

UNIT - III :ILLUMINATION

- 1) Introduction.
- 2) Terms used in illumination.
- 3) Laws of illumination.
- 4) Polar curves.
- 5) Photometry.
- 6) Various illumination Methods.
- 7) Comparison between tungsten filament Lamps and fluorescent tubes.
- 8) Basic principles of light control.
- 9) Types and design of lighting Schemes.
- 10) Flood lighting.

1) 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.

Nowadays, 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.

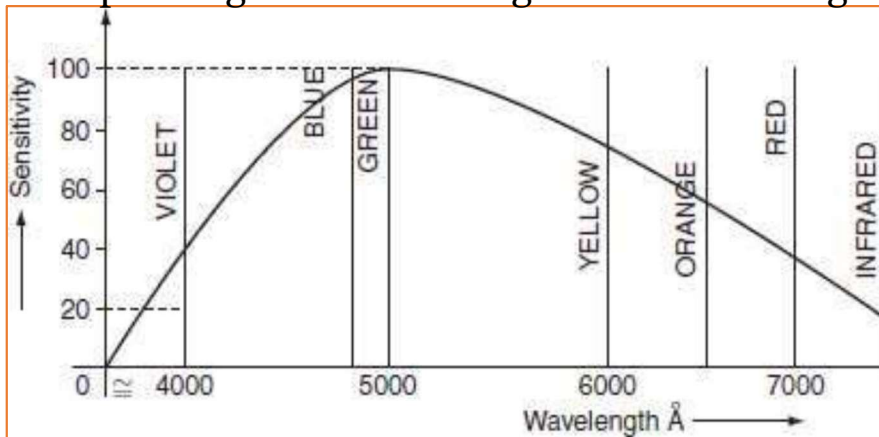
Light is a form of electromagnetic energy radiated from a body and human eye is capable of receiving it. Light is a prime factor in the human life as all activities of human being ultimately depend upon the light.

2) Terms used in illumination:

The following terms are generally used in illumination.

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 Figure.



2. 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 the Figure. 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**.

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.

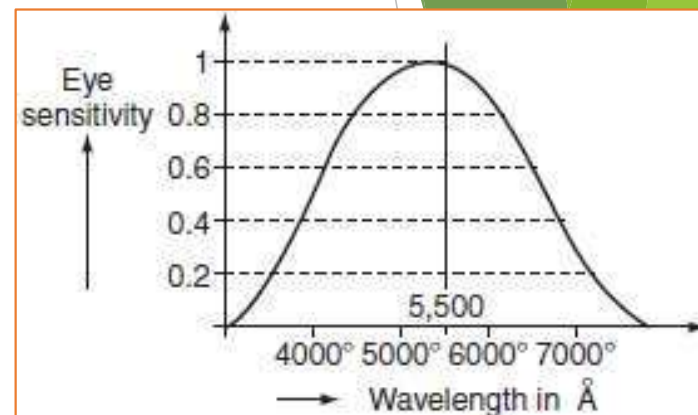
The color corresponding to $5,500 \text{ \AA}$ is **not suitable** for most of the applications since **yellowish green**. The relative sensitivity at any particular wavelength (λ) is known as **relative luminous factor (K_λ)**.

3. Light: (Q)

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 **watt- hours**, which denoted by the **symbol ' Q '**.

4. Luminous flux: (ϕ)

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**.



5. Radiant efficiency:

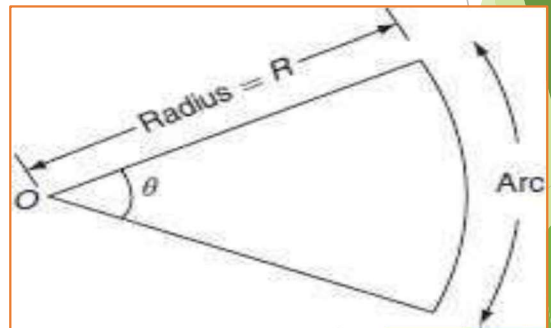
When an electric current is passed through a conductor, some heat is produced to I^2R loss, which increases its temperature of the conductor. At low temperature, conductor radiates energy in the form of heat waves, but at very high temperatures, radiated energy will be in the form of light as well as 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’.

6. Plane angle:(θ)

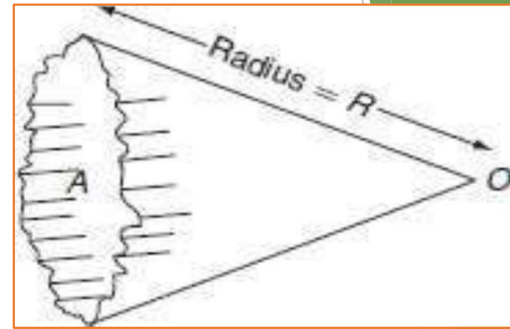
A plane angle is the angle subtended at a point in a plane by two converging lines as shown in Figure.. It is denoted by the letter ‘ θ ’ (theta) and is usually measured in degrees or radians.

$$\text{Plane angle}(\theta) = \frac{\text{Arc}}{\text{Radius}}$$



7. Solid angle:(ω)

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**. ($\omega = 4\pi$: is maximum for sphere)



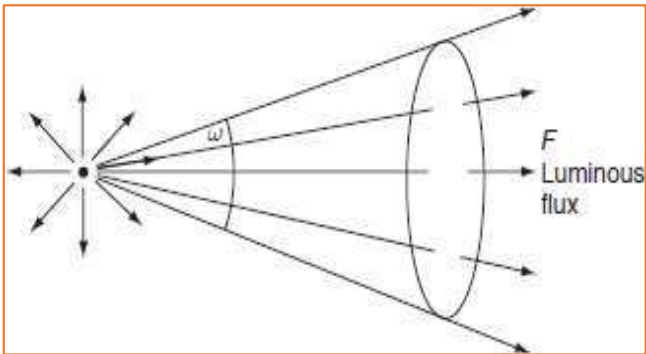
$$\text{Solid angle}(\omega) = \frac{\text{Area}}{(\text{radius})^2}$$

The Relationship between plane angle and solid angle is

$$\text{Solid angle}(\omega) = 2\pi \times [1 - \cos \theta]$$

8. Luminous intensity:(I)

Luminous intensity in a given direction is defined as the **luminous flux emitted by the source per unit solid angle** as shown in the figure. It is denoted by the symbol '**I**' and is usually measured in '**candela**'. The figure shows Luminous flux emitting from the source.



9. Lumen:

It is the unit of luminous flux. It is defined as the luminous flux emitted by a **source of one candle power of unit solid angle** in all directions.

Lumen = candle power of source \times solid angle.

$$\text{Lumen} = \text{CP} \times \omega$$

Total(max) flux emitted by a source of one candle power is ' **4π lumens**'.

10. Candle power (CP):

The CP of a source is defined as the **total luminous flux lines emitted by that source per unit solid angle**, is measured in lumen/steradian or **candela**.

11. Illumination: (E)

Illumination is defined as the **luminous flux**

received by the surface per unit area. It is usually denoted by the symbol '**E**' and is measured in **lux** or lumen/m² (or) **meter candle** (or) **foot candle**.

$$\text{Illumination, } E = \frac{\text{Luminous flux}}{\text{area}}$$

$$E = \frac{\phi}{A} = \frac{CP \times \omega}{A}$$

$$CP = \frac{\text{Lumen}}{\omega}$$

12. Lux (or) meter candle:

It is defined as the **illumination** inside of a **sphere** of **radius 1 m** and a **source of 1 CP** is fitted at the center of sphere.

13. Foot candle:

It is the unit of illumination and is defined as the illumination of the inside of a **sphere** of **radius 1 foot**, and a **source of 1 CP** is fitted at the center of it.

$$\text{We know that } 1 \text{ lux} = 1 \text{ foot candle} = \frac{1 \text{ Lumen}}{(\text{ft})^2}$$

$$1 \text{ foot candle} = \frac{\text{Lumen}}{\left(\frac{1}{3.28}\right)^2 \text{ m}^2}$$

$$\mathbf{1 \text{ foot candle} = 10.76 \text{ lux (or) m - candle}}$$

14. Brightness:(L)

Brightness of any surface is defined as the **luminous intensity per unit surface area** of the projected surface in the given direction. It is usually denoted by symbol 'L'.

If the luminous intensity of source be 'I' candela on an area A, then the **projected area is $A\cos\theta$** .

$$\text{Brightness, } L = \frac{I}{A} = \frac{I}{A\cos\theta}$$

15. Relation between I, E, and L:

Let us consider a uniform diffuse sphere with **radius 'r'** meters, at the center a **source of '1 CP'**, and **luminous intensity 'I' candela**.

$$\text{we have Brightness, } L = \frac{I}{A} = \frac{I}{\pi r^2}$$

$$\text{Illumination, } E = \frac{\phi}{A} = \frac{I \times \omega}{A}$$

$$= \frac{I \times 4\pi}{4\pi r^2} = \frac{I}{r^2}$$

$$\text{we have, } E = \frac{I}{r^2} = \frac{I \times \pi}{r^2 \times \pi} = \pi L$$

Hence, $E = \pi L = \frac{I}{r^2}$

16. Mean horizontal candle power (MHCP):

MHCP is defined as the mean of the candle power of source in all directions **in horizontal plane.**

17. Mean spherical candle power (MSCP):

MSCP is defined as the mean of the candle power of source **in all directions in all planes.**

18. Mean hemispherical candle power (MHSCP):

MHSCP is defined as the mean of the candle power of source in all directions **above or below the horizontal plane.**

19. Reduction factor:

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

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

20. Lamp efficiency:

It is defined as the ratio of the total luminous flux emitting from the source in lumens to its Electrical power input in watts. It is expressed in lumen/W.

$$\text{Lamp efficiency} = \frac{\text{Luminous flux}}{\text{power input}}$$

21. Specific consumption:

It is defined as the **ratio** of electric **power input** to its **average** candle power(**CP**).

22. Space to height ratio:(SHR)

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

$$SHR = \frac{\text{horizontal disance between two adjacent lamps}}{\text{mounting height of lamps above the working plane}}$$

23. Coefficient of utilization or utilization factor:

It is defined as the ratio of total number of lumens reaching the working plane to the total number of lumens emitting from source

$$\text{Utilization factor} = \frac{\text{total lumens reaching the working plane}}{\text{total lumens emitting from source}}$$

24. Maintenance factor:

It is defined as the ratio of illumination under **normal working conditions** to the illumination when **everything is clean**.

$$\text{Maintenance fact} = \frac{\text{illumination under normal working condition}}{\text{illumination under every thing is clean}}$$

25. Depreciation factor:

It is defined as the ratio of initial illumination to the ultimate maintained illumination on the working plane. **Its value is always more than 1.**

26. Waste light factor:

When a surface is illuminated by several numbers of the sources of light, there is certain amount of **wastage due to overlapping of light waves**; the wastage of light is taken into account **depending upon the type of area to be illuminated**.

27. Absorption factor:

Normally, when the atmosphere is full of smoke and fumes, there is a possibility of absorption of light. Hence, the **total lumens available after absorption** to the **total lumens emitted by the lamp** are known as absorption factor.

28. Reflection factor or coefficient of reflection:

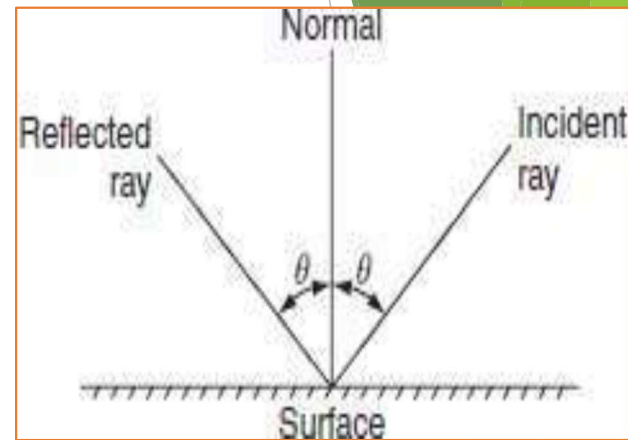
When light rays hit on a surface, it is reflected from the surface at an angle of incidence shown in Figure. A portion of incident light is absorbed by the surface.

The ratio of luminous flux leaving the surface to the luminous flux incident on it is known as reflection factor. Its value will be always less than 1.

29. Beam factor:

It is defined as the ratio of 'lumens in the beam of a projector' to the 'lumens given out by lamps'. Its value is usually varying from **0.3 to 0.6**.

This factor is taken into account for the **absorption of light by reflector and front glass** of the projector lamp.



3). Laws of illumination:

Mainly there are two laws of illumination.

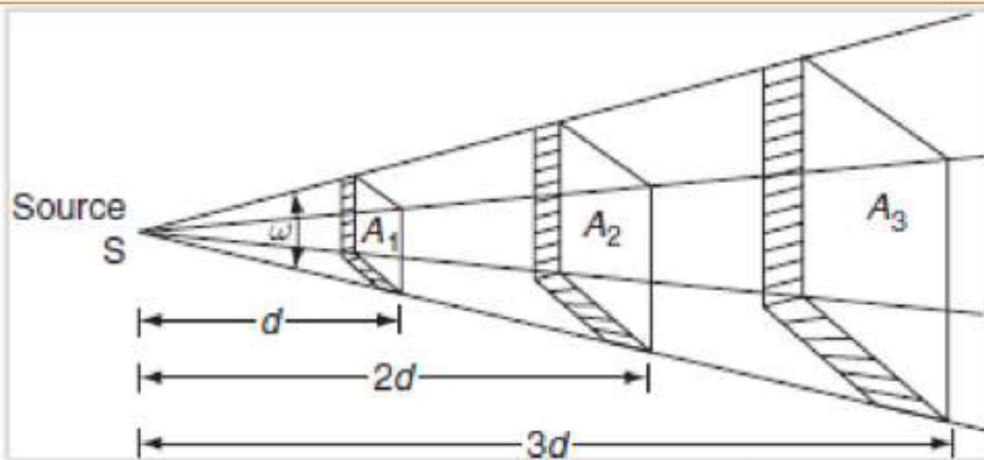
1. Inverse square law.
2. Lambert's cosine law.

1. Inverse square law:

Statement:

“This law states that the illumination of a surface is inversely proportional to the square of distance between the surface and a point source”.

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_1 , A_2 , and A_3 square meters, which are separated by a distances of d , $2d$, and $3d$ from the point source respectively and ‘ ω ’ be the solid angle as shown in Figure.



for Area, A_1 : **Solid angle**, $\omega = \frac{A_1}{d^2}$

Luminous flux reaching the area A_1 is:

ϕ = luminous intensity \times solid angle

$$\phi = I \times \omega = I \times \frac{A_1}{d^2}$$

\therefore Illumination ' E_1 ' on the surface area ' A_1 ' is :

$$E_1 = \frac{\phi}{A} = \frac{IA_1}{d^2} \times \frac{1}{A_1}$$

$$\therefore E_1 = \frac{I}{d^2}$$

Similarly, illumination ' E_2 ' on the surface *area* A_2 is:

$$E_2 = \frac{I}{(2d)^2}$$

And, illumination ' E_3 ' on the surface *area* A_3 is:

$$E_3 = \frac{I}{(3d)^2}$$

From the above equations E_1 , E_2 , E_3 we can write,

$$E_1 : E_2 : E_3 = \frac{1}{d^2} : \frac{1}{(2d)^2} : \frac{1}{(3d)^2}$$

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

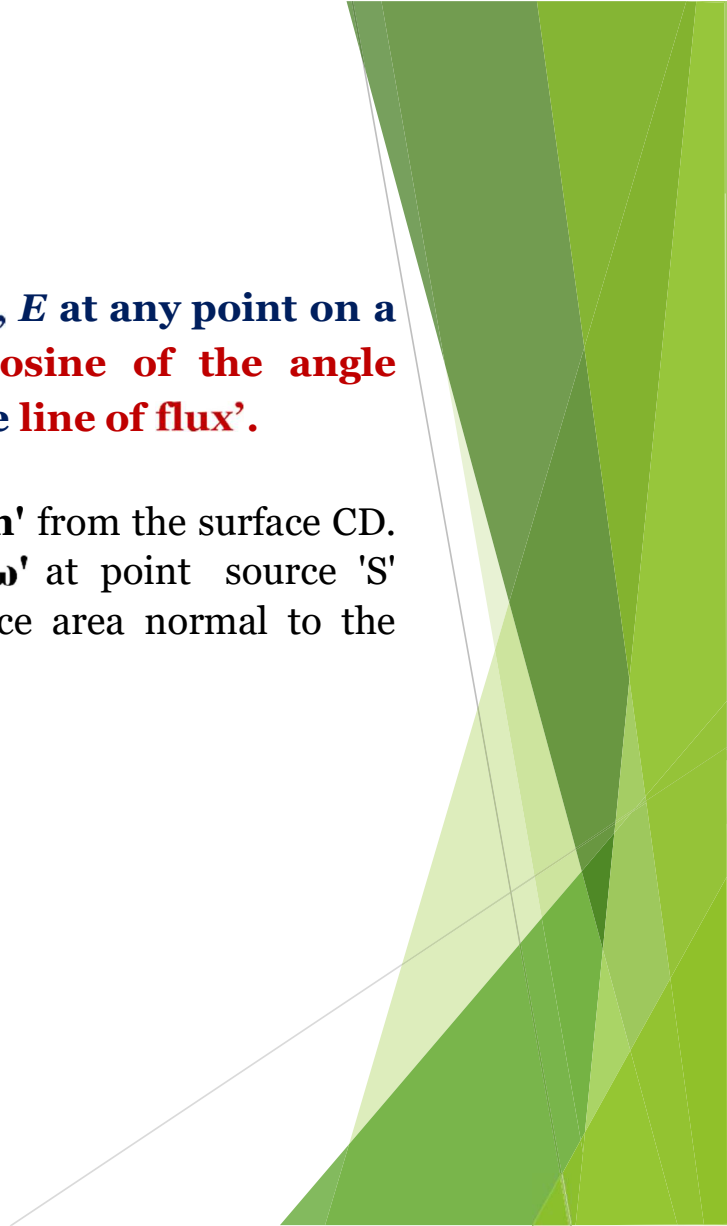
2. Lambert's cosine / cosine cube law:

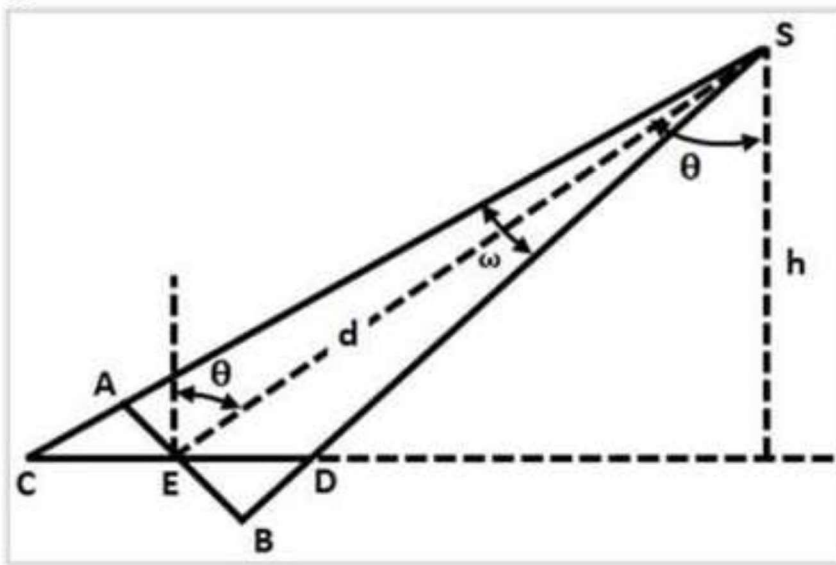
Statement:

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

Proof:

Consider a point source ' S ' at a height ' h ' from the surface CD. Assume that surface CD subtends solid angle ' ω ' at point source ' S ' as shown below. Let AB be the inclined surface area normal to the light flux with E as the center point of the surface.





From the above figure,

$$AB = CD \times \cos \theta$$

Illumination on surface AB is,

$$E_{AB} = \frac{\phi}{A} = \frac{I \times \omega}{\text{area of } AB}$$

Illumination on surface CD is,

$$E_{CD} = \frac{\phi}{A} = \frac{I \times \omega}{\text{area of } CD} = \frac{I \times \omega}{\left(\frac{\text{area of } AB}{\cos \theta}\right)}$$

$$E_{CD} = \frac{I \times \omega}{\text{area of } AB} \times \cos \theta$$

$$\mathbf{E_{CD} = E_{AB} \cos \theta}$$

From the figure, the height of the point source from the surface is,

$$\mathbf{h = d \times \cos \theta}$$

Now illumination on CD is given as,

$$E_{CD} = \frac{I \times \omega}{\text{area of } AB} \times \cos \theta$$

$$E_{CD} = \frac{I}{\left(\frac{\text{area of } AB}{\omega}\right)} \times \cos \theta$$

From inverse square law,

$$E_{CD} = \frac{I}{d^2} \times \cos \theta$$
$$E_{CD} = \frac{I}{\frac{h^2}{(\cos^2 \theta)}} \times \cos \theta$$
$$E_{CD} = \frac{I}{h^2} \times \cos^3 \theta$$

The above equation is known as **Cosine Cube Law**.

Limitations of Laws of Illumination :

1. The inverse square law is used to measure the illuminance only on the **horizontal surfaces** i.e., the inverse square law is only applicable if the **surface is normal to the light flux**.
2. The source is considered as the **point source** in inverse square law. But, **in practice, the point source does not exist**. Hence, a lot of errors are introduced in the calculation of illuminance using inverse square law.
3. Lambert's cosine law of illuminance is used to measure the illuminance only **on inclined surfaces**.

4). Polar Curves:-

1. The luminous flux or luminous intensity emitted by a source can be determined using the **intensity distributed uniformly** over the surrounding surface.

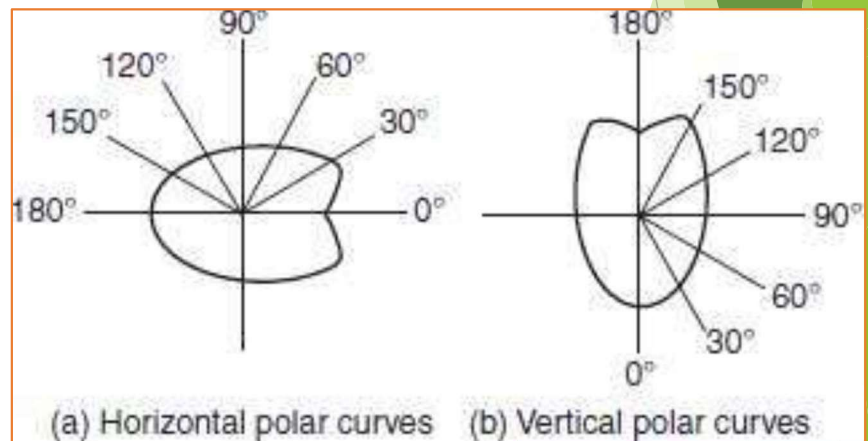
2. But in some cases its **surface not uniform in all directions**, under this, luminous intensity or the distribution of the light can be represented with the help of the **polar curves**.

3. The polar curves are drawn by taking luminous intensities in various directions at an equal angular displacement in the sphere. **A radial ordinate** pointing in any particular direction on a polar curve represents the luminous intensity of the source when it is viewed from that direction. Accordingly, there are **two different types of polar curves** and they are:



- A curve is plotted between the candle power and the angular position, if the luminous intensity, i.e., candle power is measured in the horizontal plane about the vertical axis, called '**horizontal polar curve**'.
- Curve is plotted between the candle power, if it is measured in the vertical plane and the angular position is known as '**vertical polar curve**'.

Figure shows the typical polar curves for an ordinary lamp.



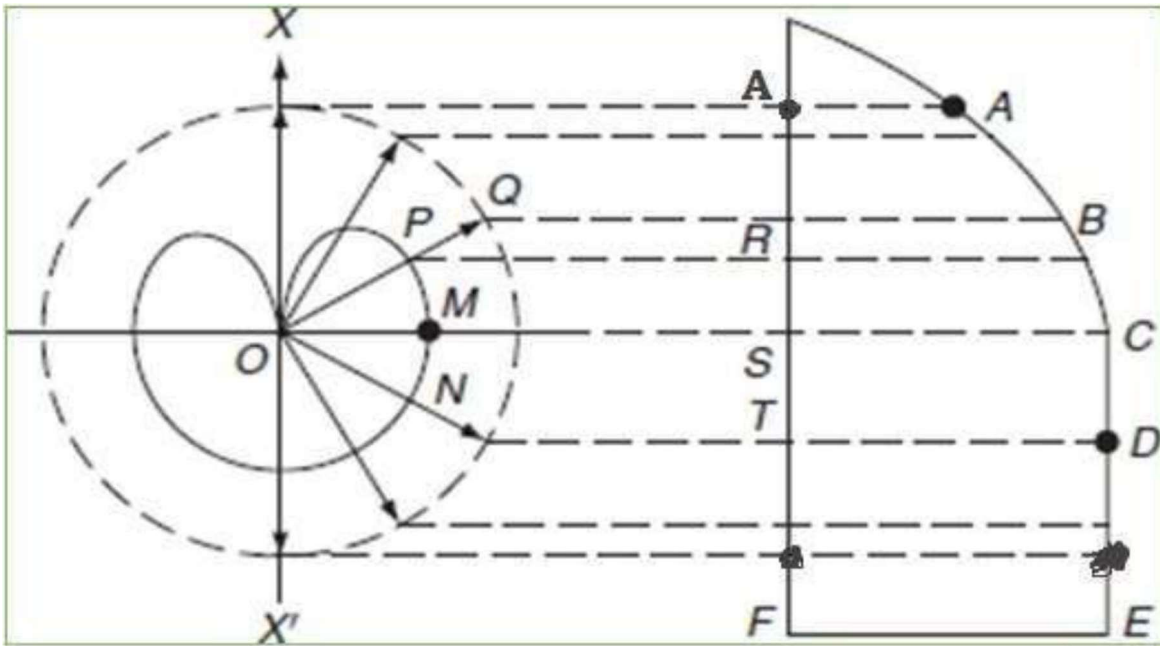
4. **Depression at 180°** in the vertical polar curve is due to the lamp holder. Slight depression at 0° in horizontal polar curve is because of coiled coil filament.

5. Polar curves are used to determine the **actual illumination of a surface** by employing the candle power in that **particular direction** as read from the vertical polar curve. These are also used to determine mean horizontal candle power (**MHCP**) and mean spherical candle power (**MSCP**).



Rousseau's construction

Let us consider a vertical polar curve is in the form of two lobes symmetrical about XOX_1 axis. A simple Rousseau's curve is shown in Figure.



Rules for constructing the Rousseau's curve :

1. Draw a circle with any convenient radius and with 'O' as center.
2. Draw a line 'AF' parallel to the axis XOX₁ and is equal to the diameter of the circle.
3. Draw any line 'OPQ' in such a way that the line meeting the circle at point 'Q'. Now let the projection be 'R' onto the parallel line 'AF'.
4. Erect an ordinate at 'R' as, RB = OP.
Now from this line 'AF' ordinate equals to the corresponding radius on the polar curve are setup such as SC = OM, TD = ON, and so on.
6. The curve ABCDEFA so obtained by joining these ordinates is known as Rousseau's curve.

The mean ordinate of this curve gives the

$$\text{Mean ordinate of the curve} = \frac{\text{area of ABCDEFA}}{\text{length of AF}}$$

5). Photometry:

Photometry involves the measurement of candle power or **luminous intensity** of a given source. The candle power of a given source in a particular direction can be measured by the comparison with a **standard source**.

In order to eliminate the errors due to the reflected light, the experiment is conducted in a **dark room with dead black walls** and ceiling. The comparison of the test lamp with the standard lamp can be done by employing a **photometer bench**.

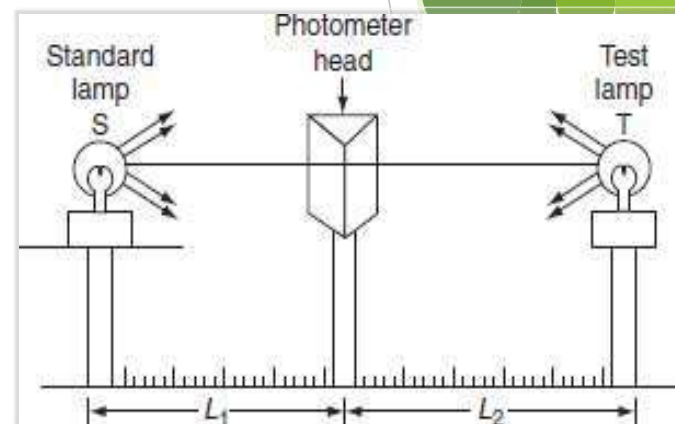
Principle of simple photometer:

“The principle methods of measurement are based upon the inverse square law”.

The photometer bench essentially consists of **two steel rods** with 2- to 3-m long. This bench carries **stands** for holding two sources (**test and standard lamps**), the carriage for the photometer head and any other apparatus employed in making measurements.

The **photometer bench** should be rigid so that the source being compared may be free from vibration, When **photometer head** and sources moving and the photometer head acts as **screen** for the comparison of the illumination of the standard lamp and the test lamp.

Let photometer bench has two sources, the standard source '**S**' whose candle power is known and the other source '**T**' whose candle power is to be determined. The photometer head acts as **screen is moved** in between the two fixed sources until the illumination on both the sides of screen is **same**.



If the distances of the standard source 'S' and the test source 'T' from the photometer head are **L₁ and L₂**, respectively, then, according to the **inverse square law**,

The CP of standard source(S) $\propto L_1^2$

The CP of Test source(T) $\propto L_2^2$

$$\frac{\text{CP of Standard source}}{\text{CP of Test source}} = \frac{L_1^2}{L_2^2}$$

$$\text{CP of Test source} = \text{CP of standard source} \times \frac{L_2^2}{L_1^2}$$

In order to obtain the **accurate Intensity(I)** of test source, the **distance of the sources** from the **photometer head** should be **measured accurately**.

Photometer heads:

The photometer heads that are most common in use are:

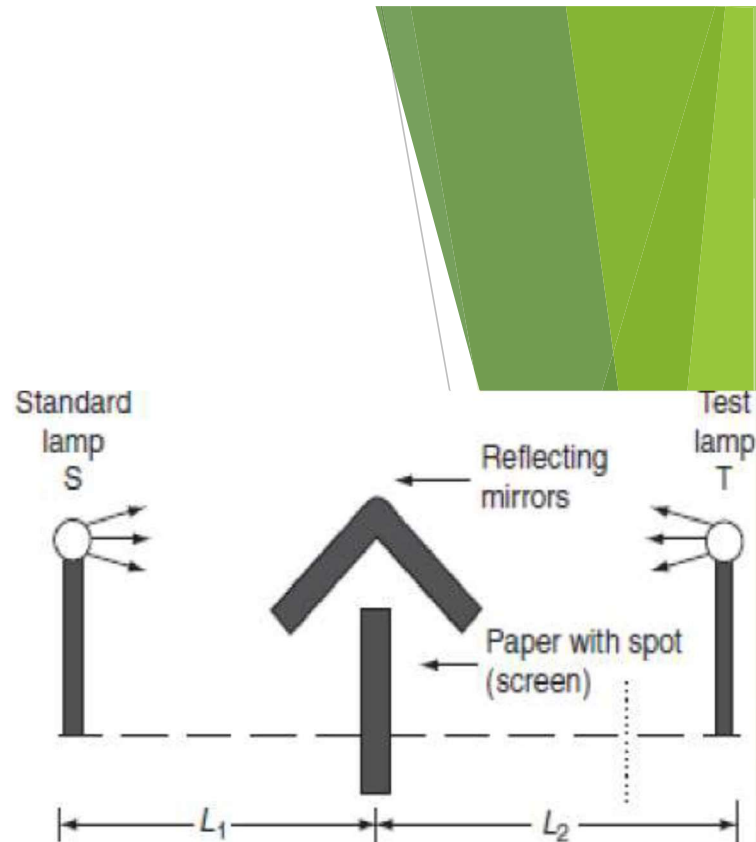
1. Bunsen-grease spot photometer.
2. Lumer–Brodhun photometer.
3. Flicker photometer.

The **first two** are best suited for , if the two sources to be compared give the light of same or approximately **similar colors**. For **differ in color**, a flicker photometer is best suited.

1. Bunsen-grease spot photometer:

1. Bunsen photometer consists of a **tissue paper**, with **a spot of grease** or wax at its center. It held vertically in a carrier between the two light sources to be compared.

2. The central spot will appear **dark** on the side, having illumination in **excess** when seen from the other side. Then, the observer will **adjust the position of photometer** head in such a way that the grease **spot is**



2. Lummer–Brodhun photometer:

There are two types of Lummer–Brodhun photometer heads.

I) Equality of brightness type.

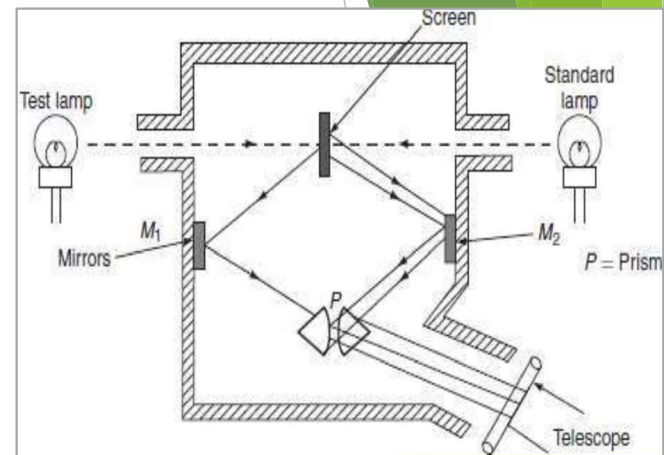
II) Contrast type.

The **Contrast type is more accurate** and therefore,

extensively used in the photometric measurements.

I) Equality of brightness type:

1. The photometer head essentially consists of **screen** made of plaster of Paris, two **mirrors M_1 and M_2** , glass cube (or) **compound prism**, and a **telescope**. The two sides of the screen are illuminated by two sources such as the standard and test lamps. The luminous flux lines emitting from the two sources are falling on the screen directly and **reflected** by it onto the mirrors M_1 and M_2 , which in turn reflect the same onto the compound prism then which pass through the telescope.

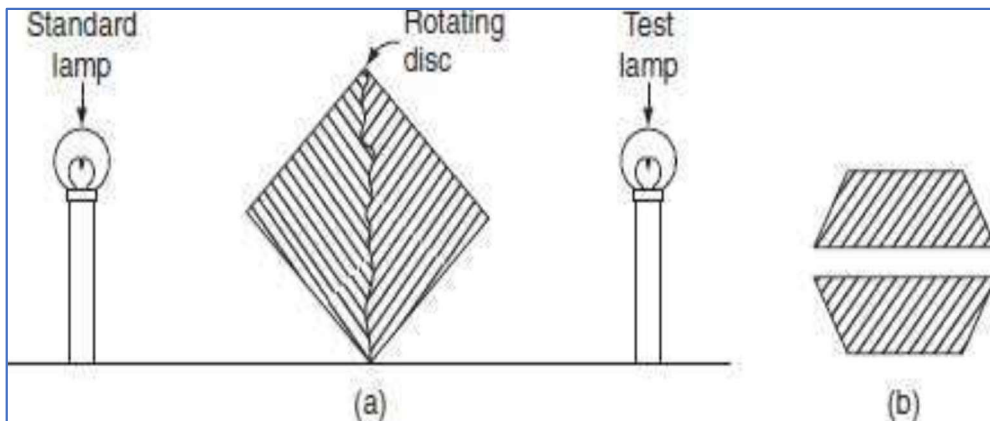


2. Thus, **observer view** the center portion of the circular area(**ring shape**) illuminated by both the test lamp and the standard lamp. The positioning of the **photometer head is adjusted** in such away that the both circular areas has **same intensity** (or) **brightness**. Now, the **distance** of photometer head from the two sources are **measured** and the candle power or luminous intensity of test lamp can be calculated by **using inverse square law**.

3. Flicker photometer:

1. The flicker photometers are employed when two sources giving light of different colors to be compared. A typically used flicker photometer is a **Simms–Abady flicker photometer**, where used **rotating disc** made up of **plaster of Paris**, is in the form of a **double-truncated cone** as shown in Figure.

2. The truncated portions of cone are fitted together to form the disc. The disc is **continuously rotated** at the required minimum speed by **small motor** in between the two sources to be compared.



6). Various illumination Methods:

Usually based upon the way of producing the light by electricity, the sources of light are classified into following four types.

1. Electric arc lamps.
2. Incandescent lamps.
3. Gaseous discharge lamps.
4. Fluorescent lamps.

5. Electric arc lamps:

In arc lamps, the electrodes are in contact with each other and are separated by some distance apart, the electric current is made to flow through these two electrodes, then ionization of air present between the two electrodes produces an arc and provides intense light when an arc is struck between two electrodes.

These are very efficient source of light. They are used in search lights, projection lamps, and other special purpose lamps such as those in flash cameras.

Generally, used arc lamps are: 1. Carbon arc lamp.

2. Flame arc lamp.

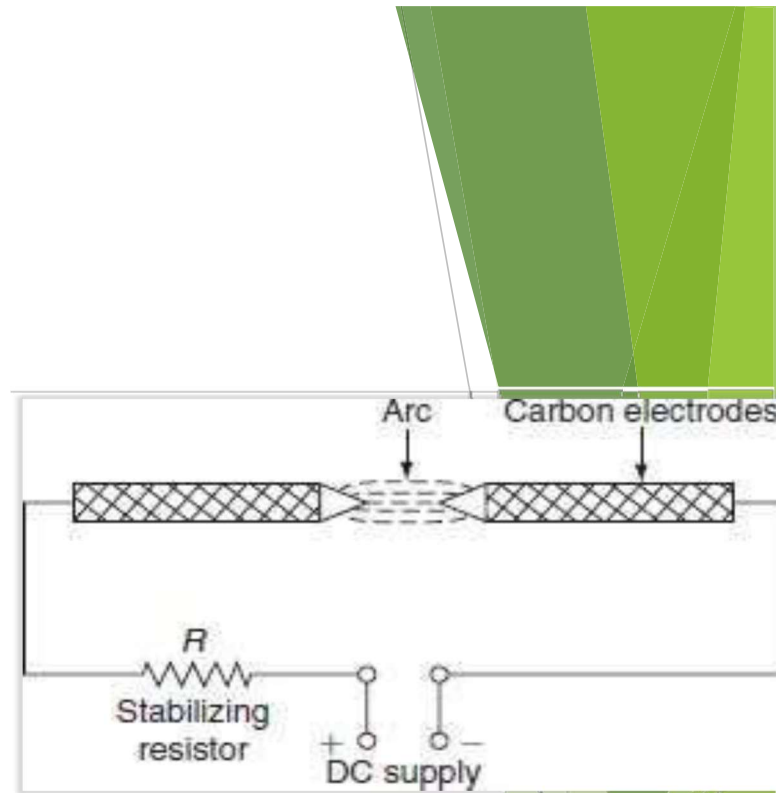
3. Magnetic arc lamp.

Carbon arc lamp:

1. Carbon arc lamp consists of two hard rod-type **electrodes made up of carbon**. Two electrodes are placed end to end and are connected to the **DC supply**. The positive electrode is of a **large size** than that of the negative electrode.

2. The DC supply across the two electrodes must not be **less than 45V**. When electric current passes through the electrodes are **in contact** and then withdrawn apart about **2–3 mm** an **arc** is established between the two rods.

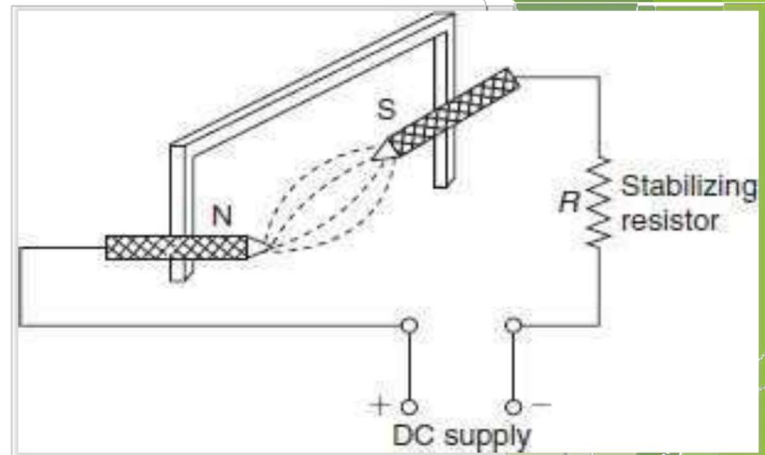
3. It is observed that carbon particles transfer from the positive rod to the negative one. So that the positive electrode gets consumed earlier than the negative electrode. Hence, the **positive electrode is of twice the diameter than that of the negative electrode**.



2. Flame arc lamp:

1. The electrodes used in flame arc lamp are made up of **85% of carbon and 15% of fluoride**. This fluoride is also known as **flame material**. Generally, the **core type electrodes are used and the cavities are filled with fluoride**. The principle of operation of the flame arc lamp is similar to the carbon arc lamp.

2. When the **arc is established** between the electrodes, **both fluoride and carbon get vaporized** and give out very high luminous intensities. The color output of the flame arc lamps depends upon the flame materials. The luminous efficiency of such lamp is **8 lumens/W**. **Resistance** is connected in service with the electrodes to **stabilize the arc**.



3. Magnetic arc lamp:

The principle of the operation of the magnetic arc lamp is similar to the carbon arc lamp. This lamp consists of **positive electrode** that is made up of **copper** and **negative electrode** that is made up of **magnetic oxide of iron**. Light energy radiated out when the arc is struck between the two electrodes. **These are rarely used lamps.**

2. Incandescent lamps:

These lamps are **temperature-dependent sources**. When electric current is made to flow through a fine metallic wire, which is known as **filament**, its temperature increases. At **low temperatures**, it emits only heat energy, but at very **high temperature**, the metallic wire emits both heat and light energy. These incandescent lamps are also known as **temperature radiators**.

Choice of material for filament:

The materials commonly used as filament for incandescent lamps are **carbon, tantalum, tungsten, and osmium**. The materials used for the filament of the incandescent lamp have the following **properties**.

1. The **melting point** of the filament material should be high.
2. The **temperature coefficient** of the material should be low.
3. It should be **high resistive** material.
4. The material should possess good **mechanical strength** to withstand vibrations.
5. The material should be **ductile**.

Tungsten filament lamps:

Construction

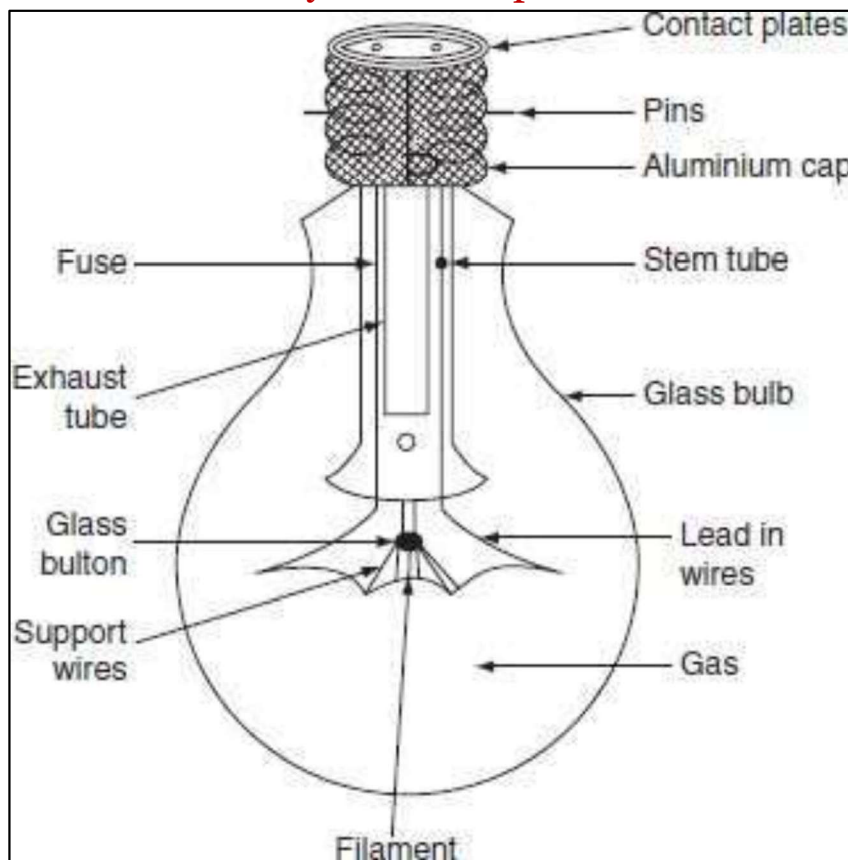
1. Figure shows the construction of the pure tungsten filament incandescent lamp. It consists of an **evacuated glass bulb** and an **aluminum or brass cap** is provided with **two pins** to insert the bulb into the socket(holder).

2. The inner side of the bulb consists of a **tungsten filament** and the **support wires** are made of molybdenum to hold the filament in proper position. A **glass button** is provided in which the support wires are inserted. A **stem tube** forms an **air-tight seal** around the filament.

Operation

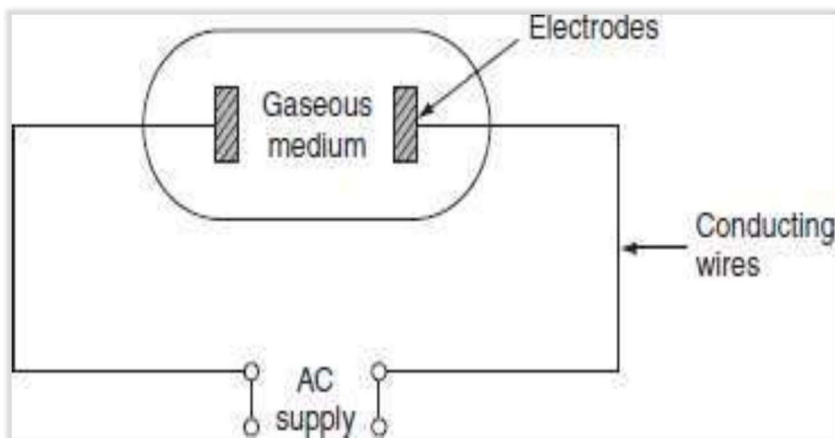
1. When **electric current** is made to flow through the fine metallic **tungsten filament**, its temperature increases. At very **high temperature**, the filament emits both heat and light radiations, which fall in the visible region.

2. The tungsten filament lamps can be operated **efficiently beyond 2,000 °C**, it can be attained by inserting a small quantity of **inert gas nitrogen** with small quantity of **organ**. But if gas is inserted instead of vacuum in the inner side of the bulb, the heat of the lamp is conducted away and it **reduces the efficiency of the lamp**.



3. Gaseous discharge lamps:

Discharge lamps have been developed to overcome the **drawbacks** of the incandescent lamp. Normally, at **high pressures atmospheric** conditions, all the gases are poor conductors of electricity. But on application of **sufficient voltage** across the two electrodes, the gases gets **ionized** then produce **electromagnetic radiation**. In the process light produced by **gaseous conduction**.



Volt–ampere characteristics of the arc in discharge tubes is negative, i.e., gaseous discharge lamp possess a **negative resistance characteristics**.

Types of discharge lamps:

Generally used discharge lamps are of two types.

They are:

1. The lamps that emit light of the **color** produced by **discharge** takes place through the **gas or vapor** present in the **discharge tube**.

Ex: 1. Neon gas, 2. Sodium vapor lamp(Low-P), and 3. Mercury vapor lamp(High-P).

2. The lamp that emits light of **color** depends upon the type of **phosphor material** coated inside the **walls** of the **discharge tube**. Initially, the discharge takes place through the vapor produces **UV radiation**, then the invisible UV rays absorbed by the phosphors and radiates light energy falls in the visible region. This UV light causes **fluorescence** in certain phosphor materials, such lamps are known as **fluorescent lamps**.

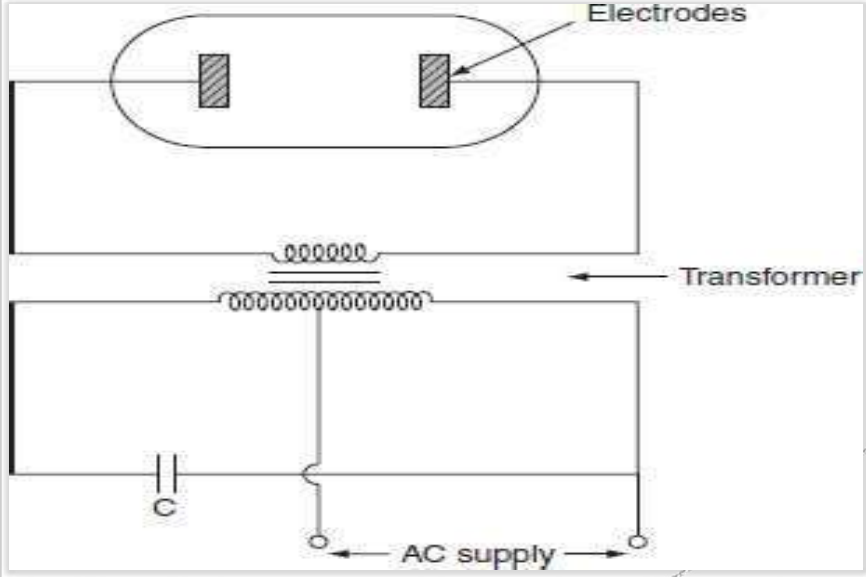
Ex: 4. Fluorescent Mercury vapor tube(Low-P).

➤ **Neon Discharge Lamp:**

1. This is a **cold cathode lamp**, in which **no filament is used to heat the electrode**. Neon lamp consists of **two electrodes** placed at the two ends of a long **discharge tube** is shown in Figure. The discharge tube is filled with **neon gas**.

2. A low voltage of 150 V on DC (or) 110 V on AC is impressed across the two electrodes using a step- down transformer(central tapped) with high **leakage**

➤ **reactance** in order to stabilize the arc. The **discharge** takes place through the neon gas that emits light or electromagnetic radiation **reddish in color**.



➤ Sodium Vapor Lamp:

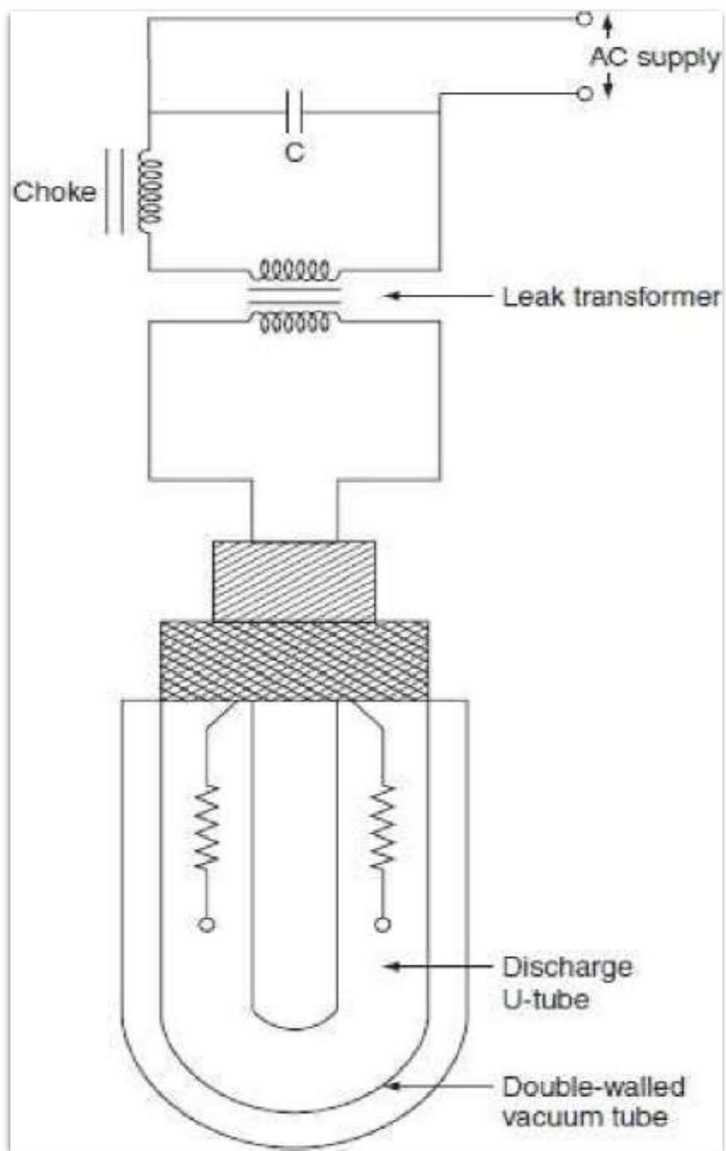
construction

1. A sodium vapor lamp is a **cold cathode** and **low-pressure lamp**. A sodium vapor discharge lamp consists of a **U-shaped tube** enclosed in a **double-walled vacuum flask**, to keep the temperature of the tube within the working region. The inner **U-tube** consists of **two oxide-coated electrodes**, which are sealed with the ends.

2. This sodium vapor lamp is low luminosity lamp, so that the **length of the lamp should be more**. In order to get the desired length, it is made in the form of a **U-shaped tube**. This long **U-tube** consists of a **small amount of neon gas** and **metallic sodium**. At the time of **start**, the neon gas vaporizes and develops **sufficient heat** to vaporize metallic sodium in the **U-shaped discharge tube**.

working

1. Initially, the **sodium** is in the form of a **solid**, deposited on the walls of inner tube. When sufficient **voltage** is impressed across the electrodes, the discharge starts in the **inert gas, i.e., neon**; it operates as a low-pressure neon **lamp with pink color**.



➤ High-pressure Mercury Vapor Lamp:

The **working** of the mercury vapor discharge lamp mainly depends upon the **pressure, voltage, temperature**, and other characteristics that influence the spectral quality and the efficiency of the lamp.

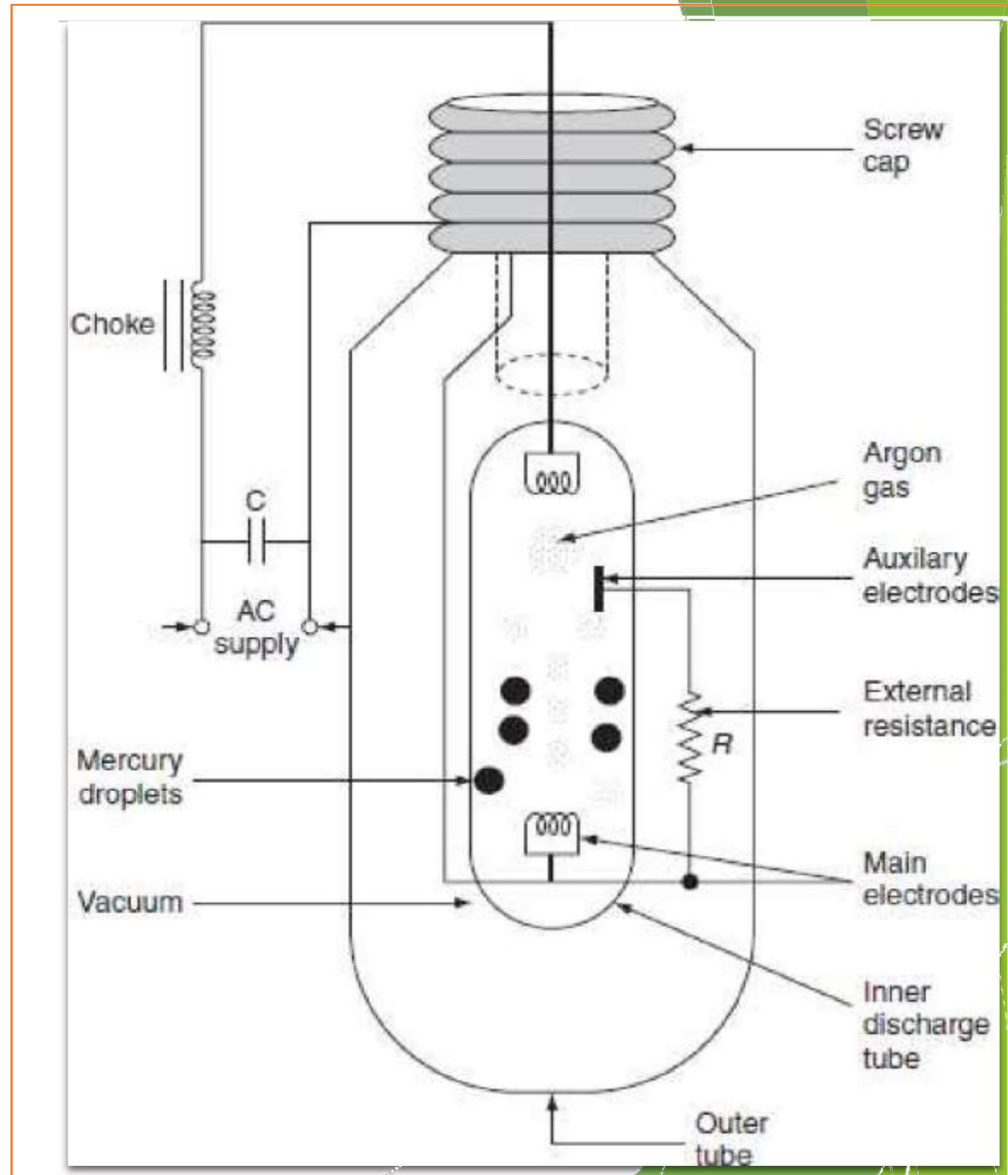
Generally used high-pressure mercury vapor lamps are of **three types**. They are:

- 1. MA type:** Preferred for 250- and 400-W rating bulbs on 200–250-V AC supply.
 - 2. MAT type:** Preferred for 300- and 500-W rating bulbs on 200–250-V AC supply.
- MB type:** Preferred for 80- and 125-W rating and they are working at very high pressures.

1. MA type Lamp

Construction

1. MA type mercury vapor discharge lamp that is similar to the construction of sodium vapor lamp. MA type lamp consists of a long discharge tube in long/U-shape and is made up of hard glass or quartz. This discharge tube is enclosed in an outer tube of ordinary glass.

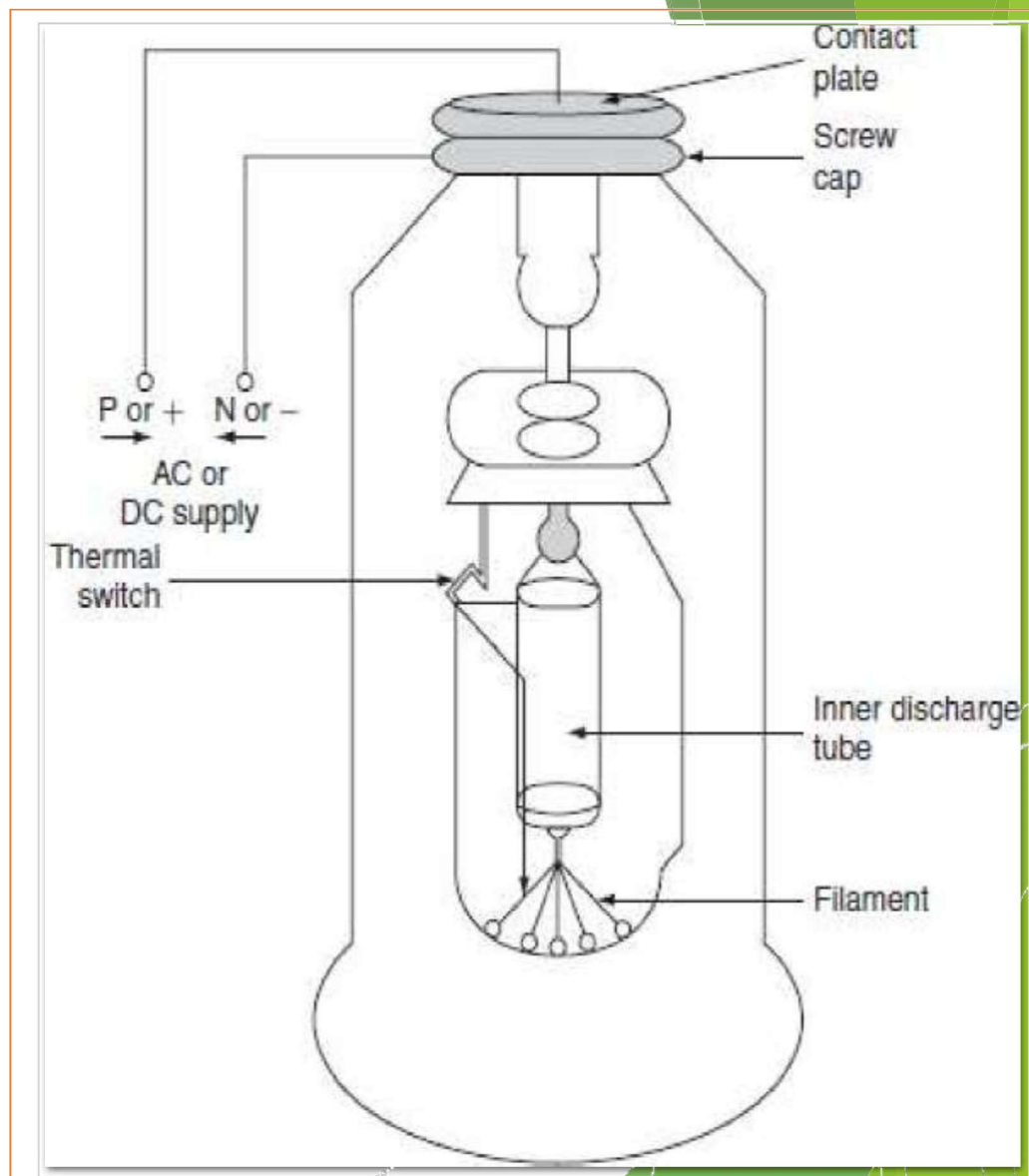


Working

1. Initially, the tube is **cold** and hence the **mercury** is in **condensed form**. When **supply** is given to the lamp, **argon gas** present between the main and the auxiliary electrodes gets **ionized**, and an arc is established, and then **discharge** takes place.
2. After few minutes, the argon gas, as a **whole**, gets **ionized** between the two main electrodes. Hence, the **discharge shifts** from the auxiliary electrode to the **two main electrodes**. During the discharge process, **heat is produced** and this heat is **sufficient to vaporize the mercury**. As a result, After **5-7 min**, the lamp starts and gives its full output.
3. Initially, the discharge through the **argon is pale blue glow** and the discharge through the **mercury vapors is greenish blue light**; here, **choke** is provided to **limit high currents** and **capacitor** is to improve the power factor of the lamp.
4. The operating temperature of the inner discharge tube is about **600°C**. The efficiency of this type of **lamp is 30-40 lumens/W**. These lamps are manufactured in **250 and 400 W** ratings for use on **200-250 V** on AC supply. Generally, the MA type lamps are used for general **industrial lighting, ports, shopping centers, railway yards**

2. MAT type Lamp construction

This is another type of **mercury vapor lamp** that is manufactured in **300 and 500 W rating** for use on **AC** as well as **DC** supplies. The construction of the MAT type lamp is similar to the MA type lamp except that, it consists of **tungsten filament** so that at the time of starting, it works as a tungsten filament lamp and also acts as a **choke** to limit the high currents to a safe value.



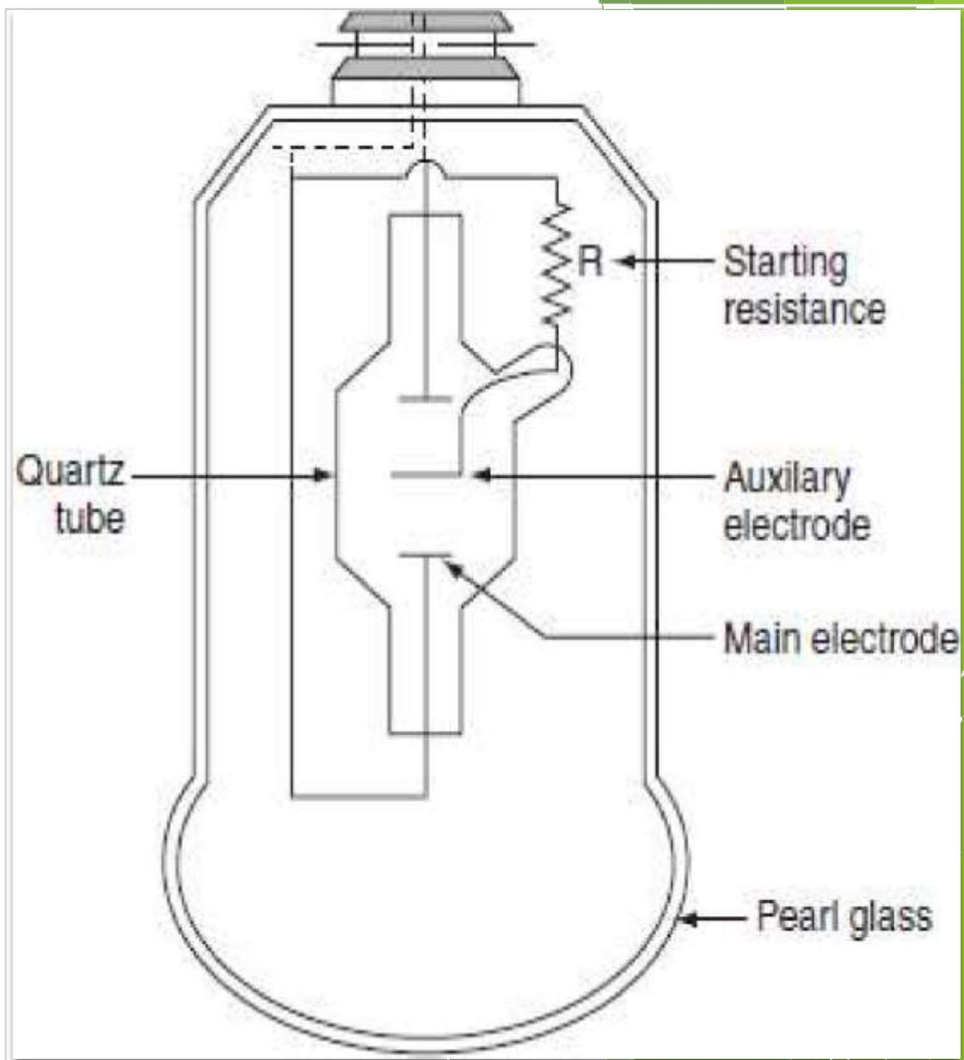
Working

1. When the supply is given, it works as a **tungsten filament lamp**, then **argon gas** present in it starts **ionizing** in the discharge tube at any particular temperature is attained then **thermal switch**(bi-metallic strip) gets opened, and the part of the **filament is detached** and voltage across the discharge tube increases.

2. Now, the **discharge** takes place through the **mercury vapor** and **emits blue colored light** from the discharge tube. In this type of lamp, **capacitor is not required** since the overall power factor of the lamp is **0.95**, this is because the filament itself acts as resistance.

1. MB type Lamp

1. The MB type lamp is also **similar to the MA type lamp**. But, **very high pressure** is maintained inside the discharge tube and it is about **5–10 times greater than atmospheric pressure**. The inner discharge tube for the MB type lamp is about **5 -cm long** and is made up of **quartz material**.

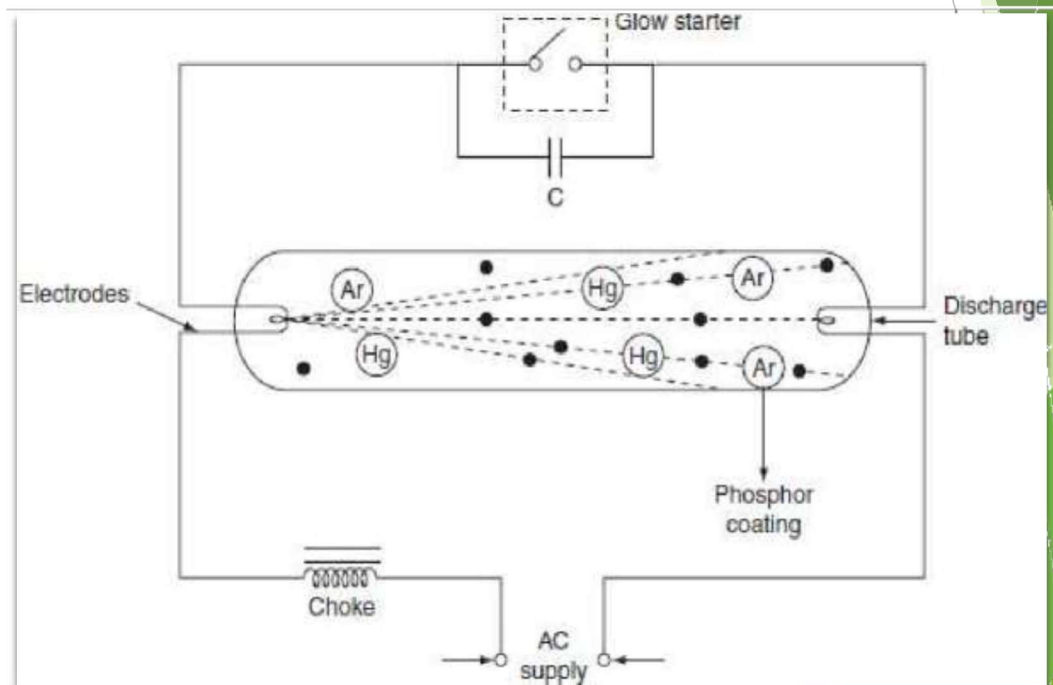


2. Fluorescent lamps(Low-pressure Mercury Vapor Lamp):

Fluorescent lamp is a **hot cathode low-pressure mercury vapor lamp**.

Construction

1. It consists of a **long horizontal tube**, due to low pressure maintained inside of the bulb. The tube consists of two **spiral tungsten electrode** coated with electron emissive material and are placed at the two edges of long tube.



**7). Comparison between “Tungsten Filament”
Lamps And “Fluorescent Tubes”:**

Incandescent Lamp	Fluorescent Lamp
1. Initial cost is less.	1. Initial cost is more.
2. Fluctuations in supply voltage has comparatively more effect on the light output.	2. Fluctuation in supply voltage has less effect on light output, as the variations in voltage are absorbed in choke.
3. It radiates the light; the color of which resembles the natural light.	3. It does not give light close to the natural light.
4. It works on AC as well as DC.	4. Change of supply needs additional equipment.
5. The luminous efficiency of the lamp is low is, about 8 – 40 lumens/W.	5. The luminous efficiency is high, which is about 50– 100 lumen/W.
6. Different color lights can be obtained by using different colored glasses.	6. Different color lights can be obtained by using different composition of fluorescent powder.

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9). Types and design of lighting schemes:

Types of lighting schemes:

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.

