UTILIZATION OF ELECTRICAL ENERGY AND TRACTION

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5th SEM ELECTRICAL ENGG.

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ILLUMINATION

INTRODUCTION

Study of illumination engineering is necessary not only to understand the principles of light control as applied to interior lighting design such as domestic and factory lighting but also to understand outdoor applications such as highway lighting and flood lighting. Now a day, the electrically produced light is preferred to the other source of illumination because of an account of its cleanliness, ease of control, steady light output, low cost, and reliability. The best illumination is that it produces no strain on the eyes. Apart from its esthetic and decorative aspects, good lighting has a strictly utilitarian value in reducing the fatigue of the workers, protecting their health, increasing production, etc.The science of illumination engineering is therefore becoming of major importance.

NATURE OF LIGHT

Light is a form of electromagnetic energy radiated from a body and human eye is capable of receiving it. Light is a prime factor in the human life as all activities of human being ultimately depend upon the light.

Various forms of incandescent bodies are the sources of light and the light emitted by such bodies depends upon their temperature. A hot body about 500–800°C becomes a red hot and about 2,500–3,000°C the body becomes white hot. While the body is red hot, the wavelength of the radiated energy will be sufficiently large and the energy available in the form of heat. Further, the temperature increases, the body changes from red-hot to white-hot state, the wavelength of the radiated energy becomes smaller and enters into the range of the wavelength of light. The wavelength of the light waves varying from 0.0004 to 0.00075 mm, i.e. 4,000-7,500 Å (1 Angstrom unit = 10–10 mm). The eye discriminates between different wavelengths in this range by the sensation of color.

The whole of the energy radiated out is not useful for illumination purpose. Radiations of very short wavelength varying from 0.0000156 × 10–6m to 0.001 × 10–6 m are not in the visible range are called as rontgen or x-rays, which are having the property of penetrating through opaque bodies.

TERMS USED IN ILLUMINATION

The following terms are generally used in illumination.

Color: The energy radiation of the heated body is monochromatic, i.e. the radiation of only one wavelength emits specific color. The wavelength of visible light lies between 4,000 and 7,500 Å. The color of the radiation corresponding to the wavelength is shown in Fig. 6.1.

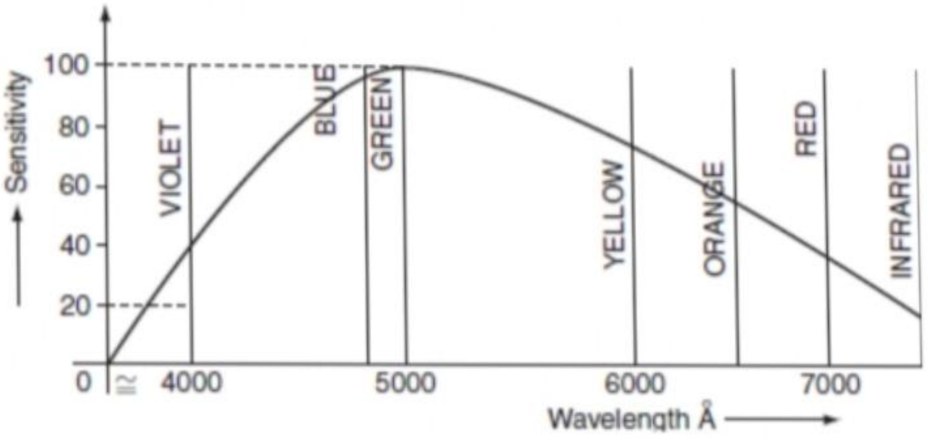

Fig. 6.1.Wavelength

Relative sensitivity: The reacting power of the human eye to the light waves of different wavelengths varies from person to person, and also varies with age. The average relative sensitivity is shown in Fig. 6.2. The eye is most sensitive for a wavelength of 5,500 Å. So that, the relative sensitivity according to this wavelength is taken as unity. Referred from Fig. 6.1, blue and violet corresponding to the short wavelengths and red to the long wavelengths, orange, yellow, and green being in the middle of the visible region of wavelength. The color corresponding to 5,500 Å is not suitable for most of the applications since yellowish green. The relative sensitivity at any particular wavelength (λ) is known as relative luminous factor (K_λ).

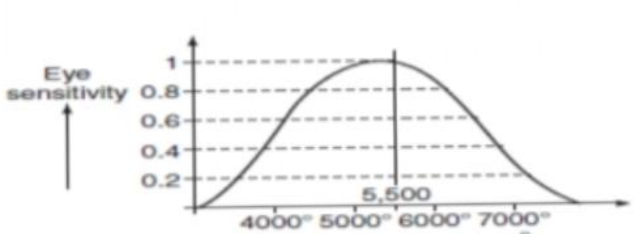

Fig. 6.2 The average relative sensitivity

Light: It is defined as the radiant energy from a hot body that produces the visual sensation upon the human eye. It is expressed in lumen-hours and it analogous to watthours,which denoted by the symbol '*Q*'.

Luminous flux: It is defined as the energy in the form of light waves radiated per second from a luminous body. It is represented by the symbol 'φ' and measured in lumens.

Ex: Suppose the luminous body is an incandescent lamp. The total electrical power input to the lamp is not converted to luminous flux, some of the power lost through conduction, convection, and radiation, etc. Afraction of the remaining radiant flux is in the form of light waves lies in between the visual range of wavelength, i.e. between 4,000 and 7,000 Å, as shown in Fig. 6.3.

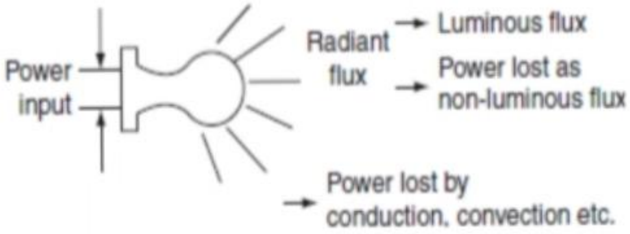

Fig. 6.3 Flux diagram

Radiant efficiency When an electric current is passed through a conductor, some heat is produced to *I*2*R* loss, which increases its temperature of the conductor. At low temperature, conductor radiates energy in the form of heat waves, but at very high temperatures, radiated energy will be in the form of light as well as heat waves. 'Radiant efficiency is defined as the ratio of energy radiated in the form of light, produces sensation of vision to the total energy radiated out by the luminous body'.

$$\text{Radiant efficiency} = \frac{\text{energy radiated in the form of light}}{\text{total energy radiated by the body}}.$$

Plane angle

A plane angle is the angle subtended at a point in a plane by two converging lines (Fig.6.4). It is denoted by the Greek letter 'θ' (theta) and is usually measured in degrees or radians. One radian is defined as the angle subtended by an arc of a circle whose length by an arc of a circle whose length is equals to the radius of the circle.

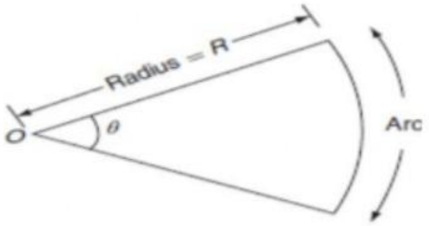

Fig. 6.4 Plane angle

$$\therefore \text{Plane angle } (\theta) = \frac{\text{arc}}{\text{radius}}. \quad (6.1)$$

Solid angle Solid angle is the angle subtended at a point in space by an area, i.e., the angle enclosed in the volume formed by numerous lines lying on the surface and meeting at the point (Fig. 6.5). It is usually denoted by symbol 'ω' and is measured in steradian.

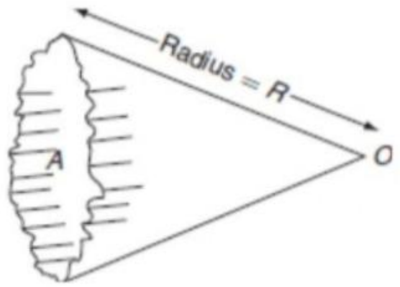

Fig.6.5 Solid angle

$$\therefore \text{Solid angle } (\omega) = \frac{\text{area}}{\text{radius}^2}. \quad (6.2)$$

The largest solid angle subtended at the center of a sphere:

$$\omega = \frac{\text{area of sphere}}{\text{radius}^2} = \frac{4\pi r^2}{R^2} = 4\pi \text{ steradians.}$$

Relationship between plane angle and solid angle

Let us consider a curved surface of a spherical segment ABC of height '*h*' and radius of the sphere '*r*' as shown in Fig. 6.6. The surface area of the curved surface of the spherical segment $ABC = 2\pi rh$. From the Fig. 6.6:

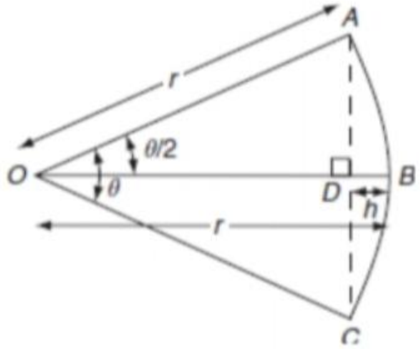

Fig.6.6 Sectional view for solid angle

$$h = r - r\cos\left(\frac{\theta}{2}\right) \quad [\therefore \text{From } \Delta ODA, OD = r\cos\theta/2]$$

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

$BD = OB - OD$ From

$\therefore$ The surface area of the segment $= 2\pi rh$

$$= 2\pi r^2 \left| r - \cos\frac{\theta}{2} \right|.$$

We know solid angle $(\omega) = \dfrac{\text{area}}{(\text{radius})^2}$

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

$$= 2\pi\left(1 - \cos\frac{\theta}{2}\right). \qquad \textbf{(6.3)}$$

From the Equation (6.3), the curve shows the variation of solid angle with plane angle is shown in Fig. 6.7.