Photometric law of distance with Cobra4 (Item No.: P2240260)

Curricular Relevance

Area of Expertise: Physics
Education Level: University
Topic: Light and Optics
Subtopic: Nature and Propagation of Light
Experiment: Photometric law of distance with Cobra4

Difficulty
Intermediate

Preparation Time
2 Hours

Execution Time
3 Hours

Recommended Group Size
2 Students

Additional Requirements:

- PC

Experiment Variations:

Keywords:

Luminous flux, quantity of light, luminous intensity, illuminance, luminance

Overview

Principle

Related topics
Luminous flux, quantity of light, luminous intensity, illuminance, luminance.

Principle
The luminous intensity emitted by a punctual source is determined as a function of distance.

Material

Position No.	Material	Order No.	Quantity
1	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	2
2	Cobra4 Sensor-Unit Energy: Current, voltage, work, power	12656-00	1
3	Cobra4 Sensor-Unit Motion	12649-00	1
4	Lamp holder E 14,on stem	06175-00	1
5	Filament lamp 6V/5A, E14	06158-00	1
6	PHYWE power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
7	Stand tube	02060-00	3
8	Distributor	06024-00	1
9	Barrel base PHYWE	02006-55	2
10	Meter scale, l = 1000 mm	03001-00	1
11	Connecting cord, 32 A, 750 mm, red	07362-01	1
12	Connecting cord, 32 A, 750 mm, blue	07362-04	1
13	Right angle clamp expert	02054-00	1
14	Photo diode, G1	39119-01	1
15	Bench clamp, for rods with diameter of max. 13 mm	37705-00	1
16	Screen, metal, 300 x 300 mm	08062-00	1
17	Software Cobra4 - multi-user licence	14550-61	1
18	Holder for Cobra4 with support rod	12680-00	1
19	USB charger for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	2

Tasks

Tasks

1. The luminous intensity emitted by a punctual source is determined as a function of distance from the source.
2. The photometric law of distance is verified by plotting illuminance as a function of the reciprocal value of the square of the distance.

Set-up and procedure

Set-up

Experimental objective
The luminous intensity is a function of the distance of the light sensor from the light source. The law for point light sources on which this is based should be determined.
Set-up
The experimental set-up is shown in Fig. 1. Align the filament of the lamp such that its wide side faces the photocell. Adjust the photodiode in such a manner that it remains oriented towards the lamp's filament when moved. Naturally, the lamp's filament and the photocell must be mounted at the same height above the table. Since the distance law, which is to be verified, is only valid for point light sources, an initial separation (sensor – lamp filament) of 15 cm should be used. In favour to do so, place the stand tube of the lamp with its end on the one meter marking and place the end of the photo cells stand tube 15 cm away. Darken the room or shield the experiment from direct sunlight. Connect one Cobra4 Wireless/USB-Link to the USB interface of the computer and plug the Cobra4 Sensor-Unit Energy on the Cobra4 Wireless/USB-Link. Then plug the Cobra4 Sensor-Unit Motion to the second Cobra4 Wireless-Link, connect it via Wifi to the computer and fix this combination with the holder to the bench clamp. Load the "Photometric law of distance" experiment. (Experiment > Open experiment). All pre-settings that are necessary for measured value recording are now carried out.

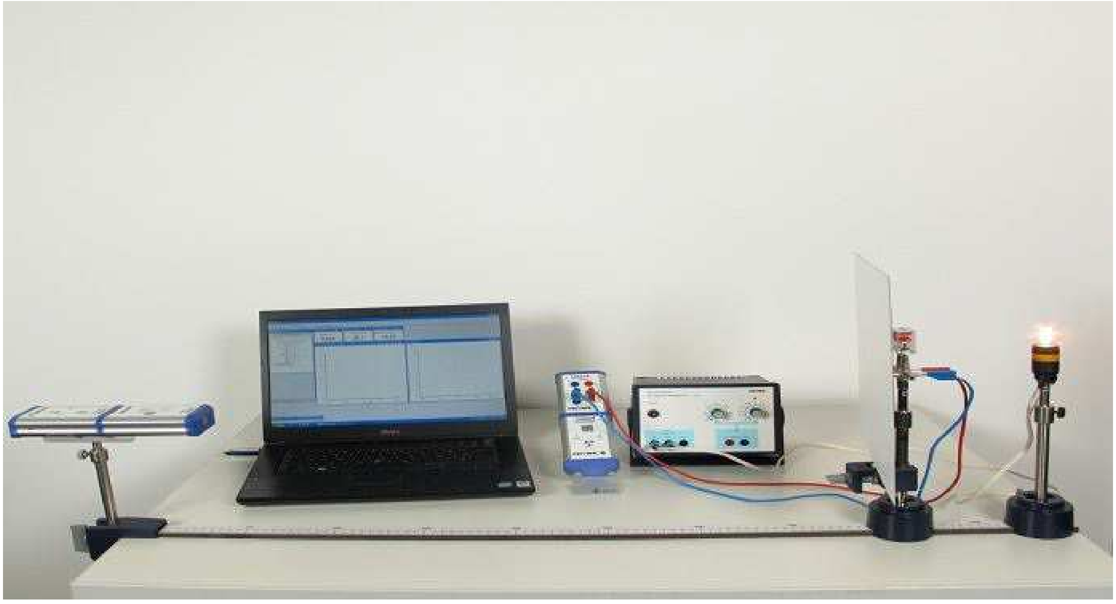

Fig. 1: Experimental set-up

Procedure

Procedure

- To measure the path with the motion sensor put the photocell in the initial position (15 cm away from lamp filament). Before starting the measurement, go to virtual channel 'Distance d' and adjust the value depicted in Fig. 2 (encircled in red). For instance, if the Motion sensor gives a value of 0.70 m you would change the value to 0.85 (0.75 m + 0.15 m) to obtain the distance between the photodiode and the lamp.

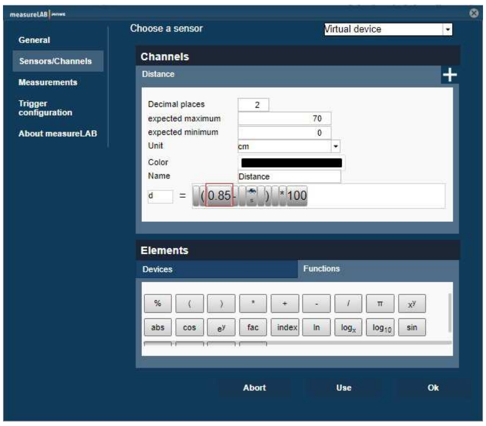

Fig. 2: Virtual Channel for Distance d

- Start the measurement by pressing on and move slowly (about 0.5 cm/s) the photocell along the meter scale away from lamp filament.
- At a distance of approximately 70 cm you can terminate the measurement by pressing on , as the luminous intensity has now become very low and in addition the diffuse light fraction is relatively large.

Theory and evaluation

Theory

Theory

A punctual light source of luminous intensity I (Candela/cd) emits a light flux Φ (Lumen/lm) throughout a solid angle ω. The luminous intensity in a solid angle element $\mathrm{d}\omega$ results to

$$I = \frac{\mathrm{d}\phi}{\mathrm{d}\omega}[\text{cd}].$$

For luminous sources extended in space (also such which emit no light by themselves, but which are reflecting), luminance B is given by :

$$B = \frac{\mathrm{d}I}{\mathrm{d}\alpha}\left[\frac{\mathrm{cd}}{\mathrm{cm}^2}\right].$$

If an area $\mathrm{d}A^*$ is illuminated by a luminous flux $d\Phi$, illuminance E (Lux/lx) is given by:

$$E = \frac{\mathrm{d}\phi}{\mathrm{d}A^*}[\text{lx}].$$

Fig. 3 gives a schematic representation of the illumination of a surface element $\mathrm{d}A^*$ through a punctual light source P. The luminous intensity of the source is I and its distance from the surface element is r, the line perpendicular to the surface element points in the direction of the connecting line with the light source.

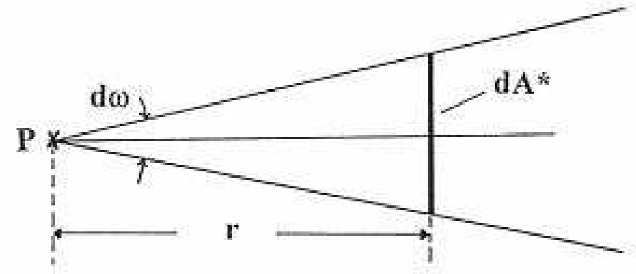

Fig. 3: Schematic determination of the photometric law of distance.

The illuminance E is given by:

$$E = \frac{\mathrm{d}\phi}{\mathrm{d}A^*} = \frac{\mathrm{d}\phi/\mathrm{d}\omega}{\mathrm{d}\omega/\mathrm{d}A^*}.$$

With $\mathrm{d}\omega$ = dA^*/r^2 one obtains the equation:

$$E = \frac{I}{r^2}.$$

This equation describes the photometric law of distance. According to this, the illuminance E of a surface decreases proportionally to the square of distance r for a constant luminous intensity I.

Evaluation

Analysis of the measurement

The luminous intensity is plotted as a function of actual distance between the lamp filament and sensor (c.f. Fig. 4).

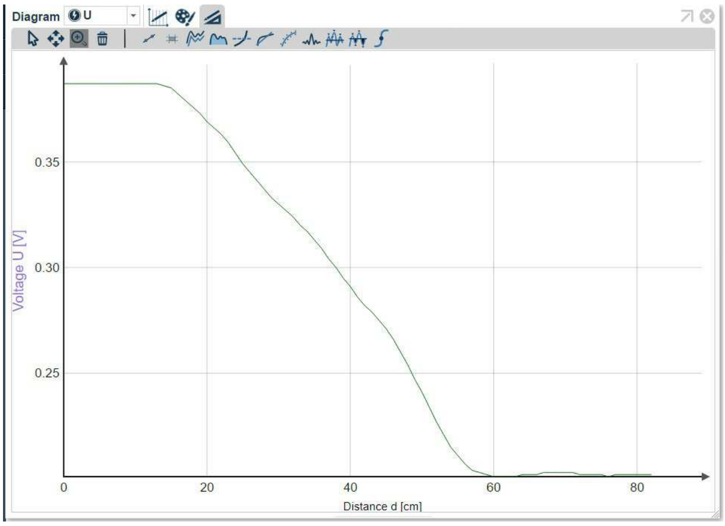

Fig. 4: Luminous intensity as a function of distance (exemplary result)

For further analysis of the inverse value $1/d^2$, go to on the right hand side:

1. Create a channel conversion of the squared inverse value with (right upper side). Simply drag your measured values for distance d into the Data pool and type in the formula as shown in Fig. 5.
2. Select the generated squared inverse value and your measured voltage values
3. Choose the option diagram to plot the inverse value against the voltage
4. In the displayed diagram, go to and select the inverse value as x axis.

An exemplary result is shown in Fig. 6.

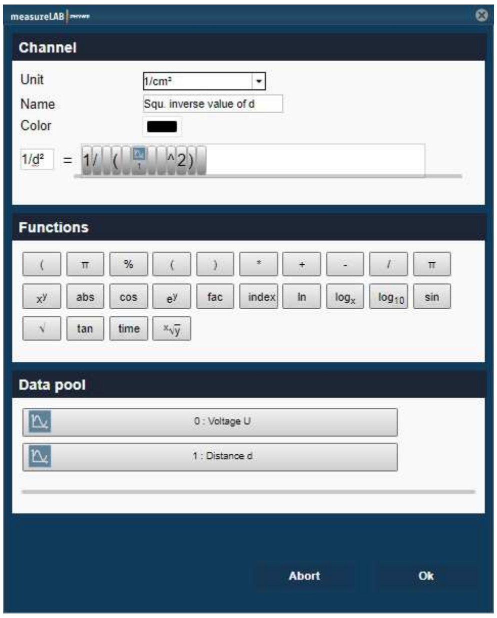

Fig. 5: Channel conversion of distance d values

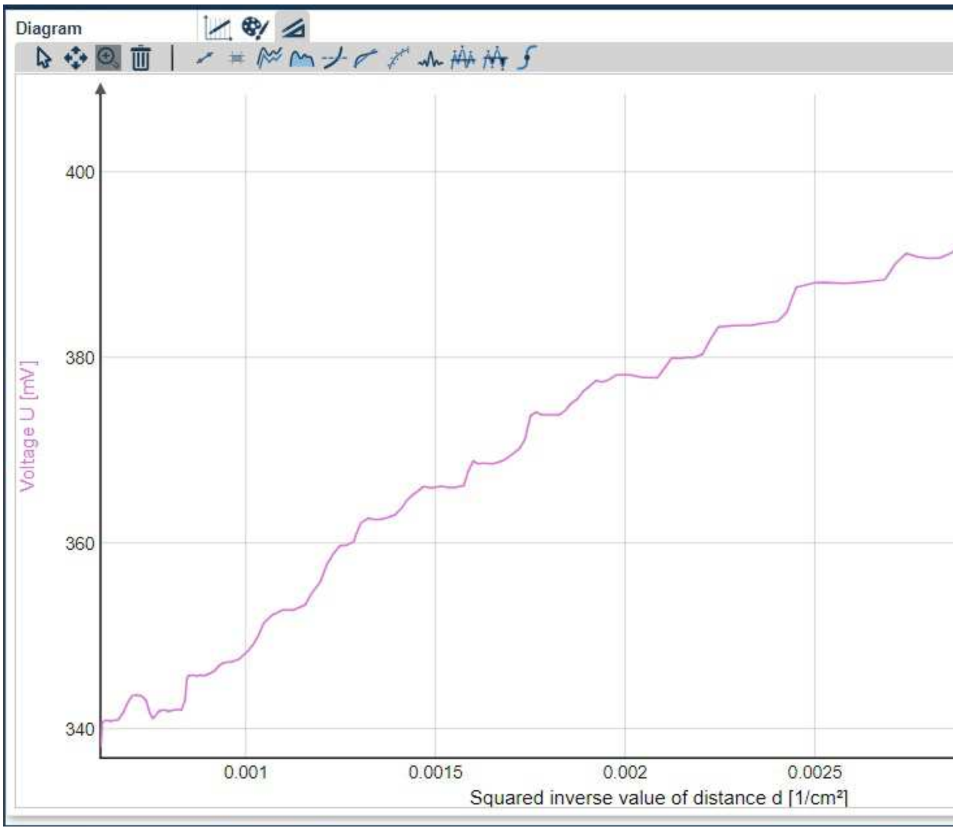

Fig. 6: Luminous intensity versus one over squared inverse value of dista