive role in this.

How does a saccharimeter work?

Tasks

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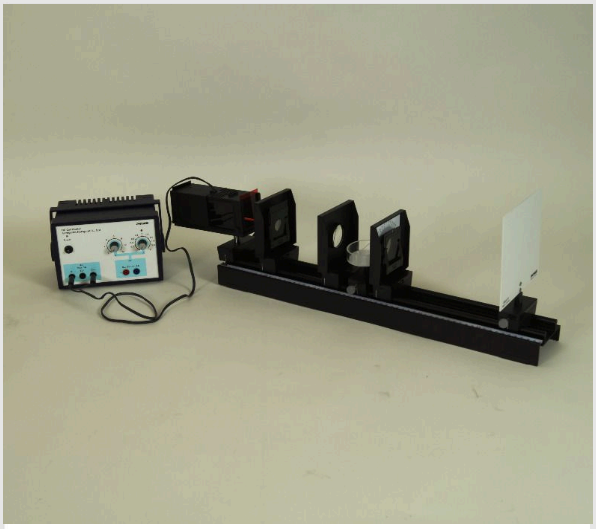

Experimental setup

Build a saccharimeter model and use it to investigate how polarised light behaves when it is passed through a sugar solution.

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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	Cuvette, double semicircular	09810-06	1
5	Colour filter set, additive (red, blue, green)	09807-00	1
6	Diaphragm with hole, d=20mm	09816-01	1
7	Lens on slide mount, f=+50mm	09820-01	1
8	Lens on slide mount, f=+100mm	09820-02	1
9	Slide mount for optical bench	09822-00	3
10	Mount with scale on slide mount	09823-00	1
11	Table with stem	09824-00	1
12	Screen, white, 150x150 mm	09826-00	1
13	Diaphragm holder, attachable	11604-09	2
14	Polarising filter, 50 mm x 50mm	08613-00	2
15	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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Structure (1/4)

- Set up the optical bench with the two tripod rods and the variable tripod foot and place the scale on the front tripod rod.

Structure (2/4)

- Place the base with the stem under the light box.
- Clamp it into the left part of the tripod base so that the lens side faces away from the optical bench.

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Structure (3/4)

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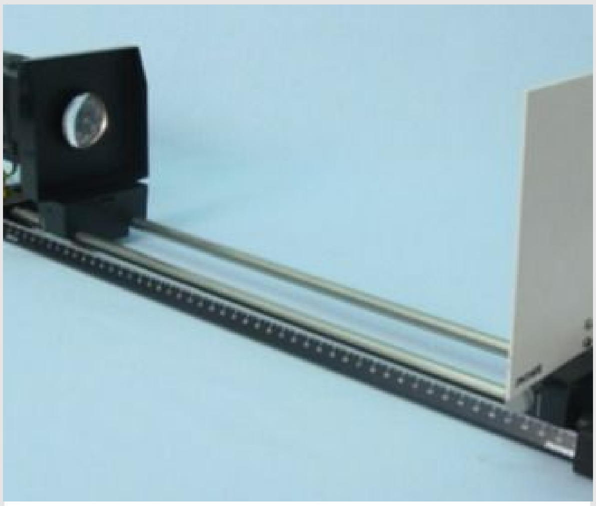

Optical bench with luminaire, lens, aperture and shade

- Slide an opaque screen in front of the luminaire lens.
- Place the screen at the right end of the optical bench and the lens with $f = +50\,\mathrm{mm}$ about 5 cm away from the luminaire.

Structure (4/4)

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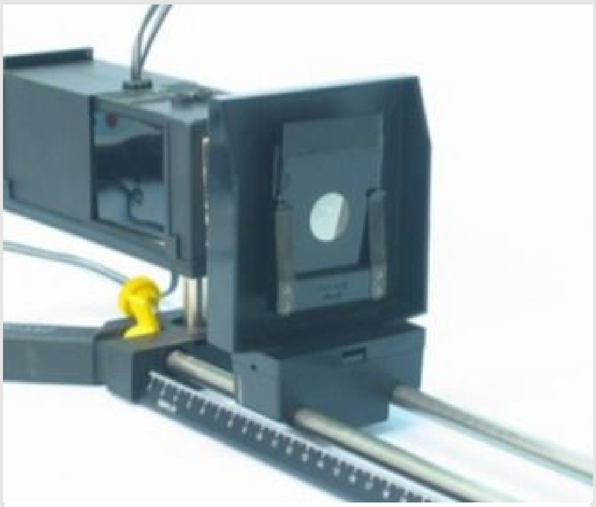

Polarising filter in the aperture holder on the lens mount

- Slide the pinhole and a polarising filter into an aperture holder and place it on the lens mount.
- This polarisation filter, on which the light first impinges, is called the **Polariser.**

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Procedure (1/6)

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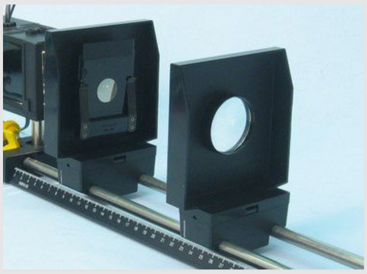

- Connect the lamp to the power supply unit (12 V~) and switch it on.
- Set the lens with $f = +100\,\mathrm{mm}$about 13 cm from the first lens on the optical bench. If necessary, move it a little; the screen now shows the hole of the aperture.

Procedure (2/6)

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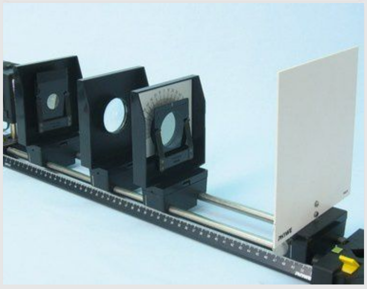

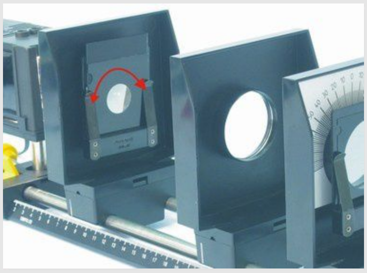

- Slide the second polarising filter onto the second aperture holder and place it on the mount with scale so that the marking line on the aperture holder is exactly at the zero mark of the scale. This polarisation filter is to serve as an analyser.
- Place the mount with scale on the optical bench at a distance of about 10 cm from the second lens.
- Turn the polariser until the screen is dark, i.e. until the filters are turned 90° against each other.

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Procedure (3/6)

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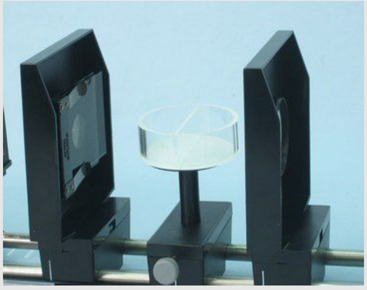

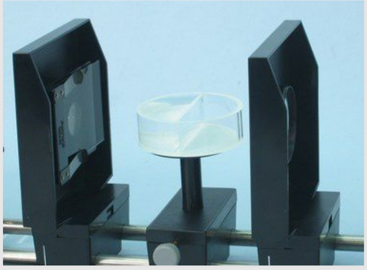

- Now place the table with stem on the second slide and place the cuvette on the table so that its partition is perpendicular to the optical axis and change the table height until the complete light beam passes through the cuvette.
- Pour enough sugar solution into one half of the cuvette so that the light beam passes through completely. Watch the screen (which was dark before).

Procedure (4/6)

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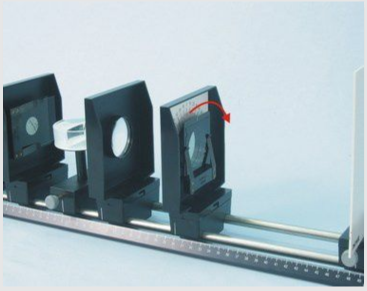

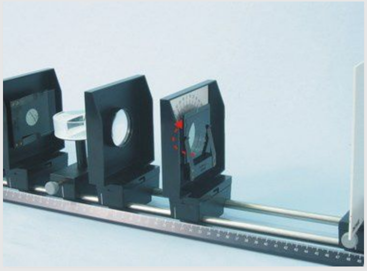

- Slowly turn the analyser to the right and back to 0°.
- Turn the aperture holder by 90° until it reaches its initial position.
- Note down your observations.

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Procedure (5/6)

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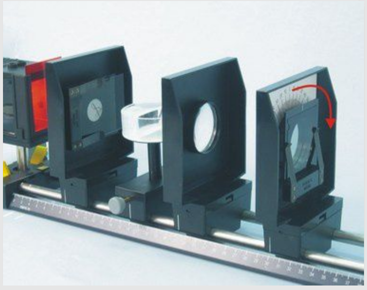

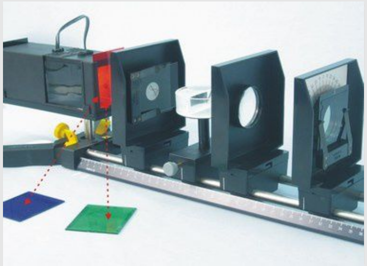

- Slide the red filter into the aperture shaft of the light and turn the analyser to the right until the shade is dark again.
- Read off the angle required for this and note it in the table in the report.
- Replace the red filter successively with the green and blue filters; determine the angles of rotation required for extinction and enter them in Table 1 as well.
- **Hint:** The light that the filters let through is not completely monochrome. Therefore, you will not achieve complete darkness on the screen. Therefore, adjust the analyser so that the greatest possible extinction occurs.

Procedure (6/6)

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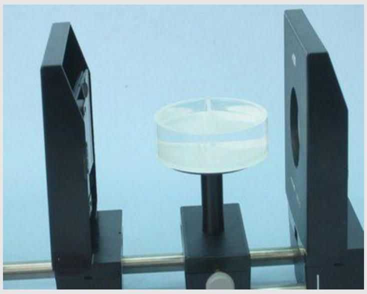

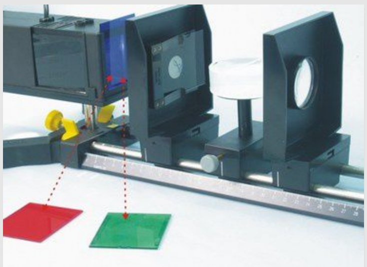

- Fill the other half of the cuvette with the sugar solution.
- Determine the angle of rotation required for the extinction for 3 colours with now double the layer thickness of the transilluminated sugar solution and enter your results in Table 1.
- Finally, select a filter, e.g. the green filter, and replace the saturated sugar solution with a less concentrated one. Compare the angle of rotation with the one you determined for the saturated sugar solution under otherwise identical experimental conditions. Make a note of your observations.
- Switch off the power supply unit.

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Report

Table 1

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Enter your measurements in the table.

Colour	Layer thickness	Rotation angle
Red	simple	
Green	simple	
Blue	simple	
Red	double	
Green	double	
Blue	double	

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Task 1

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What happens when the sugar solution is brought between the polariser and the analyser?

- ☐ The light spot on the screen appears one after the other in different colours when you turn the analyser.
- ☐ The light spot changes its shape.
- ☐ The dark screen lightens.

Check

What is the angle of rotation for a less concentrated sugar solution?

- ○ The angle of rotation remains the same.
- ○ The angle of rotation is greater than with a saturated sugar solution.
- ○ The angle of rotation is smaller than with a saturated sugar solution.

Check

Task 2

PHYWE

For which colour is the plane of polarisation of light rotated most or least when passing through a sugar solution?

- ☐ When the light is red, it is turned the weakest.
- ☐ In blue light, it is turned the most.
- ☐ When the light is red, it is turned the most.

Check

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Task 3

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What is the angle by which the plane of polarisation of light of a certain colour is rotated when passing through an optically active substance (in this case sugar solution)?

- ☐ The angle of rotation does not depend on the thickness of the layer or the concentration of the sugar solution.
- ☐ The angle of rotation depends on the layer thickness.
- ☐ The angle of rotation depends on the concentration of the sugar solution.

Check

Task 4

PHYWE

What are the essential parts of a saccharimeter and what can it be used for? Fill in the missing words:

A saccharimeter consists of a source of single-colour ______, a ______, an analyser, an (elongated) container to hold the solution to be analysed and a device to read the ______ or the degree of concentration of the sugar solution. It is used to measure (control) the ______ content of aqueous solutions.

Check

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Slide	Score / Total
Slide 24: Multiple tasks	**0/3**
Slide 25: Effect of the colour filters	**0/2**
Slide 26: Angular change due to optically active substance	**0/2**
Slide 27: Components of a saccharimeter	**0/4**

Total **0 / 11**

Solutions Repeat Export text

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