This note is for theoretical topics only. Refer class sessions for numerical and application-level questions

ILLUMINATION

1. **Solid angle**- Solid angle is the 3-Dimensional equivalent of 2-Dimensional angle. Solid angle is measured in ***Steradian***.

Steradian (sr) is defined as the angle subtended at the centre of the sphere by an area (A) on its surface numerically equal to square of the radius **(R^2)**

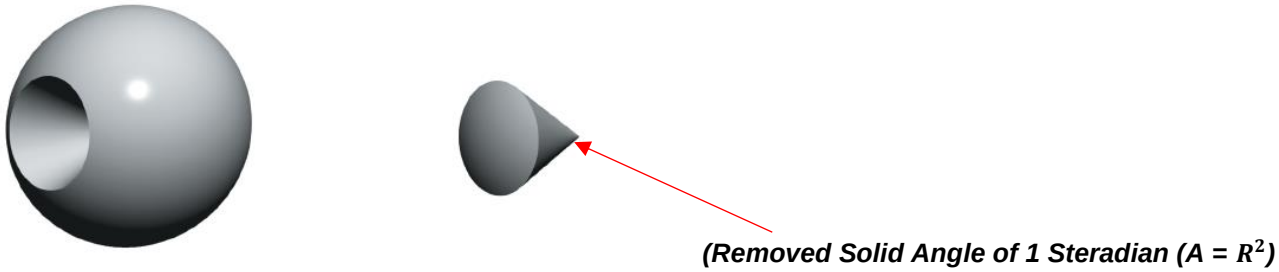


Figure 1: One steradian solid angle removed from a sphere

2. **Luminous flux (Φ)** is the light energy radiated out per second from the body in the form of luminous light waves.

   It is thus the rate of energy radiation in the form of light. It is energy per second and hence equivalent to **Power**.

   Its SI unit is **lumen (lm)**

   Approximate relation between lumen and electric unit of power i.e. watt is given as:

   1 lumen = 0.0016 watt or (Joule/sec) (approx.)

   1 watt = 625 lumen (approx.)

   Lumen is also defined as the luminous flux emitted in a unit solid angle by a source of one candle power.

   Lumen = Candle Power X Solid Angle

3. **Luminous intensity (I) or Candle-power** of a point source in a given direction is the luminous flux (number of lumens) radiated out per unit solid angle. In other words, it is solid angular flux density of a source in a specified direction.

   Its unit is Candela (cd) or lumens per steradian.

A source of one candela emits one lumen per steradian

4. **Illumination (E) or Illuminance**: When the luminous flux falls on a surface, it is said to be illuminated. Illumination is the luminous flux received by a surface per unit area.

   Its unit is Lux or lumens/m^2

   A foot-candle is a non-SI unit of illuminance or light intensity

   foot-candle is defined as one lumen per square foot

5. **Luminance:** Luminance is photometric measure of the luminous intensity per unit area of light travelling in a given direction.

   The unit is candela per square metre (cd/m^2)
   or lumens per steradian per square metre (lumens/sr/m^2)

   A non-SI term for the same unit is the ***nit***

6. **Brightness** of a surface is defined as the luminous intensity per unit projected area of the surface in the given direction.

   Unit of brightness is **Lambert**

7. **Color Rendering Index (CRI)**

   A color rendering index (CRI) is a quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source.

   It is a measure of the effect of light on the perceived color of objects. A low CRI indicates that some colors may appear unnatural when illuminated by the lamp.

   The CRI is determined by the light source's spectrum. An incandescent lamp has a continuous spectrum, a fluorescent lamp has a discrete line spectrum; the incandescent lamp has the higher CRI.

8. **Specific output or efficiency** of a lamp is the ratio of luminous flux to the power intake.

   Its unit is **lumens per watt (lm/w)**

This note is for theoretical topics only. Refer class sessions for numerical and application-level questions

Basic Photometric Measurements and Laws

Inverse Square Law

Illumination (**E**) / Illuminance of a surface is directly proportional to the luminous intensity and inversely proportional the square of the distance between the source and the surface to be illuminated, as long as the source remains the same. Inverse square law is valid only when light source approximates a point source.

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

E = Illumination

I = Luminous Intensity

d = distance between source and surface to be illuminated

Example: If the Illuminance of the surface is 40 lux (lm/m^2) at a distance of **0.5m**, the illuminance decreases to **10 lux** at a distance of **1m** as shown in ***Figure 1***

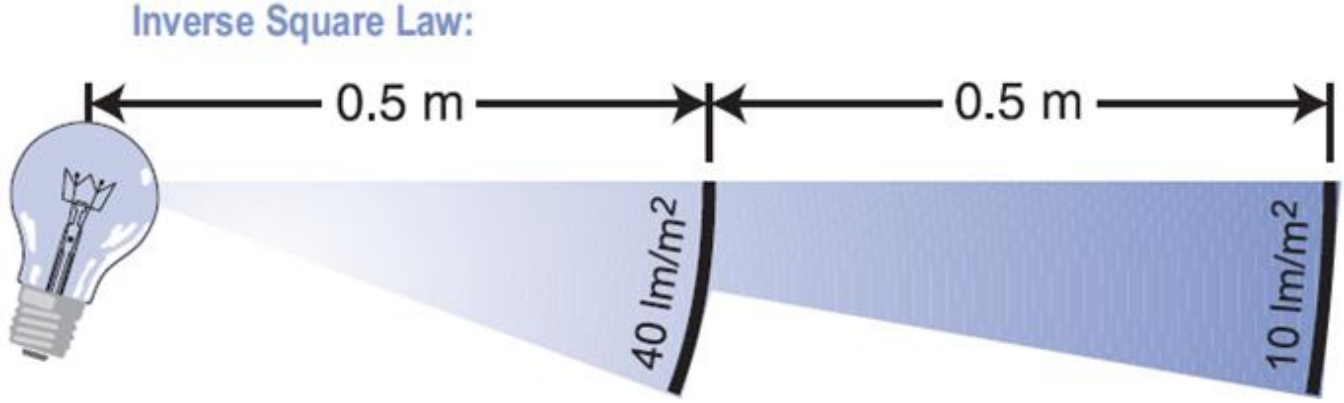


Figure 2: **Inverse Square Law**

This note is for theoretical topics only. Refer class sessions for numerical and application-level questions

Lambert's Cosine Law (Cosine emission Law)

Lambert's Cosine Law states that "The illuminance on any surface depends upon the cosine of the light's angle of incidence i.e. the illumination on a surface is proportional to the cosine of the angle between the normal to the surface and the line of flux.

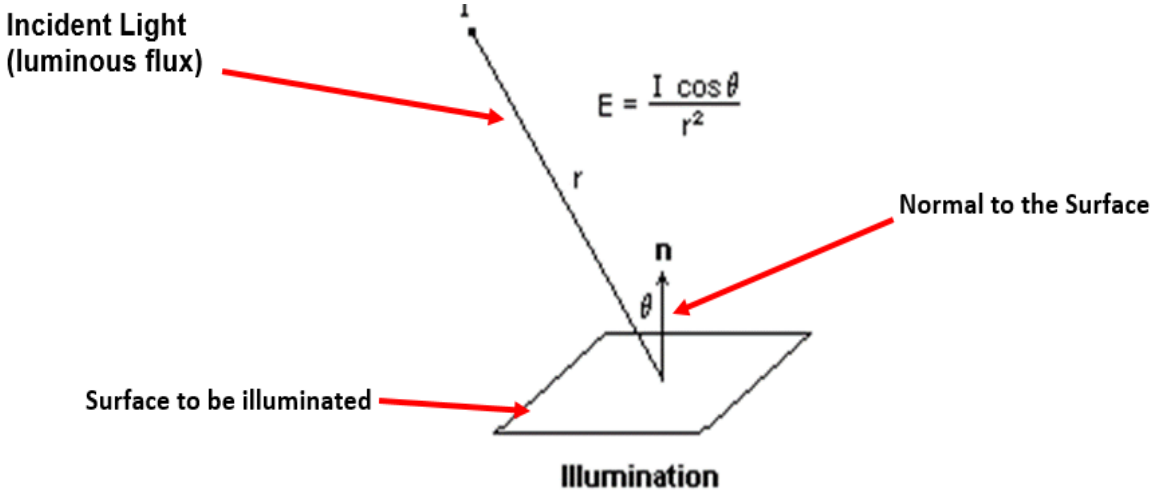


Figure 3: **Cosine Law**

Here when the plane to be illuminated is not normal to the direction of luminous flux, and is inclined by an angle θ, where θ is the angle between the line of flux and the normal to the illuminated plane.

Lambert's Cosine Law is applicable only to point sources (not for reflecting surfaces)

This note is for theoretical topics only. Refer class sessions for numerical and application level questions

Light Sources

The lighting industry makes millions of electric light sources, called lamps. Those used for providing illumination can be divided into three general classes:

1. Incandescent Lamps
2. Discharge Lamps
3. Solid-state lamps

Incandescent lamps produce light by heating a filament until it glows.

Discharge lamps produce light by ionizing a gas through electric discharge inside the lamp.

Solid-state lamps use a phenomenon called electroluminescence to convert electrical energy directly to light.

1. Incandescent Lamps

Incandescent lamp technology uses electric current to heat a coiled tungsten filament to incandescence. The glass envelope contains a mixture of nitrogen and a small amount of other inert gases such as argon. Some incandescent lamps, such as some flashlight lamps, also contain xenon. Some of these incandescent lamps are called xenon lamps

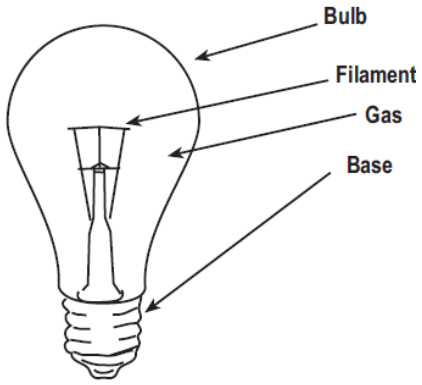


Figure 4: Incandescent Lamp

Note: The output of a tungsten filament lamp depends on Temperature of filament

This note is for theoretical topics only. Refer class sessions for numerical and application level questions

Q. Why is filament lamps filled with inert gases???

Ans: The color temperature of a normal filament lamp is typically between 2800 K and 3000 K. At the extremely high temperature of the filament, tungsten tends to evaporate. This leads to the familiar blackening of an incandescent lamp envelope.

1. The evaporation of the tungsten filament can be reduced by filling the lamp envelope with a suitable gas that does not chemically attack the filament i.e. inert gas.
2. Gases also cool the filament by conducting heat away from it, and they decrease lamp efficiency. The gas used must, therefore, be carefully chosen. It should adequately suppress tungsten evaporation without overcooling the filament.
3. In addition, it should not readily pass an electric current, for otherwise arcing may occur which would destroy the lamp.

Argon and nitrogen are the gases most commonly used.

Nitrogen will minimize the risk of arcing but will absorb more heat than argon.

Argon is used by itself in general service lamps.

A mixture of the Argon & Nitrogen gases is used in incandescent lamps where the tendency for arcing is more likely, such as in projector lamps.

Lamps filled with krypton gas have a longer life than argon and nitrogen lamps and cost more.

The GLS (General Lighting Service) is a traditional type of light bulb that has been in use since the early twentieth century (Incandescent lamps)

GLS "General Lighting Service" lamps produce light as a result of the heating effect of an electrical current. Most of the electricity goes to producing heat and a little to producing light. A fine tungsten wire is first coiled and coiled again to form the incandescent filament of the GLS lamp. GLS lamp is considered as a resistive load. So the power factor of GLS is 1(unity)

Figure 5: GLS Lamps

This note is for theoretical topics only. Refer class sessions for numerical and application-level questions

Halogen Lamps

Unlike incandescent lamps, halogen lamps use a halogen gas fill (typically iodine or bromine), to produce what is called a "halogen cycle" inside the lamp. In the halogen cycle, halogen gas combines with the tungsten that evaporates from the lamp filament, eventually re-depositing the tungsten on the filament instead of allowing it to accumulate on the bulb wall as it does in standard incandescent lamps. The tungsten- halogen lamp has several differences from incandescent lamps

1. The lamps have a longer life (2000-3500 hours).
2. The higher operating temperature of the filament improves luminous efficacy.
3. The lamp produces a "whiter" or "cooler" light, which has a higher correlated color temperature (CCT) than standard incandescent lamps.
4. The bulbs are more compact, offering opportunities for better optical control.
5. Halogen lamps are sometimes called "quartz" lamps because their higher temperature requires quartz envelopes instead of the softer glass used for other incandescent lamps.

Halogen lamps are used in automotive headlamps, under-cabinet lighting, and work lights. In addition, halogen reflectors like MR and PAR lamps are often preferred for directed lighting such as spotlights and floodlights. They are also increasingly being used as a more efficient alternative to incandescent reflectors.

2. Discharge Lamps

Discharge lamps produce light by passing an electric current through a gas that emits light when ionized by the current. An auxiliary device known as a ballast supplies voltage to the lamp's electrodes, which have been coated with a mixture of alkaline earth oxides to enhance electron emission.

Two general categories of discharge lamps are used to provide illumination:

1. **High-intensity discharge Lamps**
2. **Fluorescent lamps**

1. High-Intensity Discharge Lamps HID Lamps

Four types of high-intensity discharge (HID) lamps are most widely available

1. High-pressure mercury vapour lamps,

2. Metal-halide lamps

3. High-pressure sodium lamps,

4. Xenon lamps.

1. High-Pressure Mercury Vapor Lamps

In a high-pressure mercury vapor lamp, light is produced by an electric discharge through gaseous mercury. The mercury, typically along with argon gas, is contained within a quartz arc tube, which is surrounded by an outer bulb of borosilicate glass.

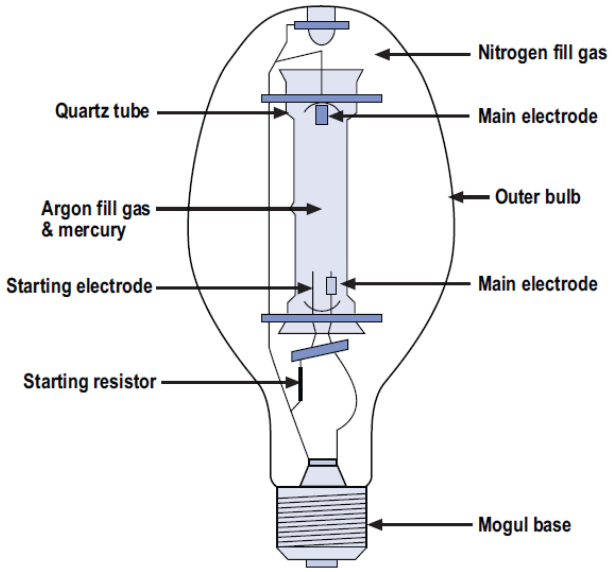


Figure 6: High-Pressure Mercury Vapor Lamps

2. Metal-Halide Lamps

A metal-halide lamp is a mercury vapor lamp with other metal compounds (known as halides) added to the arc tube to improve both color and luminous efficacy.

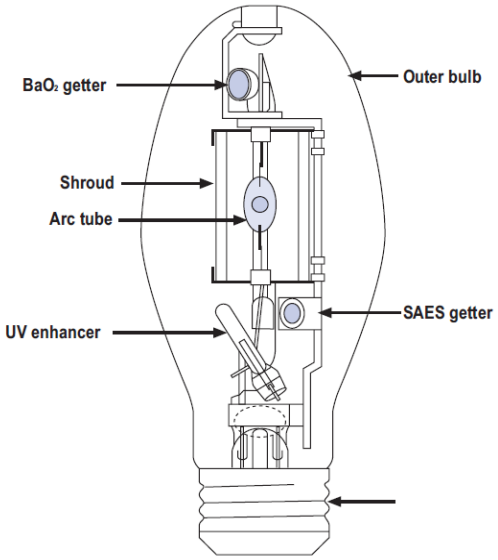


Figure 7: Metal-Halide Lamp

3. High-Pressure Sodium Lamps

A sodium-vapor lamp is a gas-discharge lamp that uses sodium in an excited state to produce light at a characteristic wavelength near 589 nm.

There are two varieties of such lamps:

1. Low-pressure sodium lamp
2. High-pressure sodium lamp

Both the low pressure and high pressure are filled with both sodium and neon gas.

Low-pressure sodium lamps are highly efficient electrical light sources, but their yellow light restricts applications to outdoor lighting such as street lamps.

High-pressure sodium lamps produce a broader spectrum of light than the low-pressure lamps, but they still have poorer color rendering producing the monochromatic yellow light. (Low CRI < 30)

On turning on a sodium vapor lamp, initially, it emits a dim red/ pink light, which warms up sodium metal. After a few minutes, the light turns into bright yellow, due to vaporization of sodium, which is a nearly monochromatic light. Objects, lighted by sodium vapor lamp are not easily distinguished in color, because they appear almost entirely yellow due to the reflection of this narrow bandwidth of yellow light.

Light is produced in a high-pressure sodium (HPS) lamp by an electric discharge through combined vapors of mercury and sodium, with the sodium radiation dominating the spectral emission. The hard glass outer bulb may be clear, or its inner surface may be coated with a diffuse powder to reduce the brightness of the arc tube

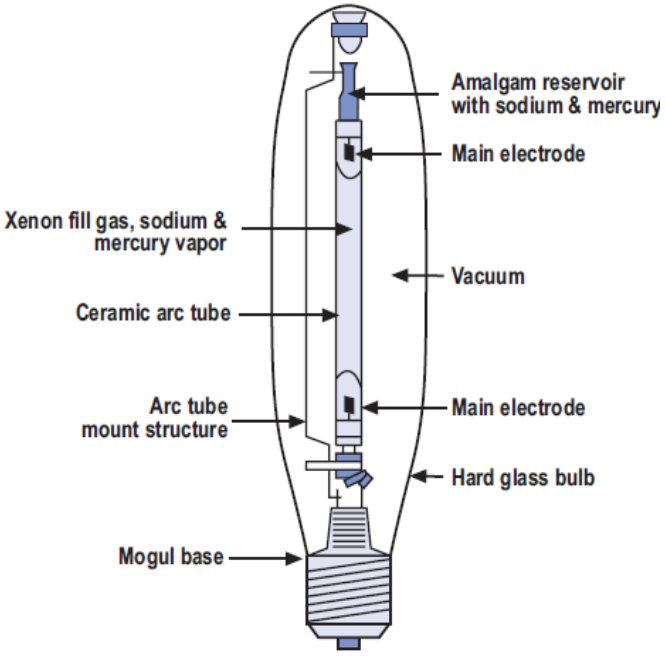


Figure 8: High-Pressure Sodium Lamps

Working

In order to start the sodium vapor lamp, **400-600V** of striking voltage required for 40- and 100-W lamps. These voltages can be obtained from a high reactance transformer or an autotransformer. The operating power factor of the lamp is very poor so that a capacitor is placed to improve the power factor to above 0.8.

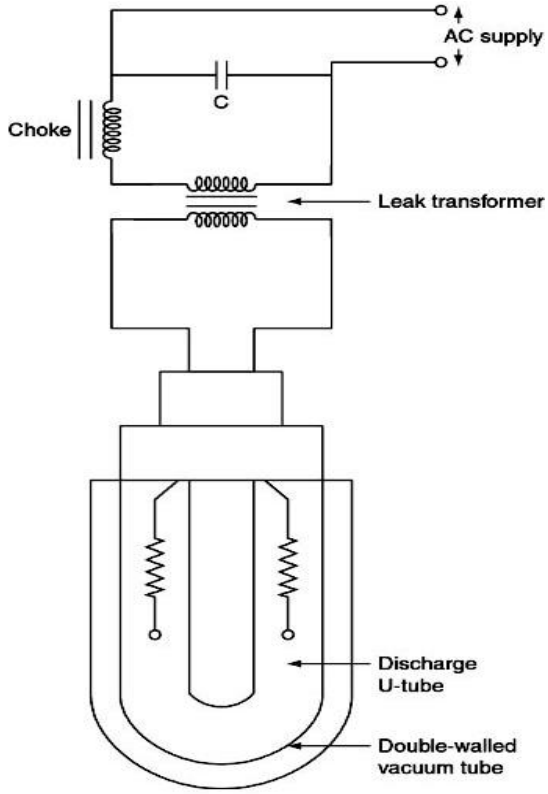


Figure 9: Circuit Diagram of Sodium Vapour Lamps

Initially, the sodium is in the form of a solid, deposited on the walls of the 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 (initial color). At the time of start, the neon gas vaporizes and develops sufficient heat to vaporize metallic sodium in the U-shaped tube. The temperature of the lamp increases gradually and the metallic sodium vaporizes and then ionizes thereby producing the monochromatic yellow light. This lamp takes 10-15 min to give its full light output.

This note is for theoretical topics only. Refer class sessions for numerical and application level questions

Q.1 When a sodium vapor lamp is switched on, initially the color is

A. Pink
B. Yellow
C. Green
D. Blue

Q.2 The capacitor used in autotransformer circuit for sodium vapor lamps is for

A. Protection against accidental power failure
B. Controlling illumination level of the lamp
C. For regulating discharge voltage
D. For improving the power factor of the circuit

Q.3 Which of the, following vapors/gas will give yellow color in a filament lamp?

A. Sodium
B. Helium
C. Mercury
D. Magnesium

Q.4 Neon gas in sodium vapor lamp

A. Changes the color of light
B. Acts as a shield around the filament
C. Assists in developing enough heat to vaporize the sodium
D. Prevents vaporization of filament

Q.5 Power factor is highest in case of

A. Mercury arc lamp
B. Sodium vapor lamps
C. Tube lights
D. GLS lamps

Ans: 1 Pink (Option A)

Ans: 2 for improving the power factor of the circuit (Option D)

Ans: 3 Sodium (Option A)

Ans: 4 Assists in developing enough heat to vaporize the sodium (Option C)

Ans: 5 GLS Lamps (Option D)

4. Xenon Lamps

Xenon lamps do not contain mercury vapor. They contain xenon gas, kept at a pressure of several atmospheres. Xenon lamps are available in wattages from 5 to 32,000 watts.

Figure 10: Xenon Lamps

A xenon arc lamp is a highly specialized type of gas discharge lamp, an electric light that produces light by passing electricity through ionized xenon gas at high pressure. It produces a bright white light that closely mimics natural sunlight, with applications in **movie projectors** in theaters, in searchlights, and for specialized uses in industry and research to simulate sunlight, often for product testing.

Xenon headlamps in automobiles are actually metal-halide lamps, where a xenon arc is only used during start-up to correct the color temperature.

2. Fluorescent lamps

A fluorescent lamp, or fluorescent tube, is a low-pressure mercury-vapor gas-discharge lamp that uses fluorescence to produce visible light. An electric current in the gas excites mercury vapor, which produces short-wave ultraviolet light that then causes a phosphor coating on the inside of the lamp to glow. A fluorescent lamp converts electrical energy into useful light much more efficiently than incandescent lamps. The typical luminous efficacy of fluorescent lighting systems is **50–100 lumens / watt**, several times the efficacy of incandescent bulbs with comparable light output.

Fluorescent lamp tube is filled with a mix of argon, xenon, neon, or krypton, and mercury vapor. The pressure inside the lamp is around 0.3% of atmospheric pressure.

The partial pressure of the mercury vapor alone is about 0.8 Pa

The inner surface of the lamp is coated with a fluorescent coating made of varying blends of metallic and rare-earth phosphor salts.

The lamp's electrodes are typically made of coiled tungsten and are coated with a mixture of barium, strontium and calcium oxides to improve thermionic emission.

Fluorescent lamps are negative differential resistance devices, so as more current flows through them, the electrical resistance of the fluorescent lamp drops, allowing for even more current to flow. Connected directly to a constant-voltage power supply, a fluorescent lamp would rapidly self-destruct because of the uncontrolled current flow. To prevent this, fluorescent lamps must use a **ballast** to regulate the current flow through the lamp.

Choke must provide a suitable striking (ignition) voltage across the bulb at starting such that an electric arc can sustain between the electrodes afterward. Secondly, the ballast is responsible for limiting the current flow across the lamp during the normal operation of it.

As the initial impedance is high, the striking voltage required to ignite the arc would also be higher than the normal operating voltage (around 300% higher) of a fluorescent lamp. Immediately after the lamp is struck, the impedance drops to its minimum value, representing negative resistance characteristics that need some form of current limiting to prevent lamp destruction from excessive current.

A: Fluorescent tube, B: Power (+220 volts), C: Starter, D: Switch (bi-metallic thermostat), E: Capacitor, F: Filaments, G: Ballast

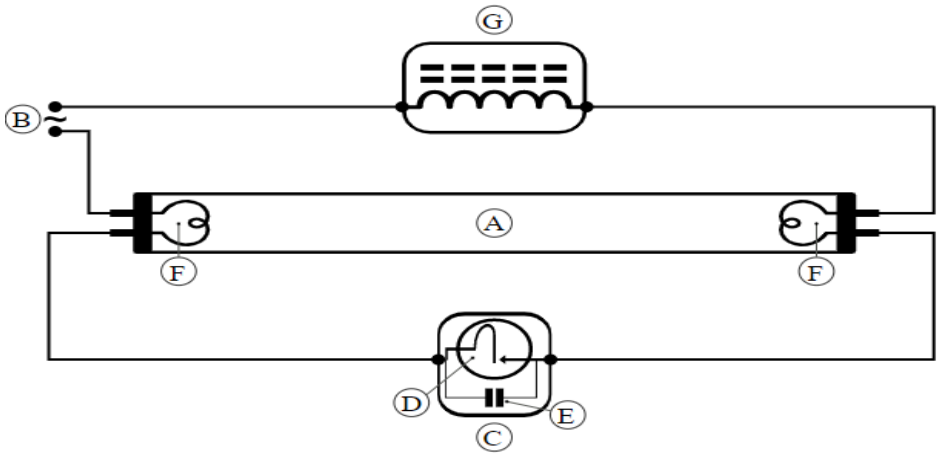
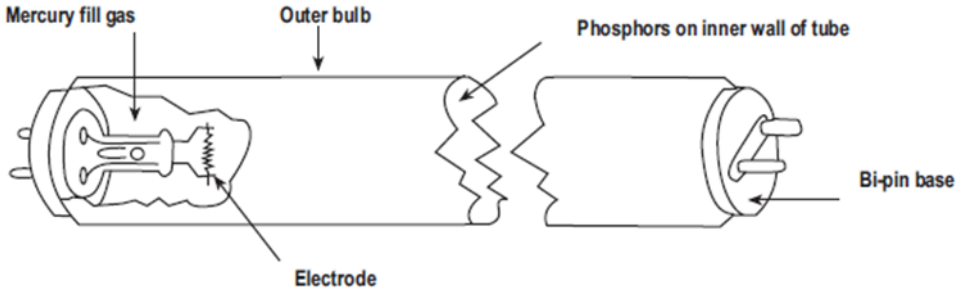


Figure 11: A preheat fluorescent lamp circuit using an automatic starting switch



Q: 6 In a fluorescent tube circuit, choke acts as

A. Starter
B. The power factor improving device
C. Source of heat
D. Current limiting device

Ans Current limiting device

There are mainly two functions of the choke coil

1. Limit the current
2. Produce high voltage across tube light

1. Limit the current

In a gas discharge, such as a fluorescent lamp, current causes resistance to decrease. This is because as more electrons and ions flow through a particular area, they bump into more atoms, which frees up electrons, creating more charged particles.

In this way, current will climb on its own in a gas discharge, as long as there is adequate voltage (and household AC current has a lot of voltage).

If the current in a fluorescent light isn't controlled, it can blow out the various electrical components.

2. Produces High voltage Across Tube light

Choke is a coil/ballast (inductor) which is used to induce the high voltage across it. This high voltage is required to ionize the gases in the starter.

Choice of material for the filament

The materials commonly used as the filament for incandescent lamps are

- **Carbon,**
- **Tantalum,**
- **Tungsten, and**
- **Osmium.**

Q: 7 Which of the following filament material has the lowest melting point?

Carbon, Tantalum, Tungsten, and Osmium.

Ans:

The melting point of the carbon is 3550°C

The melting point of the tungsten is 3422°C

The melting point of the Osmium is 3033°C

The melting point of the tantalum is 3017°C

Q: 8 Properties of the materials used for the filament of the incandescent lamp

Ans:

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 the good mechanical strength to withstand vibrations.
5. The material should be ductile.

Property of Tungsten

1. The working temperature of tungsten is 2,500-3,000°C
2. Its resistance at working temperature is about 12-15 times the cold resistance
3. It has the positive temperature coefficient of resistance of 0.0045
4. Its resistivity is 5.6 – 12.5 μΩ –cm
5. The density of tungsten is 19.3
6. The efficiency of tungsten when working at 2,000°C is 18 lumens/W
7. Its vapor pressure is low when compared to carbon
8. Tungsten has the highest melting point (3422 °C, 3695°K, 6192 °F)

3. Solid State Lamps

LEDs (Light-Emitting Diodes)

LEDs are solid-state semiconductor devices that convert electrical energy directly into light. LEDs can be extremely small and durable; some LEDs can provide much longer lamp life than other sources.

Note: (A self-study on LED may be done by aspirants and plenty of online resources are available as this is a fast evolving technology)

This note is for theoretical topics only. Refer class sessions for numerical and application-level questions

Luminous Efficacy Table

Type of Lamp	Typical luminous efficacy (lumens/watt)
Tungsten incandescent light bulb	**12.5-17.5 lm/W**
Halogen lamp	**16-24 lm/W**
Fluorescent lamp	**45-75 lm/W**
LED lamp	**30-90 lm/W**
Metal halide lamp	**75-100 lm/W**
High pressure sodium vapour lamp	**85-150 lm/W**
Low pressure sodium vapour lamp	**100-200 lm/W**
Mercury vapour lamp	**35-65 lm/W**

Note: Energy saving lamps have high luminous efficacy (more lumens per watt)

Lumens to watts calculation

The power **P** in watts (W) is equal to the **luminous flux (Φ)** in lumens (lm), divided by the luminous efficacy **η** in lumens per watt (lm/W)

Power in (Watts) = lumens / (lumens per watt)

Example

What is the power consumption of a lamp that has luminous flux of 1000 lumens and luminous efficacy of 20 lumens per watt (lm/W)?

Ans: Power Rating of the lamp is given by P = 1000 lm / 20 lm/W = 50W

This note is for theoretical topics only. Refer class sessions for numerical and application level questions

Types of Lamps and CRI

Type of Lamp	Power rating (W)	Colour Rendering Index (CRI) (100 is the highest CRI)	Life (hours)
1. Low-pressure sodium lamps	**up to 180**	**< 0 Monochromatic Yellow Colour**	16,000
2. High-pressure sodium lamps	**1000W**	**< 30 Poor**	6,000–24,000
3. High-pressure mercury vapour lamps	**80 – 750W**	**< 60 Fair**	20,000
4. Compact fluorescent lamps (FS)	**5– 55W**	**80 Good**	5,000–10,000
5. Tubular Fluorescent Lamps (FD)	**4 – 100W**	**60 – 98 Fair to Good**	10,000–15,000
6. Quartz Metal Halide Lamps	**2,000W**	**65-95 Good To Excellent**	6,000–20,000
7. Ceramic Discharge Metal Halide Lamps	**1000W**	**80-96 Good**	24,000
8. Incandescent lamps (I)	**5 – 500W**	**~100 High (Continuous Spectrum)**	1,000–3,000
9. Low-Voltage Tungsten Halogen Lamps	**12 – 100W**	**~ 100 Good to excellent**	2,000–5,000
10. Tungsten Halogen Lamps (HS)	**2,000W**	**~100 Good to excellent**	2,000–4,000
11. LED Lamps	**60W**	**70-95 Good**	**50,000 hours** (20-25 times halogen bulbs 8-10 times life of CFL)
12. Ultra High CRI LED lamps	**100W**	**~100 Good to excellent**	

Color rendering index (CRI) is a measure of how “real” or accurate colors look under a white light source.

CRI values range from 0 to 100
For most applications, the higher the CRI, the better.

This note is for theoretical topics only. Refer class sessions for numerical and application level questions

Color Rendering Index of different lamps

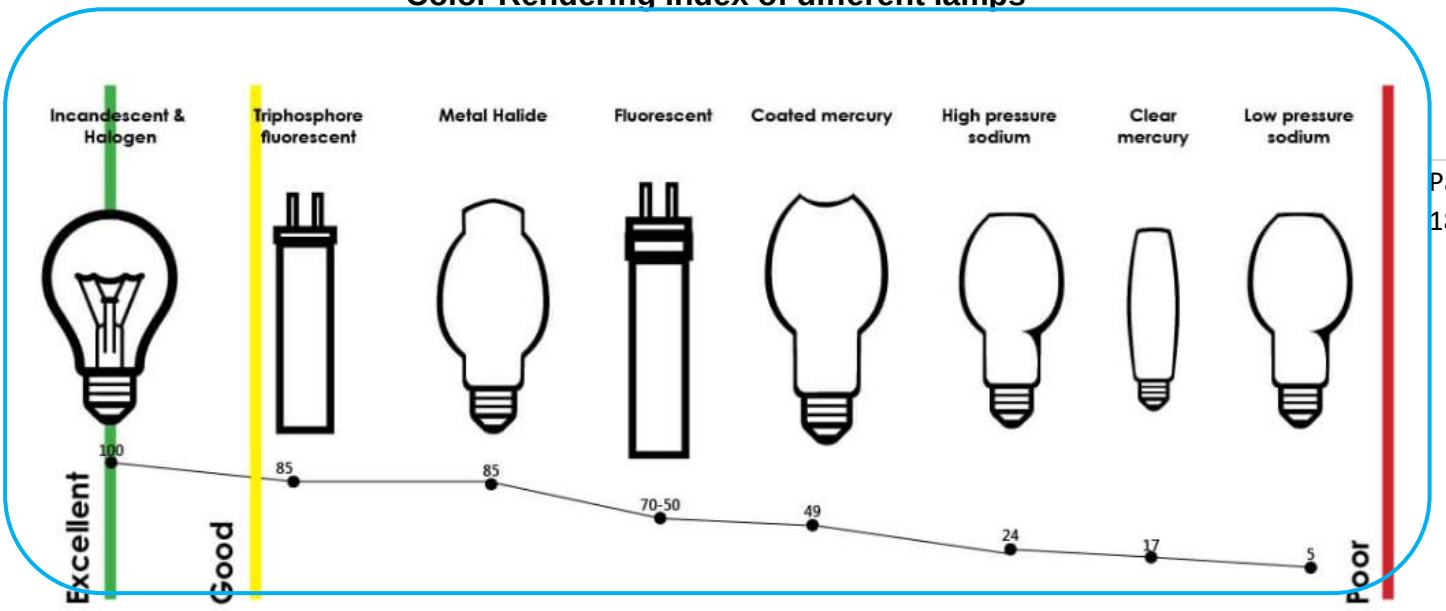


Figure: 12 CRI comparison

Note: The optimal CRI is the one that faithfully reproduces the true colour of articles

This note is for theoretical topics only. Refer class sessions for numerical and application-level questions

Lamps & Applications

Type of Lamp	Applications	
1. Low-pressure sodium lamps	Street Lighting (where safety, low cost is the priority & Color Rendering is not a requirement)	
2. High-pressure sodium lamps	Street Lighting (where Color Rendering is a requirement)	
3. High-pressure mercury vapour lamps	Outdoor lighting / street lighting (usage limited)	
4. Compact fluorescent lamps	Indoor lighting Domestic/commercial	
5. Tubular Fluorescent Lamps	Indoor lighting Domestic/commercial	
6. Incandescent lamps	Indoor lighting & Decorative purpose	
7. Metal Halide Lamps	They are used for wide area overhead lighting of commercial, industrial, and public spaces, such as parking lots, **sports arenas**, factories, and retail stores, as well as residential security lighting and automotive headlamps (xenon headlights).	* SSC JE 2018 Question.
8. Halogen Lamps	**Flood Lights, Theatre lights, Automotive headlamps, medical halogen penlights**	Repeated Ques. In KPSC, SSC, RRB
9. Tungsten Halogen Lamps (HS)	Majority of theatrical and studio (film and television) fixtures, portable projectors	**Carbon ARC** Lamps are used in Cinema Projectors
10. LED Lamps	**All purposes ****	LED lamps have been dominating & replacing most lamps for almost all applications
11. Ultra High CRI LED lamps	Residential, hospitality, color matching, film& photography, Horticulture, products for fluorescence	

This note is for theoretical topics only. Refer class sessions for numerical and application level questions

Level -1 Questions

(SSC, RRB JE/State PSC/ KSEB previous questions)

1. Solid angle is measured in
   A. Solid Angle
   B. Radian
   C. Steradian
   D. Candela
2. Candela is the unit of
   A. Luminous flux
   B. Luminous intensity
   C. Wavelength
   D. None of the above
3. Cricket stadium is lighted using
   A. Fluorescent Lamps
   B. Metal Halide Lamps
   C. Halogen Lamps
   D. HP Sodium Vapor Lamps
4. The lamp with lowest CRI is
   A. Sodium Vapor Lamp
   B. LED
   C. Metal Halide
   D. GLS lamps
5. Which of the following is NOT used as filament
   A. Tungsten
   B. Carbon
   C. Lead
   D. Osmium
6. The illumination is directly proportional to the cosine of the angle made by the normal to the illuminated surface with the direction of the incident flux. Above statement is associated with
   A. Inverse Square Law
   B. Macbeth's law of illumination
   C. Bunsen's law of illumination
   D. Lambert's cosine law
7. Low level of illumination is not an issue in case of_____?
   A. Theatres
   B. Fine precision work
   C. Railway platform
   D. Auditorium
8. Which of the following lamps gives nearly monochromatic light?
   A. Sodium vapor lamp
   B. GLS Lamp
   C. Tube light
   D. Mercury vapor lamp
9. 1 Lumen per square meter is
   A. 1 Lux
   B. 1 Candela
   C. 1 Lux/ meter
   D. 1 foot-candle
10. The optical instrument used to measure the intensity of light produced by an unknown source in comparison to a standard source is
    A. Candle meters
    B. Radiometers
    C. Bunsen meter
    D. Photometer
11. Approx. lumens in a 7W LED is
    A. 100 lumens
    B. 300 lumens
    C. 600 lumens
    D. 900 lumens
12. For the same wattage which lamp is cheapest?
    A. Sodium Vapor Lamp
    B. Mercury Vapor Lamp
    C. Fluorescent tube
    D. GLS Lamp
13. Light is produced in electric discharge lamps by
    A. Heating effect of current
    B. Magnetic effect of current
    C. Ionization in a gas or vapor
    D. Carbon electrodes
14. The color of the light given out by a sodium vapor discharge lamp at starting is
    A. Pink
    B. Bluish Green
    C. Yellow
    D. Blue
15. Lumen/watt is the unit of
    A. Light Flux
    B. Luminous Intensity
    C. Brightness
    D. Luminous Efficiency

16. The S.I unit of Luminance is
    A. Candela(cd)
    B. Lux
    C. cd/m^2
    D. Candela/sr

17. Foot-candle is the unit of
    A. Illumination
    B. Luminous flux
    C. Luminous Intensity
    D. Brightness

18. Melting temperature of tungsten is approx.
    A. 2000° K
    B. 2500° K
    C. 3695° K
    D. 7500° K

19. The radiant efficiency of the luminous source depends on
    A. The shape of the source
    B. The temperature of the source
    C. The wavelength of the light rays
    D. All of the above

20. Nitrogen or argon is filled in GLS lamps to
    A. Reduce the glare
    B. Improve efficiency
    C. Change the color of light
    D. Retard evaporation of tungsten filament

21. The light output of Sodium vapor lamps is normally in the range
    A. 10 to 18 lumens/watt
    B. 50 to 100 lumens/watt
    C. 100 to 200 lumens/watt
    D. 18 to 30 lumens/watt

22. The number of times an Indian domestic fluorescent lamp will flicker in 1 second will be close to _____
    A. 25 times
    B. 50 times
    C. 100 times
    D. Cannot be predicted with this info.

23. The light output of GLS lamps is normally in the range
    A. 10 to 18 lm/W
    B. 20 to 50 lm/W
    C. 100 to 200 lm/W
    D. 200 to 300 lm/W

24. The lumen output of a 50W fluorescent lamp will be in the range of ____?
    A. 1000 lumens
    B. 100 lumens
    C. 500 lumens
    D. 2500 lumens

25. The essential requirement of good heating elements are
    A. High Specific resistance
    B. Free from oxidation
    C. Low-temperature coefficient of resistance
    D. All of the above

26. In a fluorescent tube circuit, choke acts as
    A. Starter
    B. The power factor improving device
    C. Source of high voltage
    D. Current limiting device

27. Carbon arc lamps are commonly used in
    A. Domestic lighting
    B. Street lighting
    C. Cinema Projector
    D. Photography

28. A 50 W bulb gives a luminous flux of 2500 lumens. The luminous efficacy is
    A. 25
    B. 2500
    C. 50
    D. 100

29. Which has longest life
    A. Sodium Vapor Lamp
    B. LED
    C. Metal Halide
    D. GLS lamps

30. The color temperature of daylight is in the range of
    A. 6000K
    B. 3000K
    C. 1000K
    D. 2500K

Illumination - Level-1 Questions KEY			
1.	C	16.	C
2.	B	17.	A
3.	B	18.	C
4.	A	19.	B
5.	C	20.	D
6.	D	21.	C
7.	C	22.	C
8.	A	23.	A
9.	A	24.	D
10.	D	25.	D
11.	C	26.	D
12.	D	27.	C
13.	C	28.	C
14.	A	29.	B
15.	D	30.	A

***NOTE**: This note is prepared on the topic Electrical Illumination for **SSC JE / KPSC, KSEB Sub Engineer/ AE level exams**, (Please refer to course outline shared in class).*
Additional exam specific points will be discussed in class / Q&A sessions
(Additional MCQs on illumination will follow in Test-series & QCards)
*Points in **RED** should be noted*

This note is for theoretical topics only. Refer class sessions for numerical and application-level questions

Additional Points from class slides:

Q. Unit of Luminous Intensity is:

(259/2004 Overseer Elec)
(241/2007 Overseer PWD)

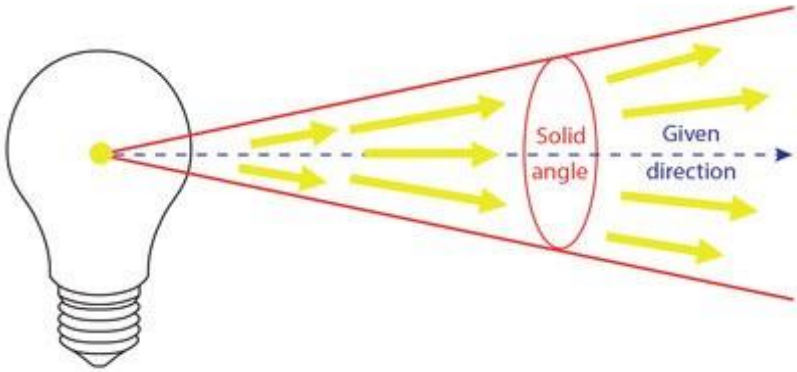
a) Candela
b) Lumen
c) Lux
d) Maxwell

Luminous Intensity Candela= LIC

Q. The unit of Solid angle is:

(245/2006 Electrician grade II)

a) Radian
b) Degree
c) Gradient
d) Steradian



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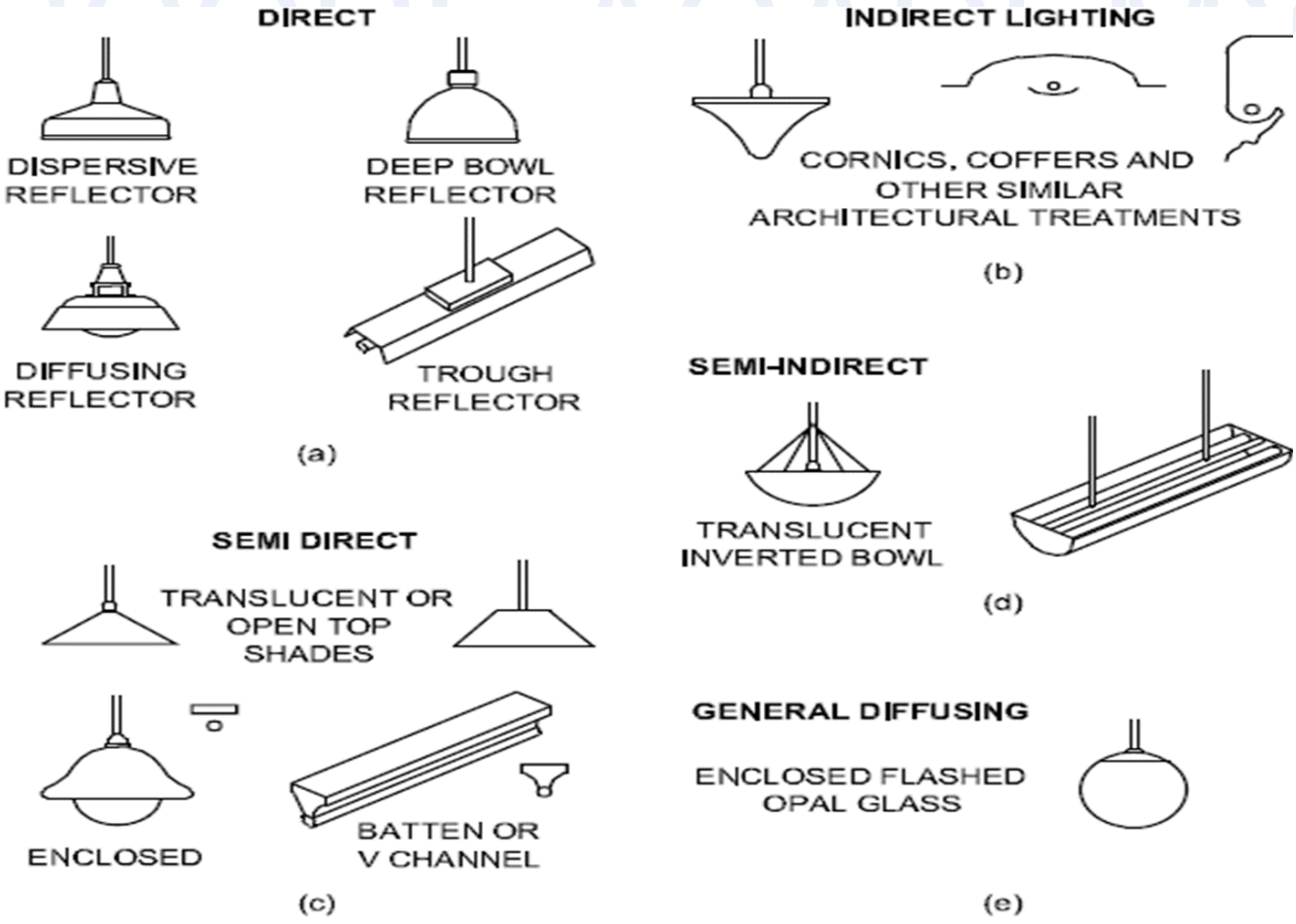
Lighting systems

Types of system	Amount of emergent light	
	Downward	Upward
Shaded or reflector system		
1 Direct	90 to 100%	0 to 10%
2 Semi direct	60 to 90%	10 to 40%
3 Semi indirect	10 to 40%	60 to 90%
4 Indirect	0 to 10%	90 to 100%
Diffused system		
1 General diffused	50%	50%



Discharge lamp: An electric lamp in which the light is obtained by a discharge of electricity between two electrodes in gas or vapor

A gas discharge lamp is one in which some inert gas is filled in a glass tube having two electrodes sealed into each end, which on heating allows the flow of electron through it

Electric gas discharge lamps are of two main types:

1. Cold cathode lamp - NO filament is used to heat the electrode for starting
2. Hot cathode lamp - a filament is provided for heating the main electrode at the time of starting

Electric gas discharge lamps

Cold Cathode Lamps

(i) Neon lamp,

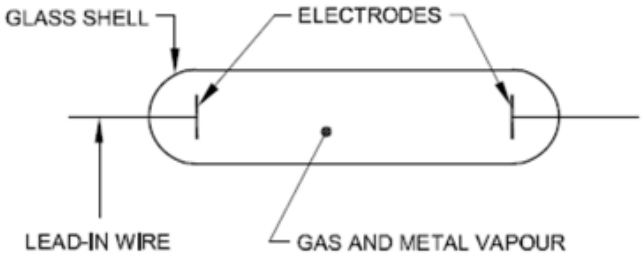
(ii) Neon sign tubes,

Hot Cathode Lamps

(i) Mercury Vapour lamp (medium pressure)

(ii) Fluroscent tube (low pressure mercury vapour lamp)

A gas discharge lamp



Gases are normally poor conductors, especially at atmospheric and higher pressures, but application of suitable voltage (known as ignition voltage) between two electrodes in a sealed envelope containing gas at low pressure ionizes the gas, and current passes from one electrode to the other through the gas medium

Neon lamp

A neon lamp (also neon glow lamp) is a miniature gas discharge lamp

The lamp typically consists of a small glass capsule that contains a mixture of neon and other gases at a low pressure and two electrodes

Application: Indicators

Neon sign tubes

Q. Neon sign tubes can be used for _____ purpose.

(103/2005 KSEB Sub Eng.)

a) Advertising

b) Search light

c) Street light

d) Domestic lighting

Classroom slides: For reference only

Refer Video Sessions & Short Notes for detailed study

Sodium vapour lamps

are used for the lighting of streets, railways, storage yards

higher efficiency

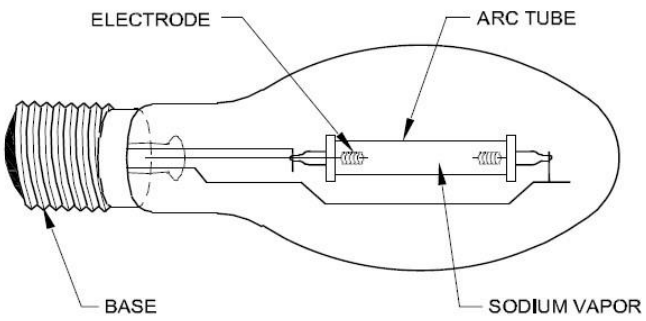
(110 lumens/watt)

The average life of a sodium vapour lamp is well over 6000 hours

High pressure sodium vapour lamp

This discharge tube :

sintered aluminium ceramic discharge arc tube



HPSV LAMP

This discharge tube contains

Sodium, Mercury, with Neon & Argon

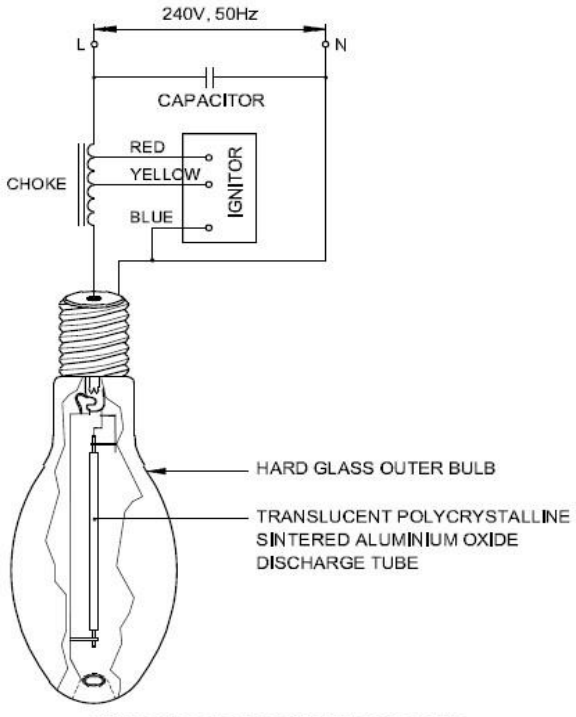
Light is produced in a high -pressure sodium (HPS) lamp by an electric discharge through combined vapors of mercury and sodium

A voltage pulse of about 2.5 kV is required to initiate the discharge in higher pressure Sodium Vapour lamp

This high voltage pulse is generated by high external ignitor or by built in thermal starter

The ignition voltage of sodium lamps varies from

400 to 600V



HIGH PRESSURE SODIUM VAPOUR LAMP

High pressure sodium vapour lamp: Working

So in the initial stage when the potential is applied to the lamp it operates as a low pressure Neon lamp with pink color @ Start (characteristics of the neon gas)
but as the lamp warms up it vaporizes the sodium, and slowly it radiates out yellow light ,and after about ten minutes the lamp starts giving its full output

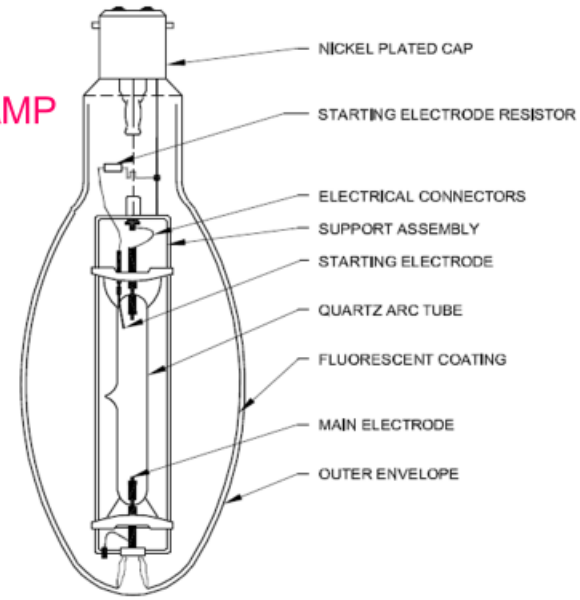
the working temperature is about 300°C

High pressure MERCURY VAPOUR LAMP (H.P.M.V)

The arc discharge is generally confined to a small fused quartz arc tube mounted within a larger borosilicate glass bulb

luminous efficacies of 35 to 65 lumens/watt

#kpsc: 50 lumens/watt



Mercury vapour lamp (M.V) – Mercury ARgon mercury argon

This note is for theoretical topics only. Refer class sessions for numerical and application-level questions
Classroom slides: For reference only

Refer Video Sessions & Short Notes for detailed study

Sl.No.	Sodium vapour lamp	Mercury vapour lamp
1	It is provided with a high leakage reactance transformer.	It is provided a with choke. (Ballast)
2	Higher light efficiency: 160 lm/w.	Lower light efficiency: 50 lm/w.
3	Ignition voltage of Sodium Vapour lamp varies from 400 to 600V.	Ignition voltage of mercury vapour lamp is less.
4	Burning position critical.	Burning position not critical.
5	Yellowish light.	Greenish blue light.
6	It posses only two main electrodes.	It posses two main electrodes and one auxiliary electrode.

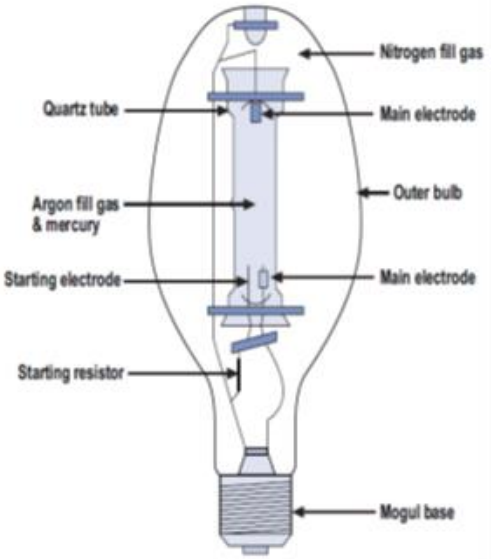
Metal Halide Lamps

This type of lamp is also known as an `MH' lamp

It is an HID lamp (High intensity Discharge), which means it provides most of its light from the electric arc within a small discharge tube

Good quality white light and good efficiency

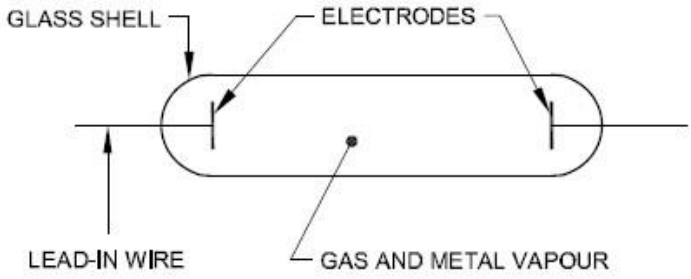
The most prominent use of the MH lamp is in commercial spaces , retail stores, parking lots, stadiums and sports fields



Metal halide lamps have an life of 15,000 - 20,000+hours

Fluorescent lamp

A gas discharge lamp



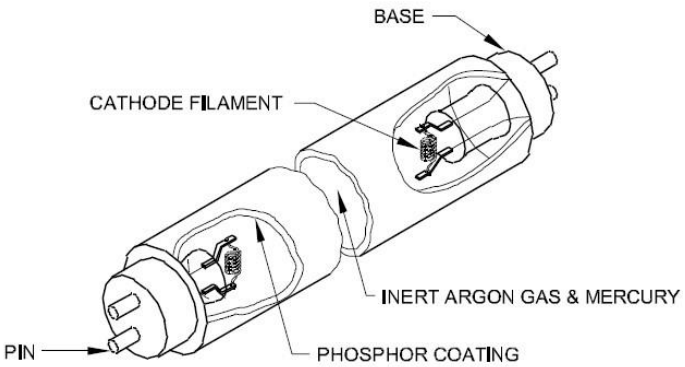
Gases are normally poor conductors, especially at atmospheric and higher pressures, but application of suitable voltage (known as ignition voltage) between two electrodes in a sealed envelope containing gas at low pressure ionizes the gas, and current passes from one electrode to the other through the gas medium

Classroom slides: For reference only

Refer Video Sessions & Short Notes for detailed study

1. The current flow through the low pressure gas is called discharge
2. This causes the gas/vapour to emit radiation in the ultraviolet region

The UV radiation cannot be perceived by the human eye

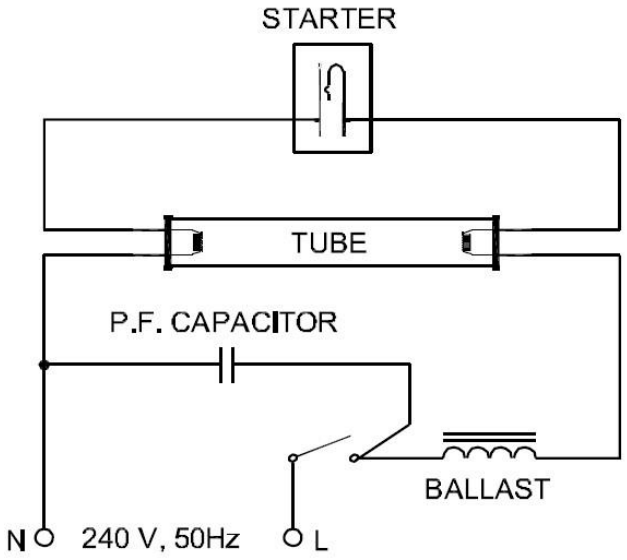


1. The inner surface of the tube is coated with a fluorescent powder or phosphor
   This phosphor emits light when exposed to ultra-violet rays

Ballast (Choke)**:** The ballast is basically a coil of many turns wound on a laminated iron core

It steps up the supply voltage to start the fluorescent tube conducting

Once the tube is conducting, it regulates the flow of heavy current to the tube cathodes to keep them from burning out



CIRCUIT DIAGRAM

Starters: A starter in the fluorescent tube circuit performs two functions

It completes the circuit at first for preheating the electrodes.

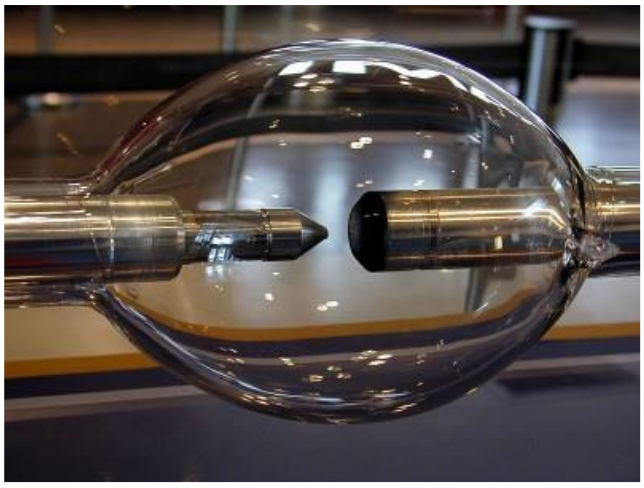
It opens the circuit to provide voltage kick for ignition

There are two types of starters

1. Glow-type
2. Thermal type

Power factor correction capacitor

An arc lamp or arc light is a lamp that produces light by an electric arc



An electric arc, or arc discharge, is an electrical breakdown of a gas that produces a prolonged electrical discharge

Xenon Arc Lamp , which produces a high intensity white light, is now used in many of the applications which formerly used the carbon arc, such as

movie projectors and searchlights

KPSC Question

Q. Carbon arc lamps are commonly used in:
(180/2009 Overseer Grade II Harbour)
(213/2009 Electrician KSFDC)
(62/2013 Overseer Grade II)

a) Domestic lighting
b) Cinema projectors
c) Street lighting
d) Photography

The wagon-wheel effect (alternatively called stroboscopic effect) is an optical illusion in which a spoked wheel appears to rotate differently from its true rotation

The wheel can appear to rotate more slowly than the true rotation, it can appear stationary, or it can appear to rotate in the opposite direction from the true rotation

Q. Under the influence of fluorescent lamps sometimes the wheels of rotating machinery appear to be stationary. This is due to:

(180/2009 Overseer Grade II Harbour)
(62/2013 Overseer Grade II Harbour)

a) Fluctuations
b) Lumisense effect
c) Stroboscopic effect
d) Low power factor

The wagon-wheel effect (alternatively called stroboscopic effect) is an optical illusion in which a spoked wheel appears to rotate differently from its true rotation

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Stroboscopic effect: In an AC cycle, zero value occurs twice per cycle, and theoretically lamps should go out twice per cycle or every hundredth part of a second on a standard 50Hz supply.

Luminous Efficacy Table

Type of Lamp	Typical luminous efficacy (lumens/watt)
Tungsten incandescent light bulb	12.5-17.5 lm/W
Halogen lamp	16-24 lm/W
Fluorescent lamp	45-75 lm/W
LED lamp	30-90 lm/W
Metal halide lamp	75-100 lm/W
High pressure sodium vapour lamp	85-150 lm/W
Low pressure sodium vapour lamp	100-200 lm/W
Mercury vapour lamp	35-65 lm/W

Note: Energy saving lamps have high luminous efficacy (more lumens per watt)

Refer Part-2:

Complete KPSC Questions with answers on Illumination !!