How is light weakened by liquid?

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/5f5064e437ffe20003f1001a

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Teacher information

Application

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Experiment set-up

How is light weakened by liquids?

When light penetrates a substance, whether solid or liquid, it is generally less intense at the end than at the beginning.

In this experiment, the students work out how light is weakened when passing through coloured liquids.

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Other teacher information

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Prior knowledge

Scientific principle

The decrease in intensity is described by the law of Lambert-Beer with :

$l = l_0 \cdot e^{-\alpha \cdot c \cdot l}$

l= distance through the liquid;$a \cdot c$ = substance-specific coefficient of decrease, depending on the wavelength of the incident light and liquid.

The equation is transformed for the calculation:

$a \cdot c = -(ln(l/l_0/l))$

The percentage decrease per unit of length is calculated with $p = (1 - e^{-\alpha \cdot c}) \cdot 100$.

In this case, the intensity therefore decreases by about 30 % per cuvette.

Notes on implementation

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- It turned out that the test with Lamy ink did not work, because the solution became lighter and lighter over time. Printer ink or food colouring has proved to be the best solution.
- The experimental setup is comparatively susceptible to scattered radiation.
- If there are difficulties reading the multimeter, use the HOLD function.
- Do not move the assembly during the measurement (photodiode sensitive, therefore also the pipette).
- If the water is too dark, the measurement is made more difficult (good measurement results with slight turbidity)
- To avoid scratching the cuvettes too quickly, it is recommended to place all four cuvettes in the holder at once (side by side)
- Make sure that the correct alignment is achieved so that the ribbed side faces outwards.

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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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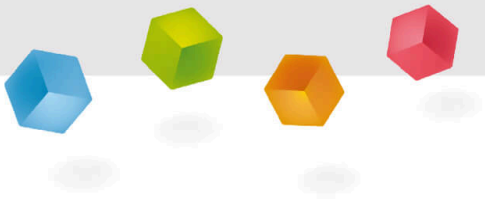

Student Information

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Motivation

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Experiment set-up

How is light weakened by liquids?

When light penetrates a substance, whether solid or liquid, it is generally less intense at the end than at the beginning.

In this experiemnt, a regularity is worked out for how light is weakened when passing through coloured liquids.

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Equipment

Position	Material	Item No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
3	Slide mount without angle scale	09851-02	2
4	Diaphragm holder, attachable	11604-09	2
5	Macro-cuvettes, PS, 4ml,100 pcs	35663-10	4
6	Universal bench	09840-00	1
7	Cell holder	09840-01	1
8	LED - red, with series resistor and 4 mm plugs	09852-20	1
9	Light sensor with amplifier, adjustable	09852-70	1
10	Power supply, 5 V DC	09852-99	1
11	Stray light tube	09852-71	1
12	Stray light tube for LED, Di = 8 mm, l = 40 mm	09852-01	1
13	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
14	Digital multimeter, 600V AC/DC, 10A AC/DC, 20 MΩ, 200 µF, 20 kHz, −20°C… 760°C	07122-00	1
15	Connecting cord, 32 A, 750 mm, red	07362-01	2
16	Connecting cord, 32 A, 750 mm, blue	07362-04	2

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Set-up (1/3)

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- Structure according to the illustrations on the right
- Allow the ribbed sides of the cuvettes to face outwards.
- They're not in the path of the beam!




Set-up (2/3)

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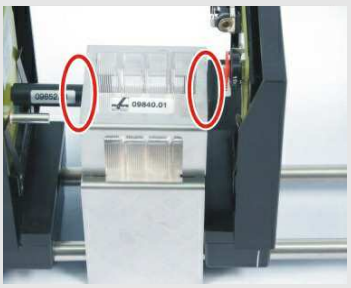
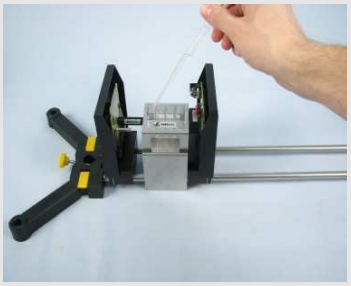
- Move the parts on the optical bench so close together that the tube of the LED touches the cuvettes.
- The tube of the photodiode should also be as close as possible to the last cuvette.
- Fill the cuvette with water (reference).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Set-up (3/3)

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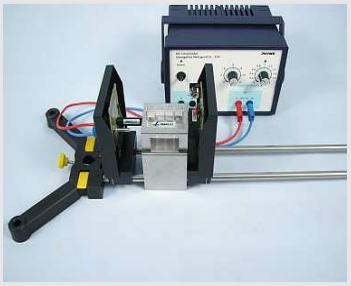
- Connect the LED to the power supply unit.
- Attention!, pay attention to the correct polarity!
- Connect the photo diodes to the 5 V DC power supply unit and connect them to the multimeter (measuring range greater than 4 V).



Procedure (1/3)

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Experiment procedure

- Fill the beaker with about 300 ml of water and add a drop of ink.
- Attention: The colouring must not be too strong!
- Reference measurement: With water-filled cuvettes, adjust the power supply unit so that the photodiode is in the sensitive range.

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Procedure (2/3)

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Experiment performance - Amplifier

- When the setting wheel of the photodiode amplifier is turned all the way to the right, a maximum voltage of about 3.9 V is measured.
- Note the measured value for the measurement with the water-filled cell in Table 1 in the protocol.
- Use the pipette to remove the water from the cuvette.
- The one closest to the LED, and replace it with the coloured water.

Procedure (3/3)

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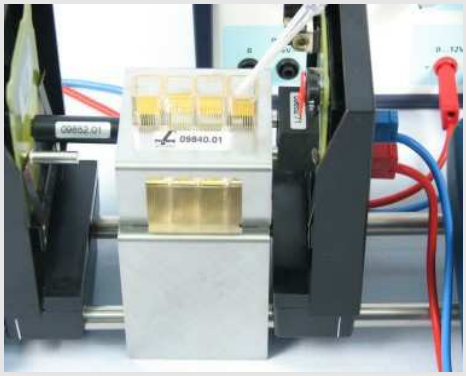
- Note the measured value on the photodiode (Table 1).
- Repeat the last two steps until all cuvettes are filled with coloured water.



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Report

Task 1

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Note the voltage at the photodiode!

Number of coloured cells	Voltage at the Photodiode in V
0	
1	
2	
3	
4	

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Task 2

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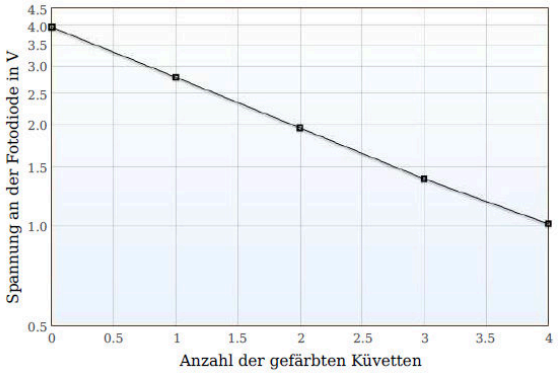
The graph could look like this:



Drag the right words into the gaps!

Between the number of cells filled with ink and the _____ at the photodiode, the graph suggests that the experiment is an _____. The intensity decreases exponentially with the _____ of cells.

voltage | exponential decrease | number

Check

Task 3

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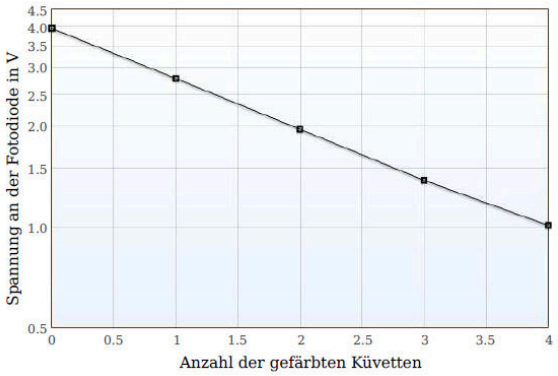

Graph - Relationship

Calculate the slope of the graph using the following formula:

$$m = \frac{ln(y_0) - ln(y_4)}{x_0 - x_4}$$

m =

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Slide	Score / Total
Slide 17: Relationship cuvettes & voltage	0/3

Total amount 0 / 3

Solutions | Repeat | Exporting text

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