Unit -3 illumination

Syllabus: Various definitions, Laws of illumination, requirements of good lighting Design of indoor lighting and outdoor lighting systems Refrigeration and Air Conditioning: Refrigeration systems, domestic refrigerator, water cooler Types of air conditioning, Window air conditioner.

Light Source

Light, also known as visible light is a segment of the electromagnetic spectrum that lies between radio waves and gamma radiation.

1. Light is a type of electromagnetic radiation that can be seen by human eyes.
2. As waves with a specific frequency and wavelength, light is a type of energy that travels through space.
3. In a vacuum, light can pass through.
4. Light can be seen, but it can also be detected by other means, like the use of cameras, telescopes, and other scientific equipment.
5. It has many different uses, from lighting and communications to medicine and materials science, and it has an important place in the natural world.
6. Magnetic and electric fields oscillate, moving energy from one place to another. This is what is known as electromagnetic radiation.
7. Except that it can be seen with the unaided eye, visible light is not all that different from other electromagnetic spectrum components.
8. The electromagnetic spectrum is made up of a stream of photons, which are unweighted, wavelike particles moving at the speed of light.
9. The smallest unit of energy that can be moved is a photon.
10. Between the infrared waves, which have longer wavelengths, and the UV rays, which have shorter wavelengths, visible light has wavelengths that range from 400-700 nm (nanometers), or 4.00 x 10-7m to 7.00 x 10-7 m.
11. A 400-700 nm wavelength corresponds to a frequency range of approximately 430-750 terahertz. (THz).

Light:

It is defined as the radiation energy from a hot body which produces the visual sensation upon the human eye. It is usually denoted by Q, expressed in lumen-hours and is analogous to watt-hour.

Luminous flux:

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

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 (cd) or lumens/steradian.

If F is the luminous flux radiated out by source within a solid angle of ω steradian in any particular direction then $I = F/\omega$ lumens/steradian or candela (cd).

Lumen:

The lumen is the unit of luminous flux and is defined as the amount of luminous flux given out in a space represented by one unit of solid angle by a source having an intensity of one candle power in all directions.

Lumens = candle power X solid angle = cp X ω

Total lumens given out by source of one candela are 4π lumens.

Candle power:

Candle power is the light radiating capacity of a source in a given direction and is defined as the number of lumens given out by the source in a unit solid angle in a given direction. It is denoted by a symbol C.P.

C.P. = lumens/ω

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 lumen.

If a flux of F lumens falls on a surface of area A, then the illumination of that surface is

$E = F/A$ lumens/m2 or lux

Lux or meter candle:

It is the unit of illumination and is defined as the luminous flux falling per square meter on the surface which is everywhere perpendicular to the rays of light from a source of one candle power and one meter away from it.

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 everywhere perpendicular to the rays of light from a source of one candle power and one foot away from it.

1 foot-candle = 1 lumen/ft2 =10.76 meter candle or lux

Candle:

It is the unit of luminous intensity. It is defined as 1/60th of the luminous intensity per cm2 of a black body radiator at the temperature of solidification of platinum (2,0430K).

Mean horizontal candle power: (M.H.C.P)

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

Mean spherical candle power: (M.S.C.P)

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

Mean hemi-spherical candle power: (M.H.S.C.P)

It is defined as the mean of candle powers in all directions above or below the horizontal plane passing through the source of lightens per square meter or meter-candle or lux.

Reduction factor:

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

Reduction factor = M.S.C.P./M.H.C.P.

Lamp efficiency:

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

Specific consumption:

It is defined as the ratio of the power input to the average candle power. It is expressed in watt per candela.

Utilization factor or co-efficient of utilization:-

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

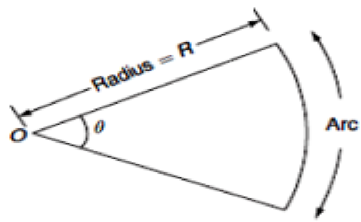
$$Utilization\ Factor = \frac{\textit{total lumens reaching the working plane}}{\textit{total lumens given out by the lamp}}$$

Absorption factor:

In the places where atmosphere is full of smoke fumes, such as in foundries, there is a possibility of absorption of light. The ratio of total lumens available after absorption to the total lumens emitted by the source of light is called the absorption factor. Its value varies from unity for clean atmosphere to 0.5 for foundries.

Plane angle:

A plane angle is the angle subtended at a point in a plane by two converging lines. It is denoted by the Greek letter 'θ' (theta) and is usually measured in degrees or radians.



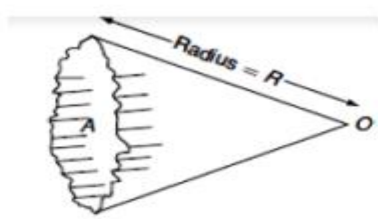
$$\theta = \frac{arc}{radious}\ radians$$

Figure 3.1 plane angle

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.

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. It is usually denoted by symbol 'ω' and is measured in steradian.



$$\omega = \frac{area}{(radious)^2} = \frac{A}{r^2}$$

Figure 3.2 solid angle

The largest solid angle subtended at a point is that due to a sphere at its centre. If r is the radius of any sphere, its surface area is 4π2 and the distance of its surface area from the centre is r, therefore, solid angle subtended at its centre by its surface,

$$\omega = \frac{4\pi r^2}{(r)^2} = 4\pi \textbf{ steradians}$$

Steradian:

It is the unit of solid angle and is defined as the solid angle that subtends a surface on the sphere equivalent to the square of the radius.

Laws of Illumination

Mainly there are two laws of illumination.

1. **Inverse square law.**
2. **Lambert's cosine law.**

1. **Inverse square law**: This law states that 'the illumination of a surface is inversely proportional to the square of distance of the surface from the source of light.

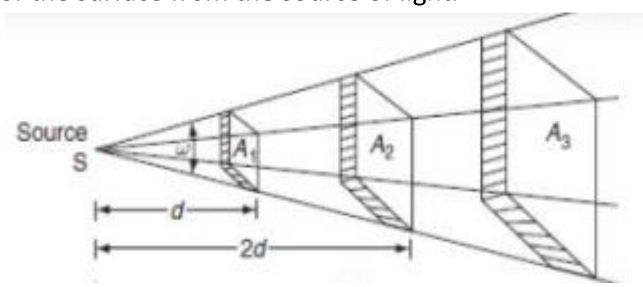


Figure 3.3 lambert's law

Let, 'S' be a point source of luminous intensity 'I' candela, the luminous flux emitting from source crossing the three parallel plates having areas A A , and A square meters, which are separated by a distances of d, 2d, and 3d from the point source respectively as shown in Fig

For are A1, solid angle

ω = A1/d2

Luminous flux reaching the area

A1 = luminous intensity × solid angle

= I * ω = I * A1/d2

Illumination 'E1' on the surface area 'A1' is:

E1 = flux/area

= I * A1/d2 * 1/A1 E1

= I/d2 lux

Similarly, illumination 'E2 ' on the surface area A2 is:

E2 = I/(2d) 2 lux

Similarly, illumination 'E3 ' on the surface area A3 is:

E3 = I/(3d) 2 lux

From above equations

E1 : E2 : E3 = I/d2 : I/(2d) 2: I/(3d) 2

Hence, from Equation, illumination on any surface is inversely proportional to the square of distance between the surface and the source.

2. **Lambert's cosine law:**

This law states that illumination, E at any point on a surface is directly proportional to the cosine of the angle between the line of flux AND the normal at that point.

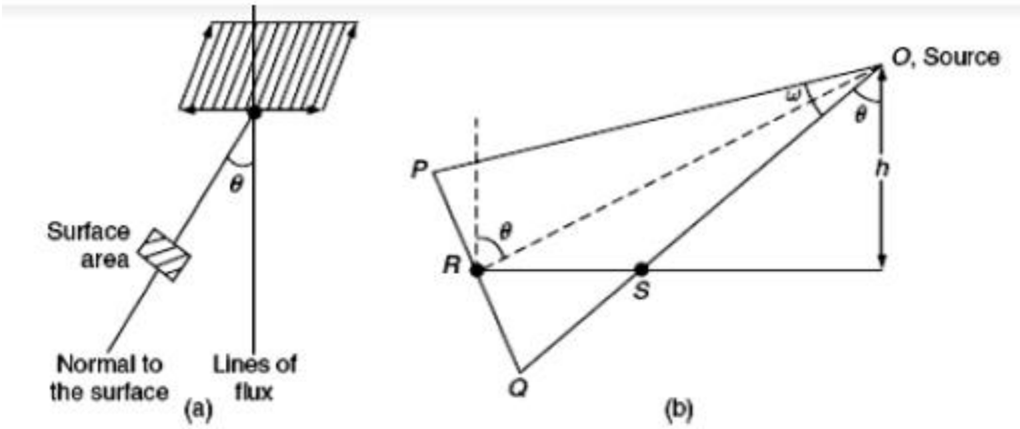


Figure 3.4 lambert's cosine law

Let us assume that the surface is inclined at an angle 'θ' to the lines of flux as shown in Fig. (a)

$PQ = RS\cos\theta.$

$\therefore$ The illumination of the surface $PQ, E_{PQ} = \dfrac{\text{flux}}{\text{area of } PQ}$

$$= \frac{I \times \omega}{\text{area of } PQ} = \frac{I}{\text{area of } PQ} \times \frac{\text{area of } PQ}{d^2} \quad [\because \omega = \text{area}/(\text{radius})^2]$$

$$= \frac{I}{d^2}.$$

$\therefore$ The illumination of the surface $RS, E_{RS} = \dfrac{\text{flux}}{\text{area of } RS} = \dfrac{\text{flux}}{\text{area of } PQ/\cos\theta}$

$[\because PQ = RS\cos\theta]$

$$= \frac{I}{d^2}\cos\theta.$$

From Fig (b)

$\cos\theta = h/d$

or $d = h/\cos\theta$

Substitute value of d in above equation

$$\therefore E_{RS} = \frac{I}{(h/\cos\theta)^2} \times \cos\theta = \frac{I}{h^2}\cos^3\theta$$

$$\therefore E_{RS} = \frac{I}{d^2}\cos\theta = \frac{I}{h^2}\cos^3\theta$$

Where d is the distance between the source and the surface in m, h is the height of source from the surface in m, and I is the luminous intensity in candela.'

Hence, above Equation is also known as 'cosine cube' law. This law states that the illumination at any point on a surface is dependent on the cube of cosine of the angle between lines of flux and normal at that point.

Example 3.1

Example 1: A 200-V lamp takes a current of 1.2 A, it produces a total flux of 2,860 lumens. Calculate:

1. the MSCP of the lamp and
2. the efficiency of the lamp.

Solution:

Given V = 200 V, I = 1.2 A, flux = 2,860 lumens.

$$\text{MSCP} = \frac{\text{total flux}}{4\pi} = \frac{2860}{4\pi} = 227.59.$$

Lamp efficiency = lumens flux/power input = 2860/(200*1.2) lumens/watt

Example 3.2

Example 2: A room with an area of 6 × 9 m is illustrated by ten 80-W lamps. The luminous efficiency of the lamp is 80 lumens/W and the coefficient of utilization is 0.65. Find the average illumination.

Solution:

Room area = 6 × 9 = 54 m .

Total wattage = 80 × 10 = 800 W.

Total flux emitted by ten lamps = 80 × 800 = 64,000 lumens.

Flux reaching the working plane = 64,000 × 0.65 = 41,600 lumens.

$$\therefore \textbf{Illumination, } E = \frac{\phi}{A} = \frac{41{,}600}{54} = 770.37 \text{ lux.}$$

Example3.3

Example 1.1. *A 250 V lamp has a total flux of 1500 lumens and takes a current of 0.4 A Calculate :*

(*i*) *Lumens per watt.* (*ii*) *M.S.C.P. per watt.*

Solution. Given : V = 250 volts ; F = 1500 lumens ; I = 0.4 A

Mean spherical candle power of lamp,

$$\text{M.S.C.P.} = \frac{F}{4\pi} = \frac{1500}{4\pi} = 119.4$$

$$(i)\ \textbf{Lumens per watt} = \frac{\text{Output of lamp in lumens}}{\text{Wattage of lamp in watts}} = \frac{1500}{250 \times 0.4} = \textbf{15.} \quad \textbf{(Ans.)}$$

(*ii*) **M.S.C.P. per watt** $= \dfrac{\text{M.S.C.P. of lamp}}{\text{Wattage of lamp}} = \dfrac{119.4}{250 \times 0.4}$ **= 1.194. (Ans.)**

Example3.4

Example 1.4. *The candle power of a lamp is 120. A plane surface is placed at a distance of 2.5 metres from this lamp. Calculate the illumination on the surface when it (i) normal, (ii) inclined to 45°, and (iii) Parallel to rays.*

Solution. (*i*) $E = \dfrac{\text{C.P.}}{d^2} = \dfrac{120}{(2.5)^2}$ **= 19.2 lux. (Ans.)**

(*ii*) $E = \dfrac{\text{C.P.}}{d^2} \times \cos 45° = \dfrac{120}{(2.5)^2} \times \cos 45°$ **= 13.58 lux. (Ans.)**

(*iii*) $E = 0$, since the rays of light are parallel to the surface, they cannot illuminate it. **(Ans.)**

Example 3.5

Example 1.5. *Derive the relation to find the illumination at any point on the plane surface due to light source suspended at height h from the plane surface.*

Solution. Refer to Fig. 1.9. Consider a point *P* on the plane surface *AB* where illumination due to light source *S* of candle power C.P. at a height *h* from the surface *AB* is to be determined.

Let *d* be the distance between source *S* and point *P*.

Then, $\cos\theta = \dfrac{h}{d}$ or $d = \dfrac{h}{\cos\theta}$

Illumination at point *P*, by laws of illumination

$$= \frac{\text{C.P.}}{d^2}\cos\theta = \frac{\text{C.P.}}{(h/\cos\theta)^2}\cos\theta = \frac{\text{C.P.}}{h^2}\cos^3\theta,$$

and illumination at any point *O*, *vertically below the source of light*

$$= \frac{\text{C.P.}}{h^2}.$$

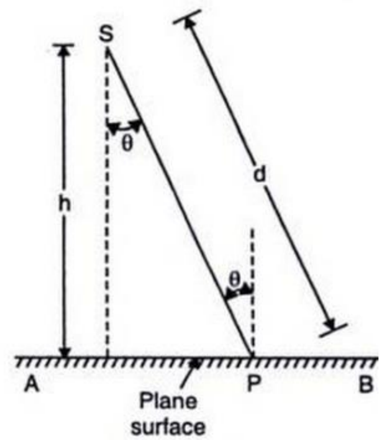


Fig. 1.9

Example 3.6

Example 1.6. *A 500 W lamp having M.S.C.P. of 800 is suspended 3 m above the working plane :*

(*i*) *Illumination directly below the lamp at the working plane.*

(*ii*) *Lamp efficiency.*

(*iii*) *Illumination at a point 2.4 m away on the horizontal plane from vertically below the lamp.*

Solution. Wattage of the lamp = 500 W

M.S.C.P. of the lamp, $I = 800$

Height of the lamp, $h = 3$ m

(*i*) **Illumination directly below the lamp at the working plane :**

Illumination directly below the lamp,

Illumination directly below the lamp,

$$E_A = \frac{I}{h^2} = \frac{800}{3^2} = \textbf{88.9 lux.} \quad \textbf{(Ans.)}$$

(*ii*) **Lamp efficiency :**

$$\text{Lamp efficiency} = \frac{\text{Luminous flux}}{\text{Power input}} = \frac{4\pi \times \text{M.S.C.P.}}{500} = \frac{4\pi \times 800}{500}$$

$$= \textbf{20.1 lumens/watt.} \quad \textbf{(Ans.)}$$

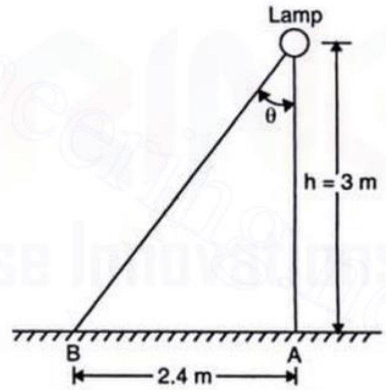


Fig. 1.10

(*iii*) **Illumination at a point 2.4 m away :**

Illumination at a point 2.4 m away on the horizontal plane from vertically below the lamp,

$$E_B = \frac{I}{h^2} \cos^3 \theta$$

Here, $$\cos\theta = \frac{3}{\sqrt{3^2 + 2.4^2}} = 0.7808$$

$\therefore$ $$E_B = \frac{800}{3^2} \times (0.7808)^3 = \textbf{42.3 lux.} \quad \textbf{(Ans.)}$$

Example3.6

Example 1.7. *A lamp with reflector is mounted 10 m above the centre of a circular area of 20 m diameter. If the combination of the lamp and reflector gives a uniform C.P. of 800 over the circular area, determine the maximum and minimum illumination produced on the area.*

(Panjab University)

Solution. Candle power of the lamp, C.P. = 800

Height of the lamp, $h = 10$ m

Diameter of the circular area = 20 m

The *maximum illumination* will occur *directly below the lamp* *i.e.*, at point *A* and

$$= \frac{\text{C.P.}}{h^2} = \frac{800}{10^2} = \textbf{8 lux.} \quad \textbf{(Ans.)}$$

The minimum illumination will occur at the periphery of the circular area *i.e.*, at point *B* and

$$= \frac{\text{C.P.}}{h^2} \cos^3 \theta$$

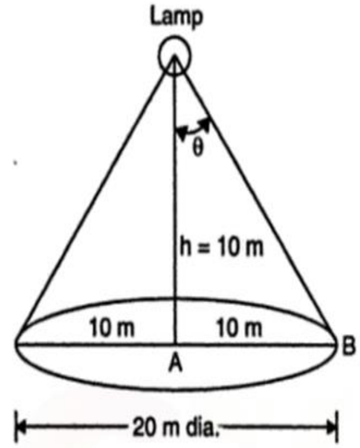


Fig. 1.11

$$= \frac{800}{10^2} \times \left(\frac{10}{\sqrt{10^2 + 10^2}} \right)^3 = \textbf{2.83 lux.} \quad \textbf{(Ans.)}$$

Example 3.7

Example 1.9. *The illumination at a point on a working plane directly below the lamp is to be 80 lumens/m². The lamp gives 180 C.P. uniformly below the horizontal plane. Determine :*

(*i*) *The height at which the lamp is suspended.*

(*ii*) *The illumination at a point on the working plane 1.5 m away from the vertical axis of the lamp.*

Solution. Luminous intensity of the lamp, I = 180 C.P.

Illumination directly below the lamp, E = 80 lumens/m².

Refer to Fig. 1.13.

(*i*) **The height at which the lamp is suspended, h :**

We know that,

$$E_A = \frac{I}{h^2}$$

$$\therefore \quad 80 = \frac{180}{h^2}$$

or $$h = \sqrt{\frac{180}{80}} = \mathbf{1.5\ m.} \quad \textbf{(Ans.)}$$

(*ii*) **The illumination at a point 1.5 m away :**

The illumination at a point on the working plane 1.5 m away from the vertical axis of the lamp,

$$E_B = \frac{I}{h^2}\cos^3\theta = \frac{180}{(1.5)^2} \times \left[\frac{1.5}{\sqrt{1.5^2 + 1.5^2}}\right]^3$$

$$= \mathbf{2.96\ lux.} \quad \textbf{(Ans.)}$$

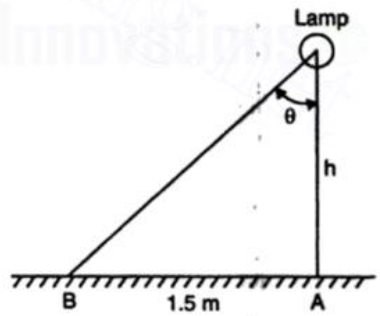


Fig. 1.13

Example 3.8

Example 1.8. *A lamp having a uniform C.P. of 300 in all directions is provided with a reflector which directs 60 per cent of the total light uniformly on to a circular area of 12 m diameter. The lamp is 5 m above the area. Calculate :*

(*i*) *The illumination at the centre and edge of the surface with and without reflector.*

(*ii*) *The average illumination over the area without the reflector.*

Solution. Candle power of the lamp C.P. = 300

Height of the lamp, h = 5 m

Efficiency of the reflector = 60%

(*i*) **The illumination at the centre without reflector.**

The illumination at the centre

$$= \frac{\text{C.P.}}{h^2} = \frac{300}{5^2} = \mathbf{12\ lux.} \quad \textbf{(Ans.)}$$

The illumination at the edge of the surface with and without the reflector :

The illumination at the edge of the surface *without reflector.*

$$= \frac{\text{C.P.}}{h^2}\cos^3\theta = \frac{300}{5^2} \times \left(\frac{5}{\sqrt{5^2 + 6^2}}\right)^3$$

$$= \mathbf{3.15\ lux.} \quad \textbf{(Ans.)}$$

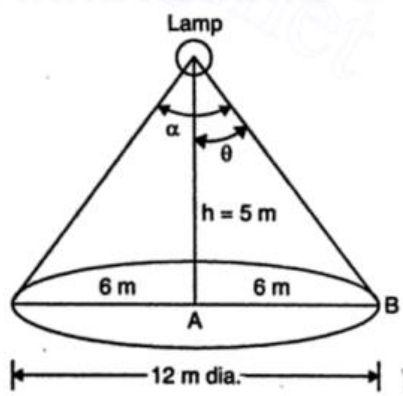


Fig. 1.12

TYPES OF LIGHTING SCHEMES (Requirement of good lightning scheme)

Usually, with the reflector and some special diffusing screens, it is possible to control the distribution of light emitted from lamps up to some extent. A good lighting scheme results in an attractive and commanding presence of objects and enhances the architectural style of the interior of a building. Depending upon the requirements and the way of light reaching the surface, lighting schemes are classified as follows:

1. Direct lighting,
2. Semi direct lighting,
3. Indirect lighting,
4. Semi-indirect lighting,
5. General lighting

Direct lighting schemes

Direct lighting scheme is most widely used for interior lighting scheme. In this scheme, by using deep reflectors, it is possible to make 90% of light falls just below the lamp. This scheme is more efficient but it suffers from hard shadows and glare. Hence, while designing such schemes, all the possibilities that will cause glare on the eye have to be eliminated. It is mainly used for industrial and general outdoor lighting.

Semi direct lighting schemes

In semi direct lighting scheme, about 60–90% of lamps luminous flux is made to fall downward directly by using some reflectors and the rest of the light is used to illuminate the walls and ceiling. This type of light scheme is employed in rooms with high ceiling. Glare can be avoided by employing diffusing globes. This scheme will improve not only the brightness but also the efficiency.

Indirect lighting schemes

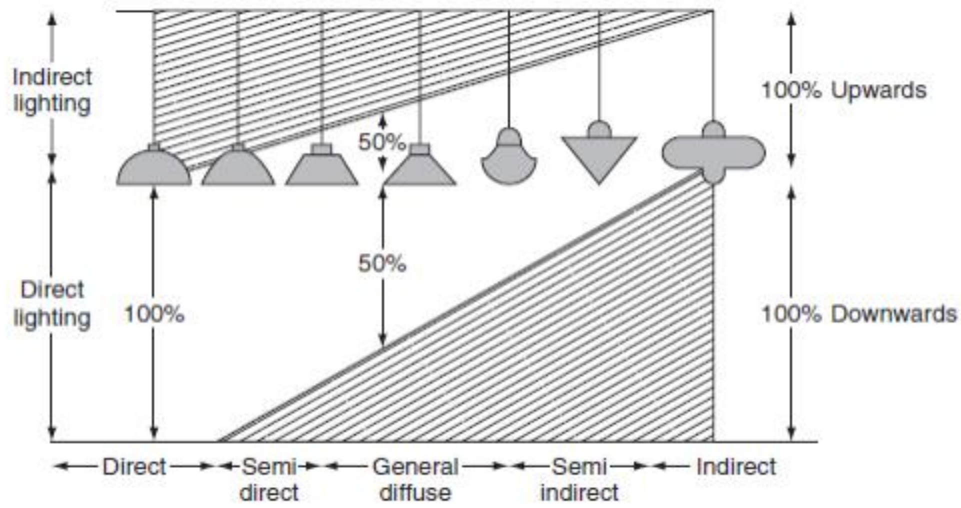
In this lighting scheme, 90% of total light is thrown upwards to the ceiling. In such scheme, the ceiling acts as the lighting source and glare is reduced to minimum. This system provides shadow less illumination, which is very useful for drawing offices and in workshops where large machines and other difficulties would cause trouble some shadows if direct lighting schemes were used.

Semi-indirect lighting schemes

In semi-indirect lighting scheme, about 60–90% of light from the lamp is thrown upwards to the ceiling and the remaining luminous flux reaches the working surface. Glare will be completely eliminated with such type of lighting scheme. This scheme is widely preferred for indoor lighting decoration purpose.

General lighting scheme

This scheme of lighting use diffusing glasses to produce the equal illumination in all directions. Mounting height of the source should be much above eye level to avoid glare.



DESIGN OF LIGHTING SCHEMES

The lighting scheme should be such that:

1. It should be able to provide sufficient illumination.
2. It should be able to provide the uniform distribution of light throughout the working plane.
3. It should be able to produce the light of suitable color.
4. It should be able to avoid glare and hard shadows as much as possible.

While designing a lighting scheme, the following factors should be taken into consideration.

1. Illumination level.
2. The size of the room.
3. The mounting height and the space of fitting.

STREET LIGHTING

Street lighting not only requires for shopping centers, promenades, etc. but also necessary for the following.

1. In order to make the street more attractive, so that obstructions on the road clearly visible to the drivers of vehicles.
2. To increase the community value of the street.

To clear the traffic easily in order to promote safety and convenience. The basic principles employed for the street lighting are given below.

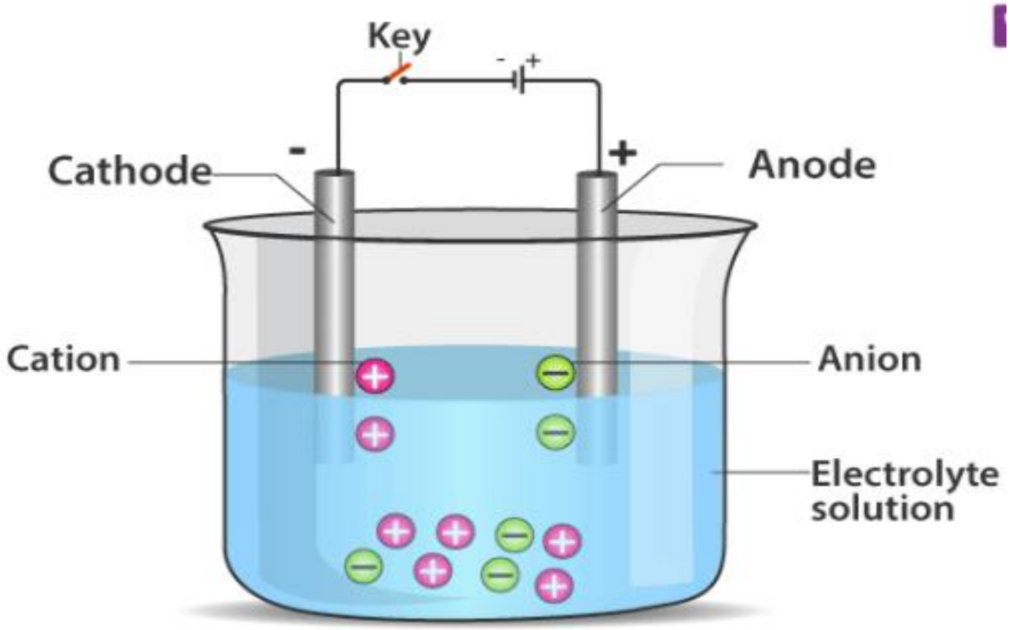
1. Diffusion principle.
2. The specular reflection principle.

Electrolysis Process

The word "electrolysis" was introduced by Michael Faraday in the 19th century. In chemistry, electrolysis is a method that uses a direct current (DC) to drive a non-spontaneous chemical reaction. This technique is commercially significant as a stage in the separation of elements from naturally occurring sources such as ores using an electrolytic cell.

Electrolysis

The fundamental process of electrolysis is the interchanging of ions and atoms by the addition or removal of electrons from the external circuit.



Electrolysis Process

- Ionic compounds contain charged particles called ions. For example, sodium chloride contains positively charged sodium ions and negatively charged chlorine ions.
- The ions must be free to move in order to start the electrolysis process. When an ionic substance is dissolved in water or melted then the ions are free to move. During electrolysis, positively charged ions move to the negative electrode and negatively charged ions move to the positive electrode. Then positively charged ions receive electrons and negatively charged ions lose electrons. Both the products of the dissociation get collected at the electrodes.
- For instance, if electricity is passed through molten sodium chloride, the sodium chloride is broken into sodium and chlorine, and they collect at their respective electrodes. The metals get precipitated and the gases escape. This ability to break down a substance with a current is used in many ways.
- Electrolysis is widely used for electroplating.

Uses of Electrolysis

- Electrolysis is done for coating one metal on another.
- The industrial use includes various metals such as aluminium, magnesium, chlorine, and fluorine etc.

What Is Electroplating?

Electroplating is a process that uses an electric current to reduce dissolved metal cations so that they form a thin coherent metal coating on an electrode.

Electroplating is a process that uses electric current to reduce dissolved metal ions by the use of electrolysis, to obtain the dissolved metal ions at the other electrode, mostly in the form of a uniform coating.

It is the process of plating one metal onto another by hydrolysis, most commonly for decorative purposes or to prevent corrosion of metals.

There are also specific types of electroplating such as copper plating, silver plating, and gold plating. It allows the manufacturers to make the product with economical materials and then coat the metals to add properties such as rust proofing, improving its appearance and improving its strength.

Working

The positive electrode should be the metal that you want to coat the object with. The negative electrode will be the object that should receive the deposit of the electroplating metal. The electrolyte should be a solution of the coating metal, as it is a metal nitrate or sulphate. We can examine electroplating better with a few example.

Difference between Electrolysis and Electroplating

Electrolysis	Electroplating
Electrolysis refers to the breaking apart of a molecule by the means of the electrochemical reaction.	Electroplating refers to the passage of current through the solution with metal such that it gets deposited on one of the electrodes.
Electrolysis is good for carrying out the non-spontaneous chemical reactions.	Electroplating is good when metallic ions need to be coated on other metals.
Electrolysis is used for the extraction of metals from its ores.	Electroplating is used for coating metals on pure metals.
Finds applications in electrosynthesis, mercury cell process, and electrorefining.	Finds application in preventing metals from corrosion.

Electrolysis of Water

Electrolysis of water is the decomposition of water into oxygen and hydrogen gas. This is achieved by passing an electric current through the water. Two electrodes are placed in the container with water. The electric current is passed through these electrodes. Stainless steel or platinum are used for the making of the electrodes.

The negatively charged electrode that is cathode is the place where the hydrogen will get accumulated while the positively charged electrode that is anode is the place where the oxygen will get accumulated. Electrolysis of water is also an example of decomposition which is also known as electrolytic decomposition.

Faraday's Law's of Electrolysis----

Faraday's – First Law of Electrolysis

It is one of the primary laws of electrolysis. It states, during electrolysis, the amount of chemical reaction which occurs at any electrode under the influence of electrical energy is proportional to the quantity of electricity passed through the electrolyte.

That is $m \propto Q \propto It$

$\therefore$ $m = ZIt$

where, Z = A constant called the *electrochemical equivalent*,

I = The steady current in amperes, and

t = Time (second) for which current I flows through the electrolyte.

Faraday's – Second Law of Electrolysis

Faraday's second law of electrolysis states that if the same amount of electricity is passed through different electrolytes, the masses of ions deposited at the electrodes are directly proportional to their chemical equivalents.

From these laws of electrolysis, we can deduce that the amount of electricity needed for oxidation-reduction depends on the stoichiometry of the electrode reaction.

Applications of Electrolysis---

Nowadays the electrolytic process is widely used in various industrial applications. The major applications of the electrolysis are given below.

Extraction of Metal from their Ores

The electrolytic process is used for extracting out the pure metal from their ores, this process is known as **electro-extraction**. In the electro-extraction, the metal ore is treated with strong acid or is melted and then a DC current is passed through the resulting solution, the solution is decomposed and pure metal is deposited on the cathode.

Refining of Metals

Electrolysis is also used for refining of metals and the process is termed as electro-refining. In **electro-refining**, the anode of impure metal is placed in a suitable electrolytic solution. When DC current is passed through the solution, pure metal is deposited on the cathode.

Manufacturing of Chemicals

The electrolytic process is also used for manufacturing of various chemicals. When an electric current is passed through the solution of some compound, the compound gets breakdown into its constituent components which are liberated at the anode and cathode, which in turn can be collected.

Electro-Deposition

The **electro-deposition** is an electrolytic process, in which one metal is deposited over the other metal or non-metal. The electro-deposition is usually used for the decorative, protective and functional purposes.

Electroplating

An electrolytic process in which a metal is deposited over any metallic or non-metallic surface is called the **electroplating**. Electroplating is usually used to protect the metals from corrosion by atmospheric air and moisture.

Electro-deposition of Rubber

Electrolysis is also employed for electro-deposition of rubber. The rubber latex obtained from the tree consists of very fine colloidal particles of rubber suspended in water. These particles of rubber are negatively charged. On electrolysis of the solution, these rubber particles move towards the anode and deposit on it.

Electro-Metallization

The electrolytic process in which the metal is deposited on a conducting base for decorative and for protective purposes is termed as **electro-metallization**. Also, by using the electro-metallization process, any non-conductive base is made conductive by depositing a layer of graphite over it.

Electro-Facing

An electrolytic process in which a metallic surface is coated with a harder metal by electro-deposition in order to increase its durability is known as **electro-facing**.

Electro-Forming

Electrolysis is also used for electro-forming, it is the reproduction of an object by electro-deposition in order to increase its durability.

In the electro-forming, i.e. reproduction of medals, coins, etc., a mould is made by impressing the object in wax. The wax surface having exact impression of the object is coated by powdered graphite to make it conducting. This mould is then dipped in an electro-forming cell as cathode. After obtaining a coating of desired thickness, the article is removed and the wax core is melted out of the metal shell.

Electro-Typing

The electrotyping is an electrolytic process for forming metal parts that exactly reproduce a model. It is a special application of electro-forming and is mainly used to reproduce printing, set up tying, medals, etc.

Anodizing

The electrolysis process of deposition of an oxide film on a metal surface is known as **anodizing**. It is mainly used to increase the thickness of the natural oxide layer on the surface of the metal parts.

Electro-Polishing

The electro-polishing is an electrolytic process that removes materials from a metallic workpiece. It is also known as **electrochemical polishing** or **electrolytic polishing.**

Electro-polishing uses a combination of rectified current and a blended chemical electrolyte bath to remove flaws from the surface of a metal part.

Electro-Refining

Electro-refining is a method for purifying a metal using electrolysis. In the electro-refining process, the anode is made of impure metal and the impurities must be lost during the passage of metal from the anode to cathode during electrolysis.

Electro-Parting

An electrolytic process of separation of two or more metals is known as **electro-parting** or **electro-stripping.**

Electro-Cleaning

Electro-cleaning is the process of removing soil, scale or corrosion from a metallic surface. It is also known as electro-pickling. It is a form of electroplating which can be applied to all electrically conductive materials.