3.4 Photometry

It deals with the measurements of the intensity of light emitted by a source, its illuminating power or intensity of illumination of a surface is called photometry.

Luminous flux ((ϕ)

Light energy emitted per second from a light source. Unit is lumen (lm).

If ϕ is the luminous flux radiated by a source within a solid angle Ω in any particular direction

then luminous intensity is given by

$$I = \frac{\phi}{\Omega}$$

If ϕ is measured in lumens and Ω in steradian.

Then

$I = \frac{\text{lumen}}{\text{steradia}}$ **or** candela

Unit: Hence, **unit of luminous intensity is Candela(Cd).**

Lumen

It is the luminous flux emitted from a standard candle.

Luminous intensity or illuminating power (I)

Illuminating power of a source in any direction is defined as the luminous flux emitted per unit solid angle in that direction.

Candela

A light has a luminous intensity of 1 candela if it emits 1 lumen (1 lm per steradian.)

Illumination or intensity of illumination (E)

The luminous flux incident normally per unit area of the surface is called illumination or intensity of illumination.

If ϕ is the total flux falling over an area A, then

llumination, $\boldsymbol{E} = \frac{\phi}{A}$

If ϕ is measured in lumen and A is in metre^2.

$E = \frac{lumen}{metre^2}$

i.e., lumen per metre^2 or lux.

COSINES LAW

In optics, Lambert's cosine law states **that the radiant intensity or luminous intensity observed from an ideal diffusely reflecting surface is directly proportional to the cosine of the angle between the direction of the incident light and the surface normal.** The law is also known as cosine emission law or Lambert's emission law.

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- A surface which obeys Lambert's law is said to be Lambertian and exhibits Lambertian reflectance. Such a surface has the same radiance when viewed from any angle.

Illuminanation: It is amount of light flux that is incident upon unit area of the given surface. Illuminance is also called as illumination

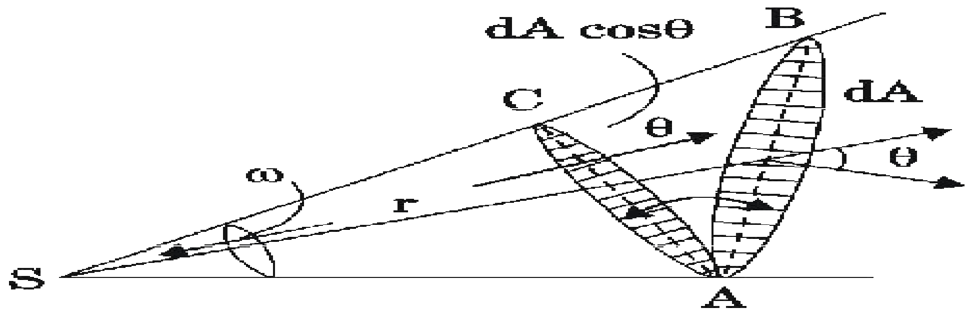

Fig:3.4.1- Light flux upon some area

If *dF* is the elemental light flux incident on an elementary area *dA* then illuminance *E* is defined as

$$\boldsymbol{E} = \frac{\boldsymbol{dF}}{\boldsymbol{dA}}$$

Its units are lumen per sqmetre.

Consider an elementary surface *AB* of area *dA* illuminated by the source *S* [fig 3.4.1] which subtends solid angle ‘Ω’ at the point source *S*.

It light flux ‘*F*’ lumens falls on the area *AB* then Intensity of illumination

$$E = \frac{F}{dA} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

If *L* is the illuminating power or luminous intensity of the source, it is defined as luminous flux per unit solid angle.

$$L = \frac{F}{\Omega}$$

$$\text{(or)} \quad F = L\Omega$$

Substituting for *F* in equation (1) we have

Intensity of Illumination $E = \frac{L\Omega}{dA}$

If ‘r’ is the distance of the surface from ‘’dA’’ from the source then

$$\Omega = \frac{dACos\theta}{r^2}$$

Substituting for ω in equation (2), we obtain

Intensity of illumination E = $\frac{LdACos\theta}{r^2dA}$

$$E = \frac{LCos\theta}{r^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Equation (3) is known as Lambert's Cosine Law.

It states that intensity of illuminance is

i)directly proportional to cosine of the angle of incidence of light radiation on the surface and

ii)inversely proportional to the square of distance between the surface and source.

Special case:

If θ = 0 degrees

E = $\frac{L}{r^2}$

INVERSE SQUARE LAW

The inverse square law defines the relationship between the irradiance from a point source and distance. It states that the intensity per unit area is inversely proportional to the square of the distance.

Consider a point source '*S*' of light. It is radiating equally in all directions. Draw two concentric spheres (fig. 3.4.2) of radii r_1 and r_2 around of source. Let the energy radiating from the source per sec be *Q*.

This energy will fall normally on the surface of sphere(1). Energy incident per sec on unit area of sphere having radius

r_1 is I = $\frac{Q}{4\pi r^2} \ldots\ldots\ldots\ldots\ldots\ldots(1)$

Since light is falling normally,here θ = 0 degrees, cosθ= 1

Similarly for sphere of radius r_2 and incident energy on unit area

$I_2 = \frac{Q}{4\pi r_2^2}$ …………………(2)

From (1) & (2)

$\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$…………………(3)

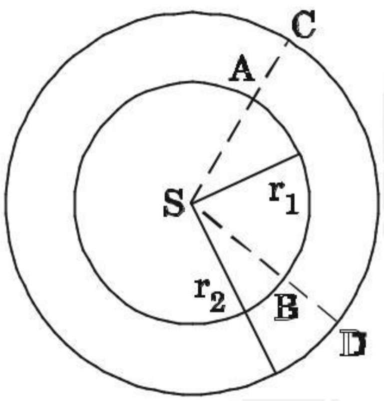

Fig:3.4.1-Concentric Spheres of radius r_1 and r_2

It states that amount of light energy falling on a given surface is inversely proportional to the square of the distance of the Surface from Source.

If we consider two surfaces *AB* dA_1 and *CD*dA_2on the two spheres then energy incident, per sec over them is

$E_1 = \frac{QdA_1}{4\pi r_1^2}$

$E_1 = \frac{QdA_2}{4\pi r_2^2}$

$\frac{QdA_1}{4\pi r_1^2} = \frac{QdA_2}{4\pi r_2^2}$

Hence$E_1 = E_2$

$\frac{QdA_1}{4\pi r_1^2} = \frac{QdA_2}{4\pi r_2^2}$

$$\frac{dA_1}{dA_2} = \frac{r_1^2}{r_2^2}$$

or from eqn (2) & (3)

$$\frac{I_1}{I_2} = \frac{dA_1}{dA_2}$$

According to the inverse square law, illuminance on a surface decreases inversely proportional to the square of the distance between the light source and illuminated surface.

Inverse square law is applied to obtain luminous intensity.