# How does the brightness of the light decrease with distance?


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/5f50708737ffe20003f10042

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# Teacher information

## Application

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Experiment set-up

**How does the brightness of the light decrease with distance?**

If you move away from a light source, it gets darker, everyone knows that.

In this experiment, the students derive a relationship between the distance to a light source and the light intensity.



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# Other teacher information

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**Prior knowledge**

Light propagates from the light source almost spherically (spherical wave). The intensity of the light is distributed evenly over the surface of the sphere. The formula for calculating a spherical surface is: $O = 4 * \pi * r^2$The surface increases square to the radius and the intensity decreases square to the distance to the light source.

**Task**

Relationship between the distance to a light source and the light intensity

# Notes on implementation

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It is important for the construction and implementation that the room is darkened and the solar cell is aligned in such a way that it can register little stray light. (In the classroom, for example, the solar cells should face the walls so that the students do not disturb each other).

The solar cell is partially covered with the cardboard so that the reference surface is the same size for the (almost) vertically incident rays. If the complete solar cell is used, the incidence angles are too different when the solar cell is close to the light source.



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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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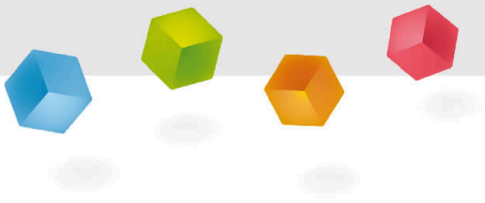

# Student Information



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# Motivation

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Experiment set-up

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**How does the brightness of the light decrease with distance?**

If you move away from a light source, it gets darker, everybody knows that.

In this experiment you derive a relationship between the distance to a light source and the light intensity.



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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 | Solar cell 3.3 x 6.5 cm, with plugs, 0.5 V, 330 mA | 06752-09 | 1 |
| 6 | Halogen lamp, 12 V/10 W, mounted with 4 mm plugs | 09852-00 | 1 |
| 7 | PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A | 13506-93 | 1 |
| 8 | Digital multimeter, 600V AC/DC, 10A AC/DC, 20 MΩ, 200 µF, 20 kHz, −20°C… 760°C | 07122-00 | 1 |
| 9 | Connecting cord, 32 A, 750 mm, red | 07362-01 | 1 |
| 10 | Connecting cord, 32 A, 750 mm, blue | 07362-04 | 1 |



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## Set-up (1/2)

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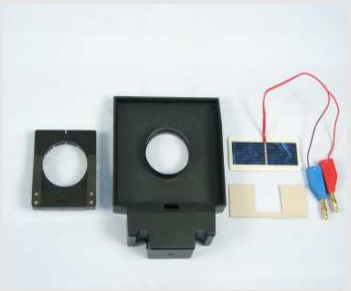
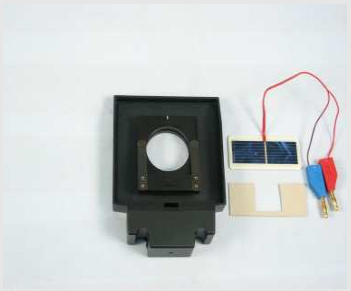
- Place the halogen lamp with a tab on the tripod material and connect it to the power supply unit.
- Cut a piece out of the cardboard.
- Put it over the solar cell, so that an area of about 25x25 mm is free



## Set-up (2/2)

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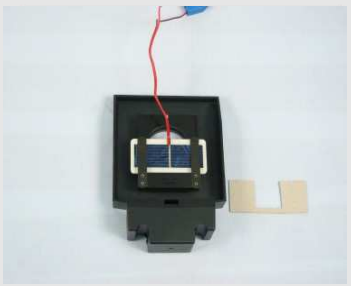
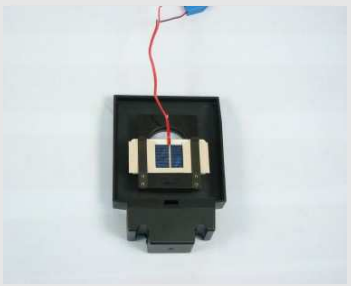
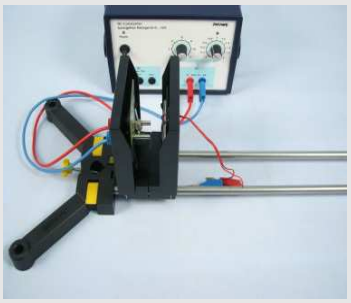
- Opposite the halogen lamp, place the solar cell in a rider on the tripod material so that the rider feet touch each other.
- Make sure that the solar cell is horizontally centered in the panel holder.
- A multimeter is connected to the solar cell as an ammeter, measuring range: 2 mA.

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## Procedure (1/2)

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Experiment procedure

- Set the power supply unit to 12 V.
- Measure the photocurrent at the solar cell after 10 seconds and note the result in Table 1 in the protocol.

The 10 seconds are needed for the halogen lamp to warm up!

The photocurrent is measured in this experiment to determine the intensity of the light.

## Procedure (2/2)

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Experiment procedure

- Remove the solar cell from the light source step by step according to the information in Table 1:

  *5,5 - 6,5 - 7,5 - 8,5 - 9,5 -10,5 - 11,5 - 12,5 - 13,5 - 14,5 - 15,5 - 20,5 - 25,5 - 30,5 - 35,5 - 40,5 - 45,5*

- The distance between the white lines on the rider's feet is measured. The photocurrent is noted in each case.
- Finally, set the supply voltage of the halogen lamp to zero.
- Perform a reference measurement for the solar cell to exclude a possible offset current from the following calculation.



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# Report

## Task 1

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Table on the next two pages!

1. Note the photocurrent, without lamp, in mA:

2. To determine the distance of the light source from the solar cell, subtract the constant value of 1.8 cm in each case. Enter the new value in the column "Distance light source - solar cell".

3. In the column "Photo current - corrected": "Photocurrent" minus "Photocurrent without lamp"

4. Calculate the expressions $y * x$, $y * x^2$,$y * x^3$ and $y * x^4$ whereat $x$ the distance from light source to solar cell and $y$ is the corrected photocurrent. Enter the results in the table.



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# Task 1

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# Task 1 - Table (1/2)

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| Distance Rider [cm] | Distance Light source - Solar cell [cm] | Photocurrent [mA] | Photocurrent corrected [mA] | $x * y$ | $y * x^2$ | $y * x^3$ | $y * x^4$ |
|---|---|---|---|---|---|---|---|
| 5,5 | | | | | | | |
| 6,5 | | | | | | | |
| 7,5 | | | | | | | |
| 8,5 | | | | | | | |
| 9,5 | | | | | | | |
| 10,5 | | | | | | | |
| 11,5 | | | | | | | |
| 12,5 | | | | | | | |
| 13,5 | | | | | | | |



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# Task 1 - Table (2/2)

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| Distance Rider [cm] | Distance Light source - Solar cell [cm] | Photocurrent [mA] | Photocurrent corrected [mA] | $x * y$ | $y * x^2$ | $y * x^3$ | $y * x^4$ |
|---|---|---|---|---|---|---|---|
| 14,5 | | | | | | | |
| 15,5 | | | | | | | |
| 20,5 | | | | | | | |
| 25,5 | | | | | | | |
| 30,5 | | | | | | | |
| 35,5 | | | | | | | |
| 40,5 | | | | | | | |
| 45,5 | | | | | | | |

# Task 2

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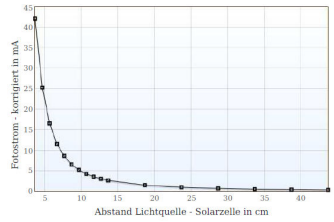
The graph could look like this:




Make a guess for the relationship between the distance and the magnitude of the measured intensity (proportional to the photocurrent)

Umdrehen

Karte 1 von 1

Drag the right words into the gaps!

The column _____ does not return a constant value, nor do the columns $y \cdot x^3$ and $y \cdot x^4$. Only the column _____ provides an approximately constant value. There is therefore a connection to _____ made.

$y \cdot x$ $\quad \cdot\frac{1}{x^2}$ $\quad y \cdot x^2$

Check



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