1.1 INTRODUCTION

Illumination differs from light very much, through generally these terms are used more or less synonymously. Strictly speaking light is the cause and illumination is the result of that light on surfaces on which it falls. Thus, the illumination makes the surface look more or less bright with a certain colour and it is this brightness and colour which the eyes sets and interprets as something useful, or pleasant or otherwise. Light may be produced by passing electric current through filaments as in the incandescent lamps, through arcs between carbon or metal rods, or through suitable gases as in neon and other light is due to fluorescence excited by radiation arising from the passage of electric current through mercury vapour. Some bodies reflect light in some measure, and when illuminated from an original source they become secondary sources of light. A good example is the moon, which illuminate the earth by means of the reflected light originating in the sun. Lamp is an equipment, which produces light. Lighting is an essential service of human for the day to day activity. Light is in the form radiant energy. Light is a cause of illumination is the result of light falling on the surface. Illumination makes a surface to be visible. It is different from lights.

DEFINITIONS OF LIGHTING

1) Light:

It is defined as the radiant energy from a hot body which produces the visual sensation upon the human eye. It is usually denoted by Q, (lumen-hours) and is analogous to W-h.

2) Luminous flux

It is defined as the total quantity of light energy emitted per second from a luminous body. It is represented by symbol 'F' or 'Φ' and is measured in lumens. The conception of luminous flux helps us to specify the output and efficiency of a given light source.

$$\phi = \frac{Q}{t}$$

where Q - light energy (or) radiant energy

3) Luminous Intensity

Luminous Intensity in any given direction is the luminous flux emitted by the source per unit solid angle, measured in the direction in which the intensity is required. It is denoted by symbol I and is measured in candela (or) lumens per steradian.

$$I = \frac{\varphi}{\omega}$$

Unit is lumens/steradian (or) candela

4) Lumen:

The lumen is the unit of luminous flux. It is defined as the amount of luminous flux emitted by a source of one candle power in a unit solid angle.

Lumens = Candle power × Solid angle

5) Candle Power (CP):

It is defined as the number of limens emitted by that source per unit solid angle in a given directions. It is denoted by CP.

CP = Lumens/Solid angle

6) Illumination:

When the light falls upon any surface, the phenomenon is called the illumination. It is defined as the number of lumens, falling on the surface, per unit area. It is denoted by symbol 'E' and is measured in lumens/m^2 (or) lux (or) metre -candle. If a flux of 'F' lumens falls on a surface of area 'A', then the illumination of the surface is given by,

$$E = \frac{F}{A}$$

Unit - lumens/m^2 (or) lux

7) Lux (or) Metre Candle

It is the unit of illumination defined as the luminous flux falling per square metre on the surface, which is perpendicular to the light rays from a source of 1 CP and one metre away from it.

8) Foot - Candle:

It is also the unit of illumination and is defined as the luminous flux falling per square foot on the surface which is every perpendicular to the rays of light from a source of 1 CP and one foot away from it.

i.e., 1 Foot-candle = 1 lumen/ft^2. 1 Foot - candle = 10.76 metre - candle or lux.

9) Candela:

It is the unit of luminous intensity. It is defined as 1/60*th* of the luminous intensity per cm^2 of a black body radiator at the temperature of solidification of platinum.

10) Mean Horizontal Candle Power (MHCP)

It is defined as the mean of candle powers in all directions in the horizontal plane containing the source of light.

11) Mean Spherical Candle Power (MSCP)

It is defined as the mean of candle powers in all directions and in all planes from source of light.

12) Mean Hemi - Spherical Candle Power (MHSCP)

It is defined as the mean of candle powers in all directions above or below the horizontal plane passing through the source of light.

13) Reduction Factor:

Reduction factor of a source of light is defined as the ratio of its mean spherical candle power to its mean horizontal candle power.

$$Reduction\ factor = \frac{MSCP}{MHCP}$$

14) Lamp efficiency:

It is defined as the ratio of the luminous flux to the power input. It is expressed in lumens per watt.

15) Brightness (or) Luminance

Brightness (or) Luminance is defined as the luminous intensity per unit projected area of either a surface source of light or a reflecting surface and is denoted by 'L'. Lambert is also the unit of brightness which is lumens/cm^2. Foot lamberts is lumens/ft^2.

16) Glare:

Glare may be defined as the brightness within the field of vision of such a character as to cause annoyance, discomfort, interference with vision or eye - fatigue.

For example, Motor car head lights.

17) Space Height ratio:

It is defined as the ratio of horizontal distance between adjacent lamps and height of their mountings.

$$Space\ height\ ratio = \frac{Horizontal\ distance\ between\ two\ adjacent\ lamps}{Mounting\ height\ of\ lamps\ above\ working\ plane}$$

18) Utilization Factor (or) Co-efficient of Utilization:

It is defined as the ratio of total lumens reaching working plane to total lumens given out by the lamp.

$$Utilization\ factor = \frac{Total\ lumens\ reaching\ the\ working\ plane}{Total\ lumens\ given\ out\ by\ the\ lamp}$$

19) Maintenance factor:

It is defined as the ratio of illumination under normal working conditions to the illumination when the things are perfectly clean.

$$Maintenance\ factor = \frac{Illumination\ normal\ working\ condition}{Illumination\ when\ everything\ is\ perfectly\ clean}$$

20) Beam factor:

The ratio of limens in the beam of projector to the lumens given out by lamps is called beam factor. Its value varies from 0.3 to 0.6. This factor takes into account the absorption of light by reflector and front glass of the projector lamp.

21) Plane angle:

A plane angle is subtended at a point and is enclosed by two straight lines lying in the same plane. A plane angle is expressed in terms of degrees or radian. A radian is the angle subtended by an arc of a circle whose length equals the radius of the circle.

22) Solid angle:

A concept which frequently is used for illumination calculation is the solid angle. Consider an area A relative to a point P in the figure 1.1.1. if all the points on the boundary of the area A are joined to P, a cone-like shape is formed at P and the angle subtended by the area A at P is known as the solid angle. Let P represent the centre of a sphere. There will be a boundary of intersection where the solid angle subtended by area A passes through the sphere. This area on the sphere surface and area A are subtending the same solid angle at P.

$$Solid\ angle\ subtended\ by\ area\ A = \frac{Area\ of\ intersection\ at\ sphere\ surface}{(Radius\ of\ sphere)^2}$$

Solid angle is expressed in steradians.

$$Solid\ angle\ subtended\ by\ a\ sphere\ at\ its\ centre = \frac{Area\ of\ sphere}{r^2} = \frac{4\pi r^2}{r^2} = 4\pi$$

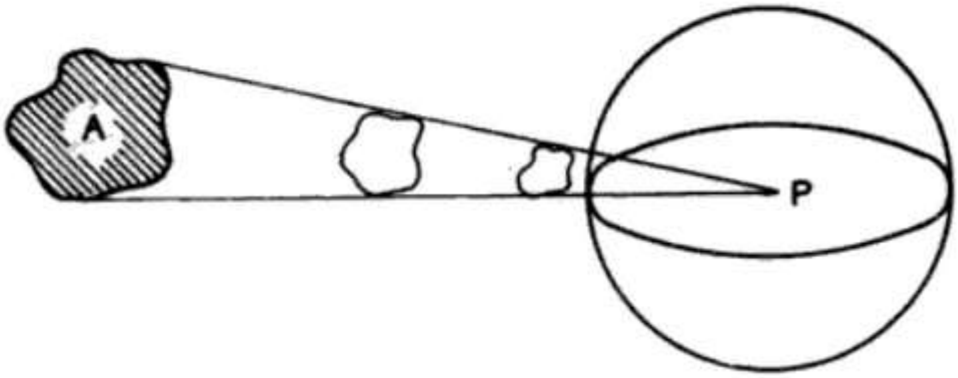

Figure 1.1.1 Concept of Solid Angle

[Source: "Generation, Distribution and Utilization of Electrical Energy" by C. L. Wadhwa, Page: 236]

Relationship between ω and θ. On referring to figure 1.1.2, let the segment ABC subtend a solid angle of ω and the lines OA and OC subtend a plane angle, θ at the centre 'O' of the circle.

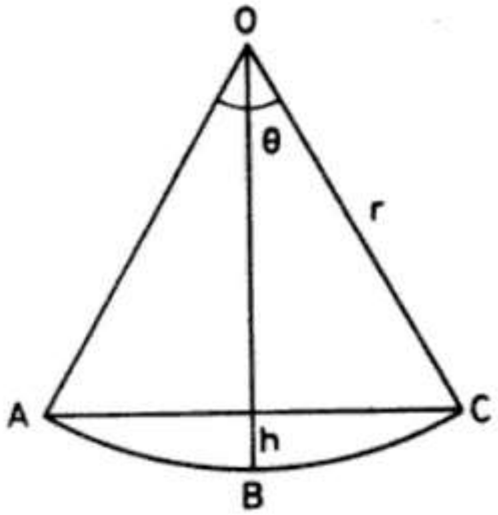

Figure 1.1.2 Relationship between Solid and Plane Angles

[Source: "Generation, Distribution and Utilization of Electrical Energy" by C. L. Wadhwa, Page: 237]

$$\omega = \frac{Surface\ area\ of\ segment\ ABC}{r^2} = \frac{2\pi rh}{r^2} = \frac{2\pi h}{r}$$

Also,

$$\frac{r-h}{r} = \cos\left(\frac{\theta}{2}\right)$$

$$h = r\left(1 - \cos\left(\frac{\theta}{2}\right)\right)$$

Substituting in the relation for ω, we get,

$$\omega = \frac{2\pi h}{r} = \frac{2\pi r\left(1 - \cos\left(\frac{\theta}{2}\right)\right)}{r} = 2\pi\left(1 - \cos\left(\frac{\theta}{2}\right)\right)$$