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

1	Cobra4 Wireless Manager	12600-00
2	Cobra4 Wireless-Link	12601-00
1	Cobra4 Sensor-Unit Energy	12656-00
1	Cobra4 Sensor-Unit Motion, ultrasound motion detector	12649-00
1	Holder for Cobra4 with support rod	12680-00
1	Power supply, 0…12 V DC/ 6 V, 12 V AC, 230 Volt	13505-93
3	Stand tube	02060-00
1	Distributor	06024-00
2	Barrel base PHYWE	02006-55
1	Meter scale, l = 1000 mm	03001-00
1	Bench clamp PHYWE	02010-00
1	PEK photodiode, G1	39119-01
1	Incandescent lamp, 6 V/5 A, E 14	06158-00
1	Lamp holder E 14, on stem	06175-00
1	Connecting cord, 32 A, l = 75 cm, red	07362-01
1	Connecting cord, 32 A, l = 75 cm, blue	07362-04
1	Right angle clamp PHYWE	02040-55
1	Screen, metal, 300×300 mm	08062-00
1	Software Cobra4 - multi-user licence	14550-61

Additionally required

1	PC with USB-interface, Windows XP or higher	

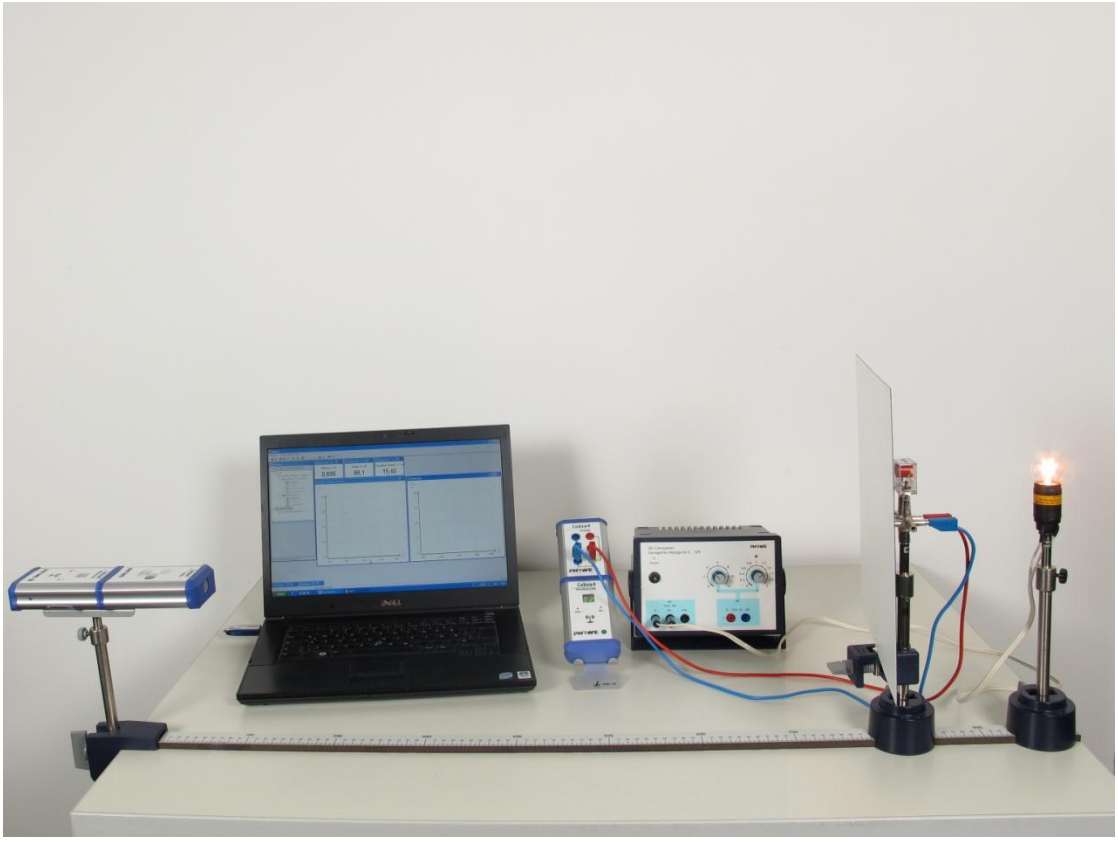

Fig. 1: Experimental set-up.

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.

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 and procedure

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. Darken the room or shield the experiment from direct sunlight. Connect the Cobra4 Wireless Manager to the USB interface of the computer, plug the Cobra4 Sensor-Unit Energy on the first Cobra4 Wireless-Link, the Cobra4 Sensor-Unit Motion to the second Cobra4 Wireless-Link 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. To measure the path with the motion sensor put the photocell in the initial position (15 cm away from lamp filament). Start the measurement (●) 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 (■), as the luminous intensity has now become very low and in addition the diffuse light fraction is relatively large, and send the results to measure (Fig. 2)

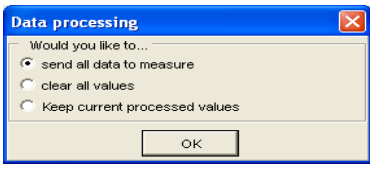

Fig. 2: Saving measurements.

Theory and evaluation

A punctual light source of luminous intensity I (Candela/cd) emits a light flux Φ (Lumen/lm) throughout a solid angle ω. Luminous intensity in a solid angle element d_ω amounts to equation 1:

$$I = \frac{d\Phi}{d_\omega}\ [cd] \qquad (1)$$

For luminous sources extended in space (also such which emit no light by themselves, but which are reflecting), luminance B is given by equation 2:

$$B = \frac{dI}{da}\ \frac{cd}{cm^2} \qquad (2)$$

If an area dA* is illuminated by a luminous flux $d\Phi$, illuminance E (Lux/lx) is given by equation 3:

$$E = \frac{d\Phi}{dA^*}\ [lx] \qquad (3)$$

Fig. 3 gives a schematic representation of the illumination of a surface element dA* through a punctual light source P. The luminous intensity of the source is I and its distance from the surface element is r; the perpendicular to the surface element points in the direction of the connecting line with the light source. The illuminance E is given by equation 4:

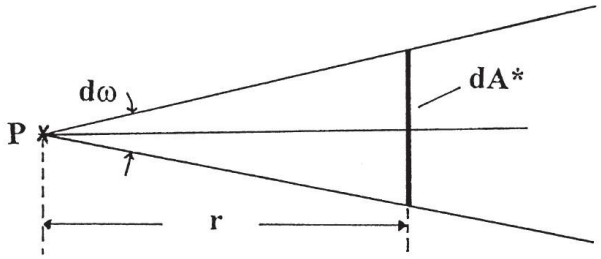

Fig. 3: Schematic determination of the photometric law of distance.

$$E = \frac{d\Phi}{dA^*} = \frac{d\Phi/d_\omega}{d_\omega/dA^*} \quad (4)$$

With $d_\omega = dA^* / r^2$ and (1) one obtains equation 5:

$$E = \frac{I}{r^2} \quad (5)$$

Equation (5) describes the photometric law of distance. According to this, the illuminance E of a surface decreases proportionally to the square of distance r for constant luminous intensity I.

Analysis of the measurement

For the analysis of the results the measured distance between screen and motion sensor is converted into the actual distance lamp/diode with aid of the calculated channel.
The luminous intensity is plotted as a function of actual distance between the lamp filament and sensor (see Fig. 4).

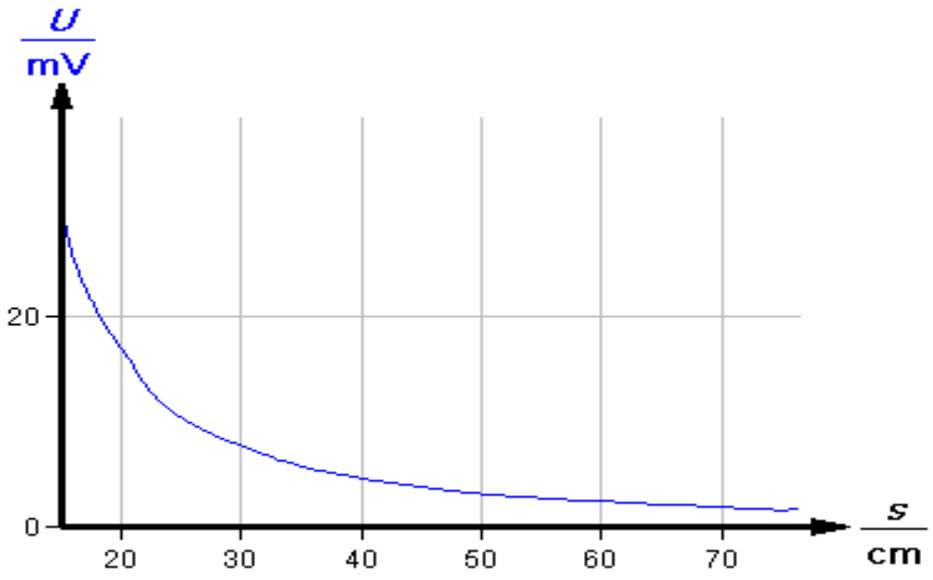

Fig. 4: Luminous intensity as a function of distance (Lamp – Diode).

After conversion use the same Analysis / Channel modification window for the calculation of the square of the inverse value 1/(s*s) (see Fig. 5):

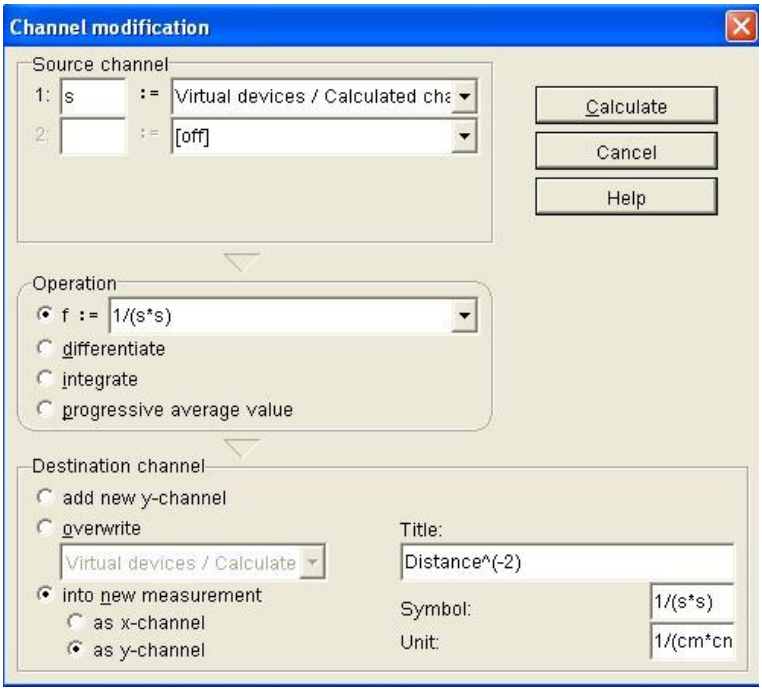

Fig. 5: Parameters of the channel modification.

In Fig. 6 the measured values of the luminous intensity are plotted as a function of the reciprocal values of the square of distance *r*. The photometric law of distance is verified by the linearity of the primary graph.

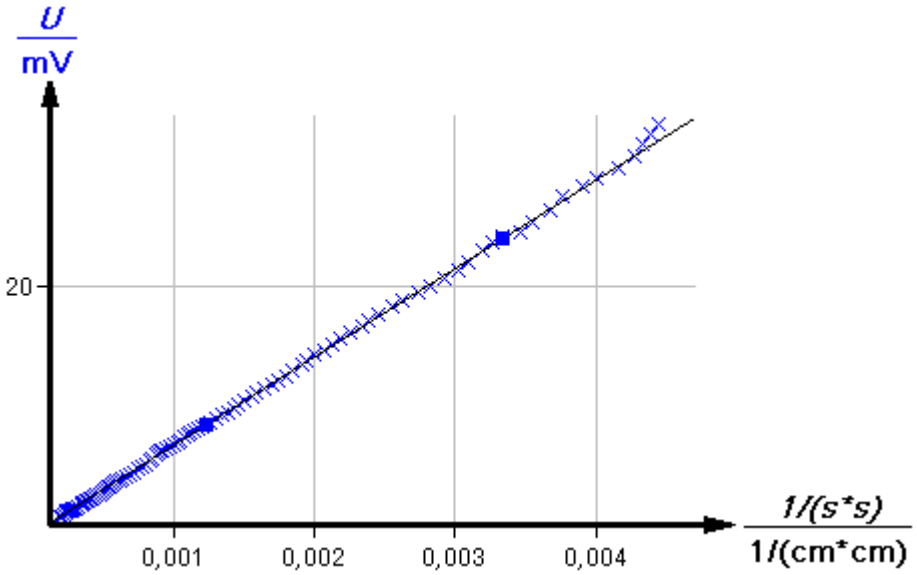

Fig. 6: Luminous intensity as a function of the square of the reciprocal of the distance (lamp – diode).