8. Photometric law of distance

Tasks:
1. The luminous intensity emitted by a punctual source is determined as a function of distance from the source. Draw the graph.
2. Plotting illuminance verifies the photometric law of distance as a function of the reciprocal value of the square of the distance. Draw the graph.

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.

Equipment list:

Lux meter, hand-held, Luxmeter probe, Optical bench, Slide mounts for optical bench, Lamp holder, Filament lamp 12V/5A, Power supply 0-12 DC, 10 A.

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 photocell 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.

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 60 cm you can terminate the measurement, as the luminous intensity has now become very low and also the diffuse light fraction is relatively large.

Fig. 1. Experimental set-up

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:

$I = d\Phi / d\omega$ [cd] (1)

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

$B = dI / dA$ [cd/cm^2] (2)

If an area d*A** is illuminated by a luminous flux dΦ, illuminance *E* (Lux/lx) is:

$E = d\Phi / dA^*$ [lx] (3)

Fig. 2 gives a schematic representation of the illumination of a surface element 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 perpendicular to the surface element points in the direction of the connecting line with the light source.
The illuminance *E* is given by:

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

With $d\omega = dA^* / r^2$

and (1) one obtains:

$E = I / r^2$ (5)

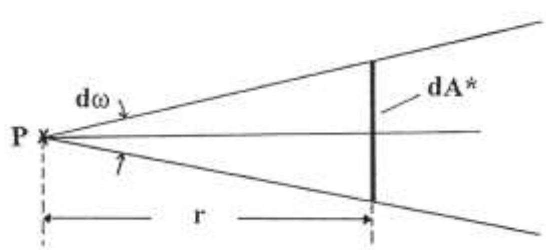

Fig. 2. Schematic determination of the photometric law of distance.

Results:

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* as is illustrated in Fig. 3.

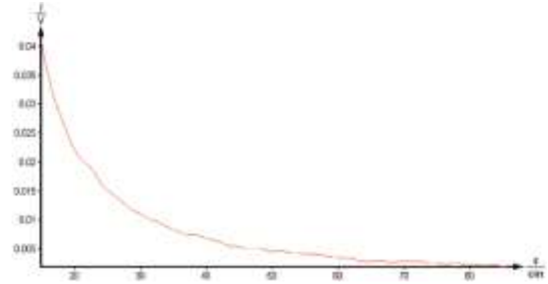

Fig. 3. Luminous intensity as a function of distance (Lamp – Photocell)

In Fig. 4 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.

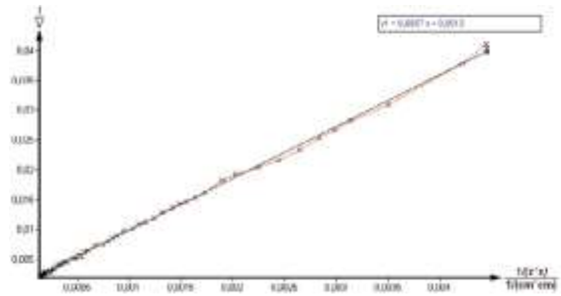

Fig. 4. Luminous intensity as a function of the square of the reciprocal of the distance (lamp – Photocell)

Conclusion: