Illuminance (inverse square law)

Physics > Light & Optics > Dispersion 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/5f4e975b38db8d0003265b8e

PHYWE

Teacher information

Application

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range of an incandescent lamp

How far does the light of an incandescent lamp actually reach? A flashlight? Or a headlight?

This experiment is about the decrease of illuminance with increasing distance from the light source.

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Other teacher information (1/3)

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Prior knowledge

The pupils should first know the basics of linear propagation of light and be able to use a light box, and in connection with the measurement of the side lengths of the illuminated surfaces, the pupils must draw on their knowledge of the core and penumbra. Because the light source is not punctiform, the edges of the shadows are not sharp.

Scientific principle

The area illuminated by a light box is determined depending on the distance to the light box.

Other teacher information (2/3)

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Learning objective

This experiment is suitable both as an introductory experiment and as a confirmation experiment for the validity of the law of distance.

Tasks

Investigations such as illuminance *E* with the distance *r* between a light source and an illuminated surface.

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Other teacher information (3/3)

Notes on construction and implementation

The teacher should make sure that the graph paper on the screen is not wavy but tightly stretched and that when marking the edges of the illuminated areas, the screen must not be shifted or tilted, so that the measuring errors do not become too large

Safety instructions

- Halogen lamps become warm during prolonged use
- Avoid looking directly into the light source

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Student Information

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Motivation

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On the road at night

How far can you see at night on the road when you are riding your bike?

From what distance can others recognize you when you have your lamp on?

The answers to these questions are hidden in the distance dependence of illuminance.

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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	Diaphragm with square	09816-03	1
5	Slide mount for optical bench	09822-00	1
6	Screen, white, 150x150 mm	09826-00	1
7	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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7	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

Set-up (1/5)

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Assembly of the optical bench

Build up the optical bench from the two tripod rods and the variable tripod foot and place the scale on the front tripod rod.

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Set-up (2/5)

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Using the light box with base and handle

- Place the base with handle under the light box.

Set-up (3/5)

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Positioning of the light box

- Clamp it into the left part of the tripod base with the lens side facing away from the optical bench.
- Slide an opaque shade in front of the lens and the shade with the square opening into the shaft at the other end of the lamp.

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Set-up (4/5)

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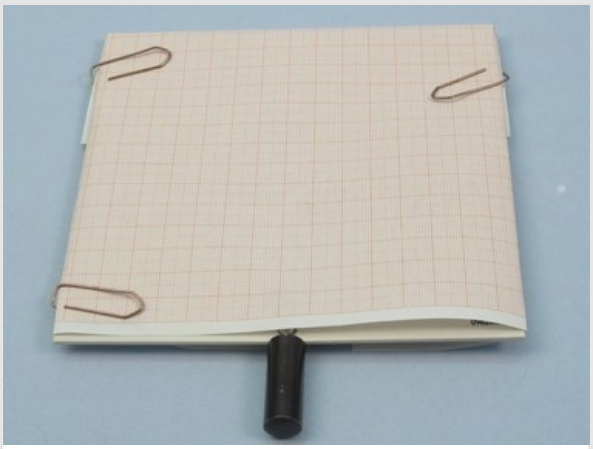
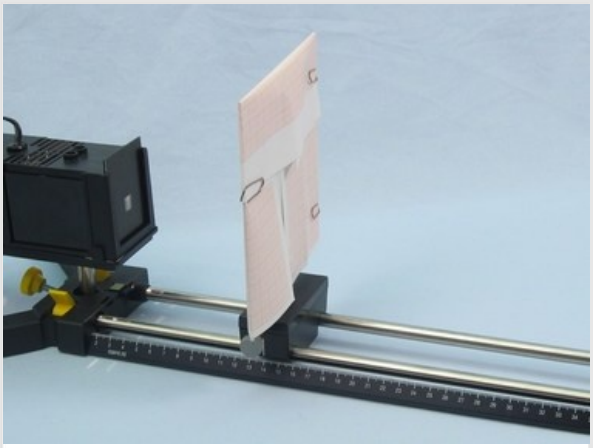


Attaching the millimetre paper

- Place the graph paper sheet on the screen, fold the protruding parts backwards and fasten the paper with 3 paper clips tightly to the screen.

Set-up (5/5)

PHYWE



Attaching the millimetre paper

- Place the shade on the optical bench using the tab by the lamp.

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Procedure (1/2)

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Connecting the light box

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

Procedure (2/2)

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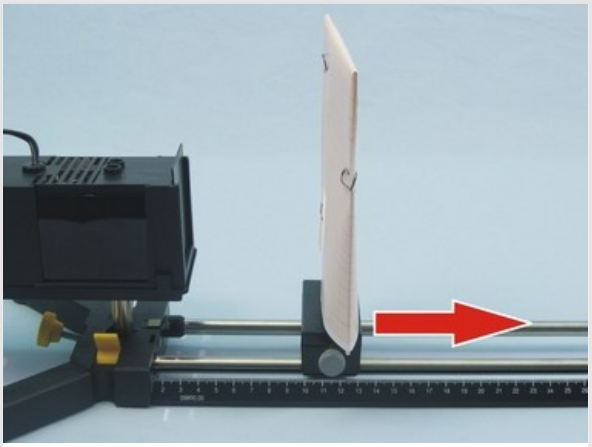

Positioning of the shield

Slowly move the screen to the right while observing the illuminated area.

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Procedure (2/2)

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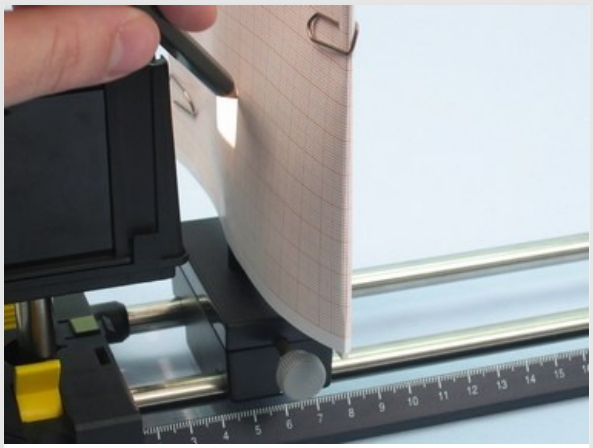

Marking of the illuminated area

- Place the screen at the 6 cm mark. (The screen has now a distance of r= 6 cm from the light source (filament of the lamp in the lamp)).
- Mark the edges of the illuminated area with a pencil (dashed).

Procedure (2/2)

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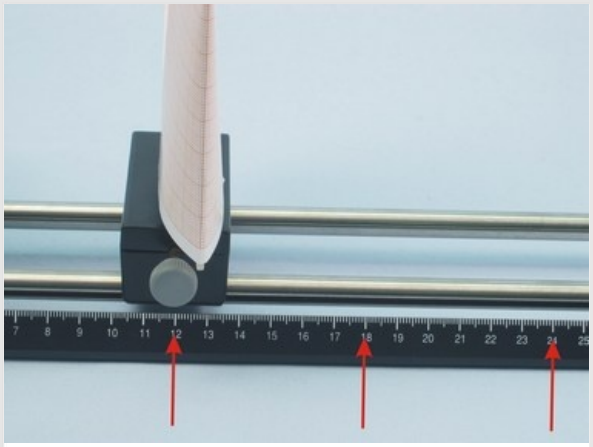

Marking of the illuminated area

- Place the screen at 12 cm, 18 cm and 24 cm intervals.
- Mark the respective edges of the illuminated area in the same way.
- Switch off the power supply unit.
- Loosen the graph paper from the screen and draw the illuminated areas by joining the marks of their edges.
- Measure the side lengths *a*and *b*of the illuminated areas and enter them in the table in the protocol.

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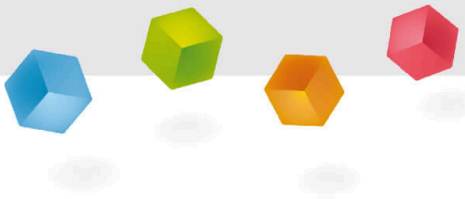

Report

Task 1

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Change of the illuminated area with increasing distance of the screen from the light source: Enter your measured values in the table. For the illuminated areas, refract the areas A = a-b and the squares of their respective distances r from the light source.

r in cm	a in cm	b in cm	a*b in cm²	r² in cm²	A/r²
3 (aperture)					
6					
12					
18					
24					

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Task 2

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Compare the values of A = a-b and r 2 . What is probably the relationship between A and r^2 ?

A and r^2 are (probably) _____ to each other.

Check

Task 3

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Check your guess: Calculate the quotients A/r^2 (to 2 decimal places) and enter your results in the last column of Table 1 in the section "Observations and Measurement Results". Write down the relationship between A and r^2 in mathematical form and in words.

$A / r^2 =$ _____

.

$A \sim r^2$, i.e. _____ of the illuminated area and _____ of its distance from the light source are proportional to each other.

the square

the size

Check

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Task 4

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The light emitted by the light source is therefore distributed over four times the area of the surface, e.g. at double the distance r, i.e. illuminance E (or brightness) has fallen to a quarter.

So what is the relationship between E and r?

Task 5

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The illuminance E is also proportional to the luminous intensity I of the light source.

What is the relationship between E, I and r?

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