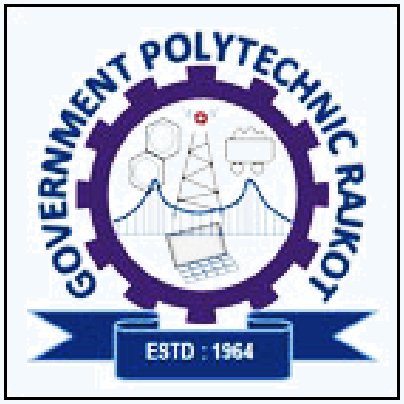
# Utilization of Electrical Energy 3340903

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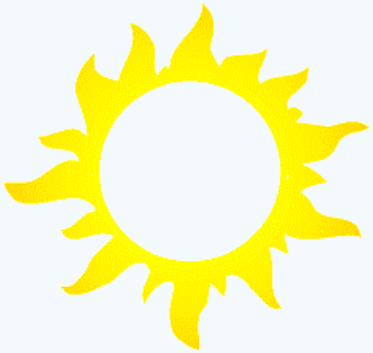
Government Polytechnic, Rajkot

# Unit – 1

# Illumination

# Light

- All activities of human beings ultimately depends upon light.



- Natural Light
  - Sun
  - Moon
- Artificial Light

**Limitations**

1. **Space**
2. **Time**

# Light

- Artificial Light
  - Easy control
  - Reliable
  - Constant Output
  - Remote control
  - Atomization
  - Clean
  - Pollution free
  - Cheap
  - User friendly
    - Protecting health, eyes, nervous system
    - Low accident risk at work space


# Nature of Light

- Light is a form of radiant energy
- heat is radiated from hot body

- Red-hot
  - Large wave-length
  - Energy in form of heat
- White-hot
  - Small wave-length
  - Range of light wave-length
  - Low energy

Speed of Light= $3 \times 10^8\ m/s$

Wavelength of Light
0.4 to 0.75 micron

1 micron(μm)= $10^{-6}\ m$

1 Angstrom( Å)= $10^{-10}\ m$

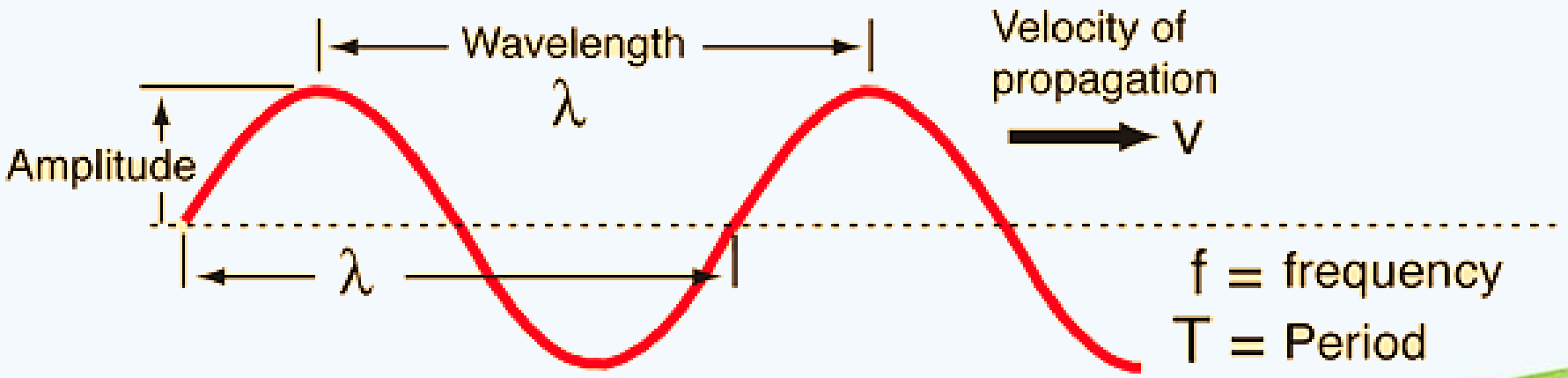
# Relation : Frequency & Wavelength

$$v = f\lambda$$

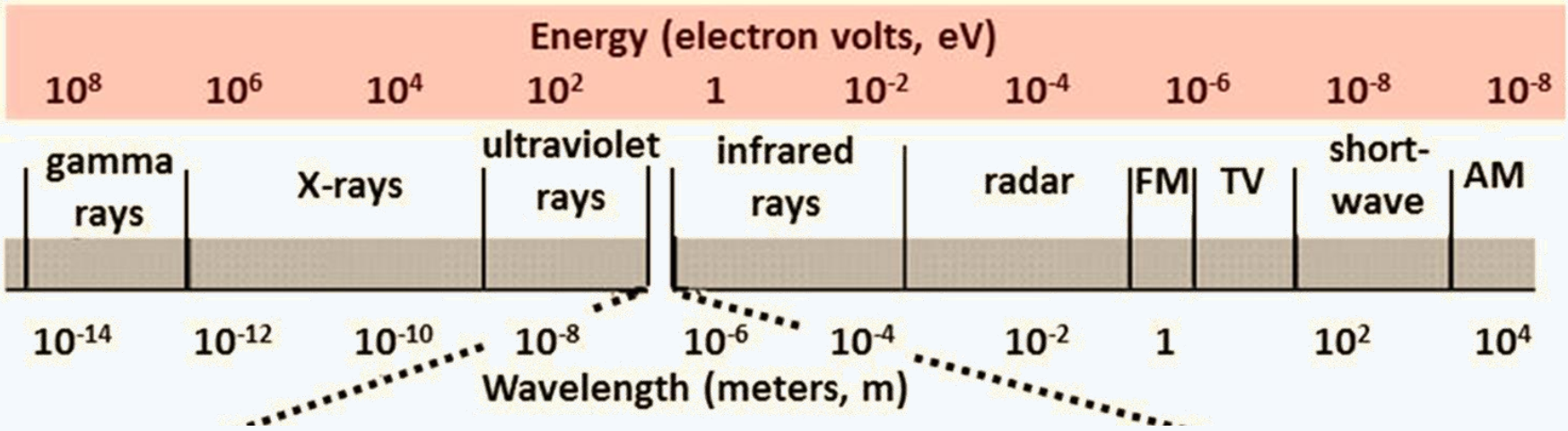
$f = Frequency, \mathbf{Hz}$

$\lambda = Wavelength, m$

$v = \mathbf{Velocity, m/Sec}$



# Electromagnetic waves spectrum

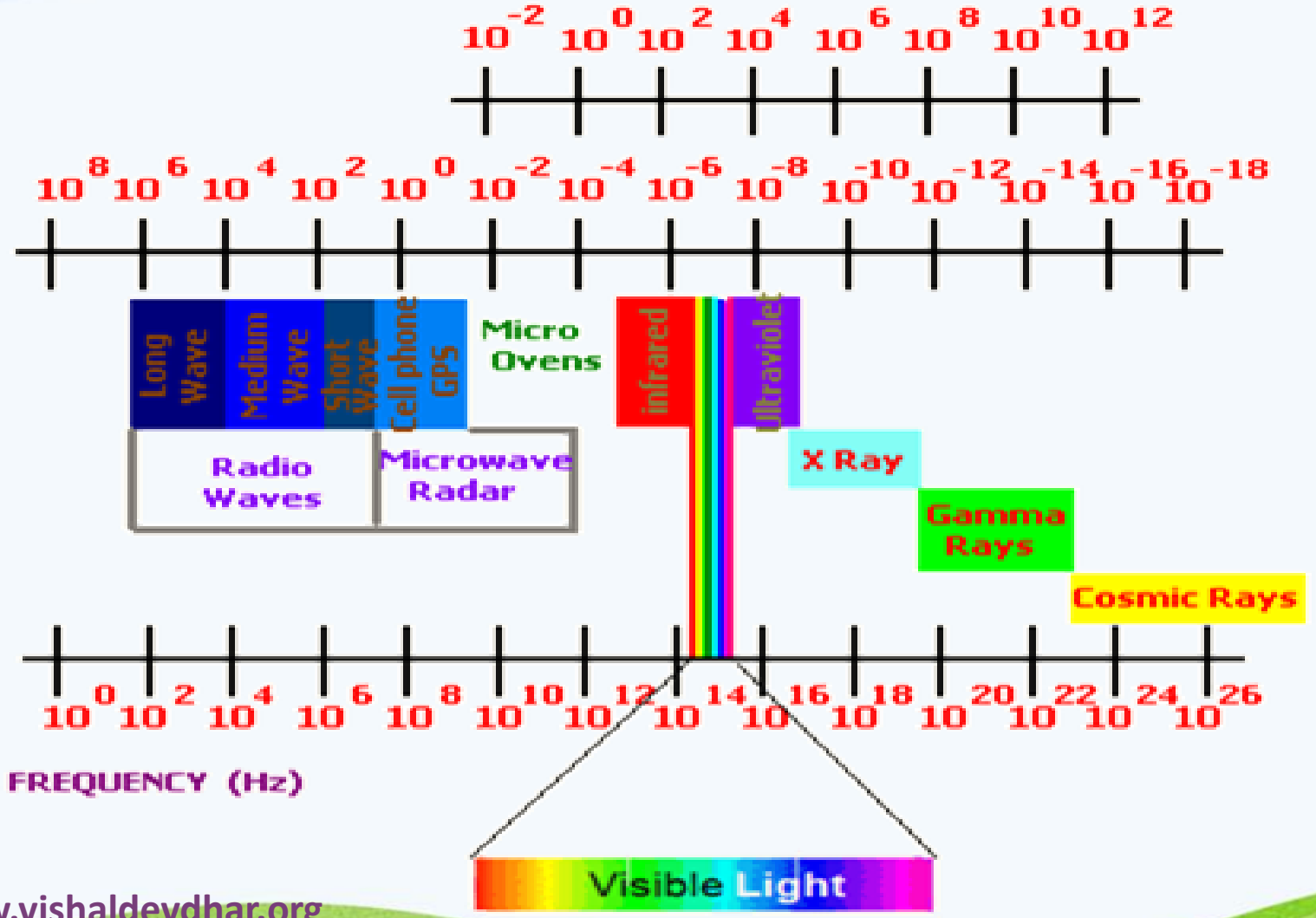



## Visible Spectrum – Wavelengths in nanometers


Violet 400-450nm
Blue 450-500nm
Green 500-570nm

Red 610-700
Orange 590-610
Yellow 570-590

# Electromagnetic waves spectrum



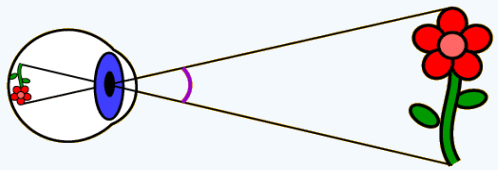
# Terms related to Illumination

- **Light : Q(Lumen-hour)**

  Radiated energy range that will give visual sensation

- **Luminous Flux : F (Lumen)**

  Rate of flow of light from luminous source



# Terms related to Illumination

❖Luminous Intensity : I (Candela)

A point light source when gives luminous flux per unit solid angle in one direction is known as luminous intensity.

$$I = \frac{F}{w} = \frac{Luminous\ Flux}{Steradian}$$

❖Illumination : E (Lumen/$m^2$ or Lux)

Available quantity of luminous flux on unit surface area.

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

# Terms related to Illumination

- **Brightness : L (Nit or Stib)**

  Luminous intensity per unit projected area of the surface in given direction.

- **Lumen :**

  Amount luminous flux given out in a space represented by one unit of solid angle by a source having intensity of one candle power in all direction. $Lumens = Candle\ Power \times Solid\ Angle$

# Terms related to Illumination

❖ **Candle Power : (c.p)**

Light radiating capacity of a source in given direction.

**OR**

Number of lumens given out by the source in a unit solid angle in a given direction.

$$\text{Candle Power} = \frac{\text{Lumens}}{\text{Solid Angle}}$$

# Terms related to Illumination

❖**Lux or Meter Candle :**

Luminous flux falling per $m^2$ on the surface which is everywhere perpendicular to the rays of light from a source of 1cp and 1m away from it.

OR

Luminous flux falling on a surface of a sphere of 1m radius where a light source of 1cp is kept in the centre of sphere.

# Terms related to Illumination

❖ **Foot Candle :**

Luminous flux falling on a surface of a sphere of 1feet radius where a light source of 1cp is kept in the centre of sphere.

$$1\ Foot\ Candle = \frac{Lumen}{Foot^2} = \frac{Lumen}{0.305^2} = \frac{10.75\ Lumen}{m^2}$$

$$1\ meter\ Candle = \frac{Lumen}{m^2}$$

$$1\ meter = 3.28\ feet$$

$$1\ feet = 0.305\ meter$$

# Terms related to Illumination

- **Mean Horizontal Candle Power (MHCP)**

  The mean of candle power in all direction in the horizontal plane containing the source of light.

- **Mean Spherical Candle Power (MSCP)**

  The mean of candle power in all direction and in all planes from the source of light.

# Terms related to Illumination

- **Mean Hemispherical Candle Power (MHSCP)**

  The mean of candle power in all direction above/below the horizontal plane from the source of light.

- **Reduction Factor**

  The ratio of MSCP to MHCP is known as reduction factor.

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

# Terms related to Illumination

- **Nit**

  One candle per square meter.

- **Stib**

  One candle per square centimeter.

- **Glare**

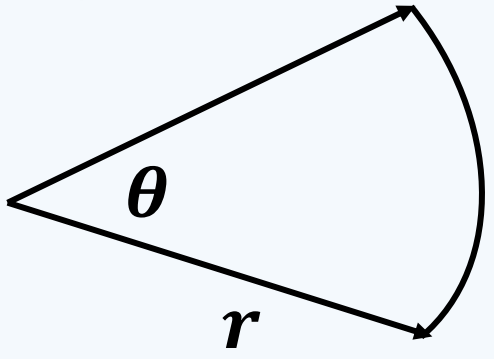
  Brightness within the field of vision cause any kind of discomfort to eye fatigue.

# Terms related to Illumination

- **Plane Angle : θ (Radians)**

  It is particular point by two straight line in one plane.

  Maximum value of θ is 2π radians.

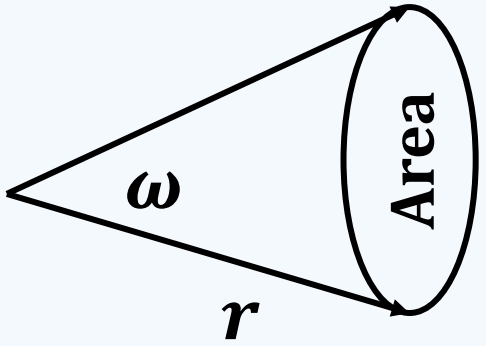



$$Plane\ Angle(\theta) = \frac{Arc}{Radius} = \frac{A}{r}\ radians$$

# Terms related to Illumination

❖Solid Angle : ω (steradians)

It is angle generated by the surface passing through the point in space and the periphery of the area.




$$Solid\ Angle(\omega) = \frac{Area}{Radius^2} = \frac{A}{r^2}\ steradians$$

# Terms related to Illumination

## ❖Relation between Plane Angle & Solid Angle

$$\text{Solid Angle}(\omega) = \frac{Area}{Radius^2}$$

$$= \frac{2\pi r H}{r^2}$$

$$= \frac{2\pi r H}{r^2}$$

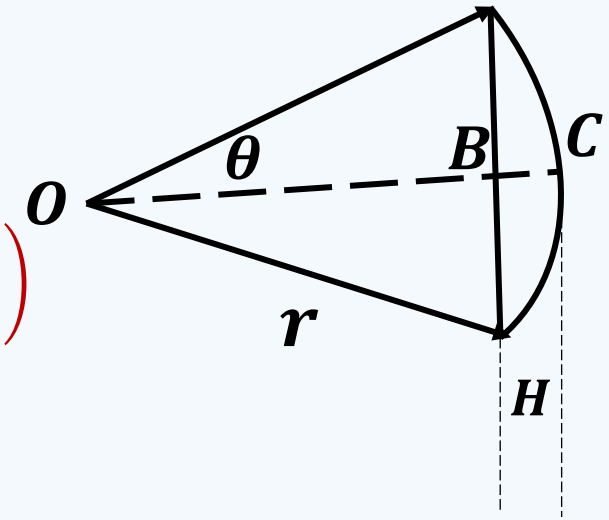
$$= \frac{2\pi r^2}{r^2}\left(1 - \cos\frac{\theta}{2}\right)$$

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

$$H = OC - OB$$

$$= r - r\cos\frac{\theta}{2}$$

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



# Terms related to Illumination

❖ **Lamp Efficiency**

The ratio of output luminous flux by lamp to electrical energy required to produce it.

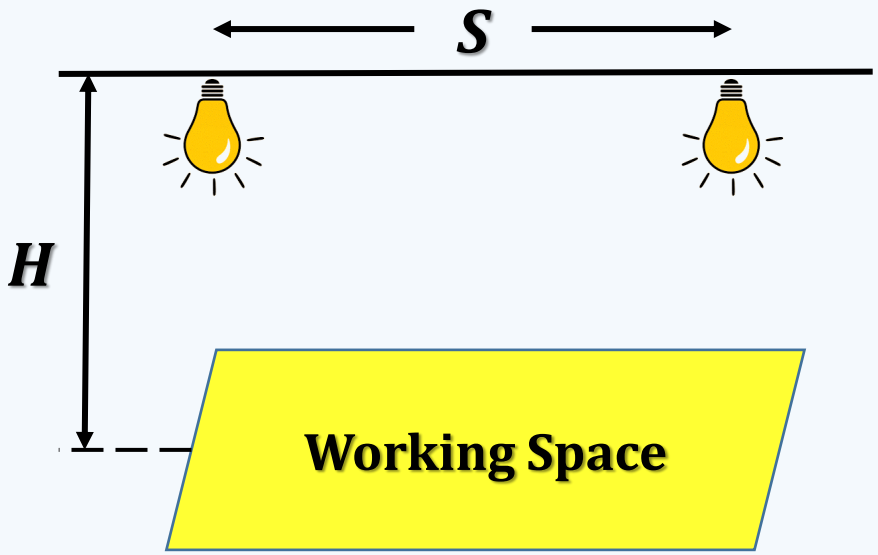
$$\text{Lamp Efficiency} = \frac{\text{Lumens output by lamp}}{\text{Watt input to lamp}}$$

# Terms related to Illumination

- **Space Height Ratio : SHR (Between 1.0 to 2.0)**

  Horizontal distance between two lamps to the mounting height of the lamp.

$$SHR = \frac{S}{H}$$



# Terms related to Illumination

- **Utilization Factor**

$$UF = \frac{\text{Total lumens received by working plane}}{\text{Total lumens emitted by lamp}}$$

Direct Lighting – 0.25 to 0.5

Indirect Lighting – 0.1 to 0.3

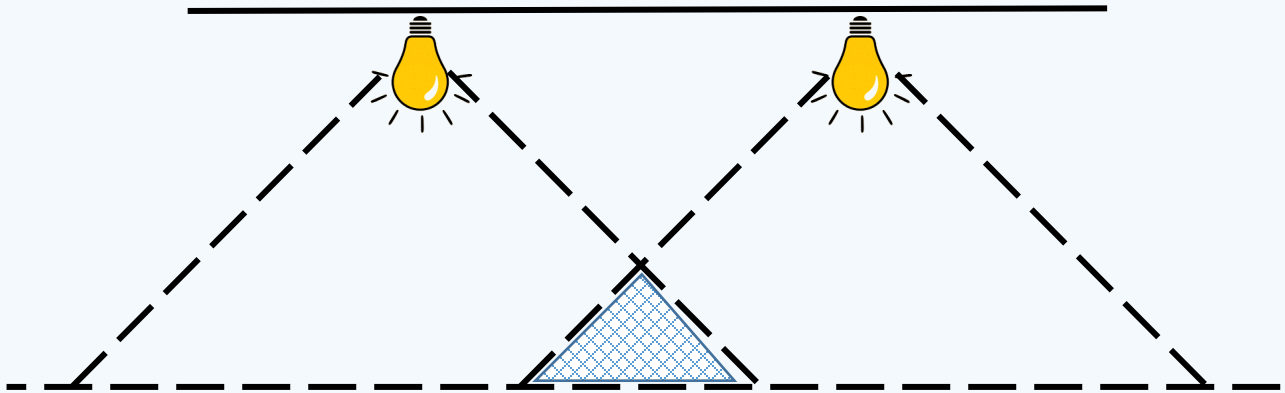
- **Depreciation Factor**

$$DF = \frac{\text{Lumens received from lamp in normal condition}}{\text{Lumens received when surface of lamp is clean}}$$

DF = 0.4 to 0.8

# Terms related to Illumination

- Waste Light Factor



*Overlapping*

# Terms related to Illumination

- **Absorption Factor**

$$AF = \frac{\text{Lumens available after absorption on surface}}{\text{Lumens output by lamp}}$$

AF = 0.5 to 1

- **Reflection Factor**

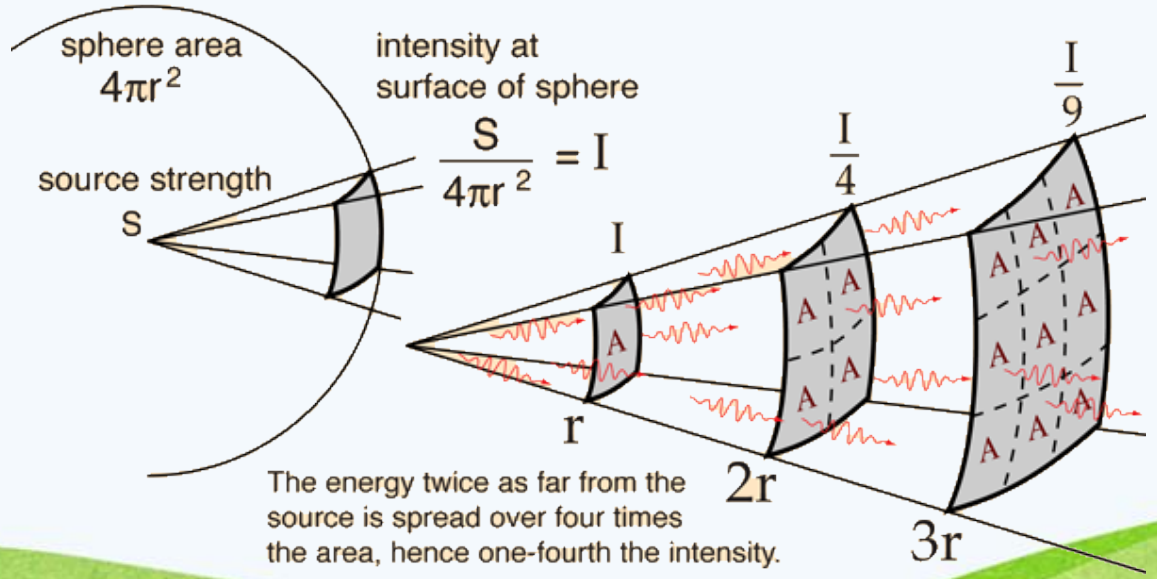
$$RF = \frac{\text{Lumens Reflected}}{\text{Lumens Incident}}$$

# Laws of Illumination

## ❖Law of Inverse Squares

Illumination received on any surface is inversely proportional to the square of the distance between surface and a light source.

$$Illumination = \frac{cp}{d^2}$$



# Laws of Illumination

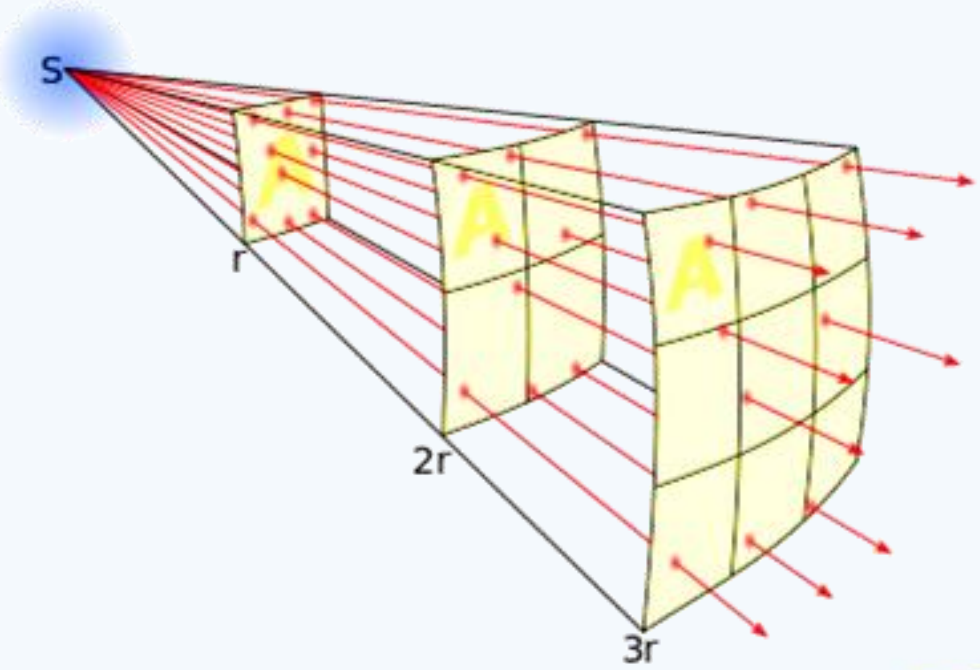
## ❖Law of Inverse Squares

$I =$ *Intensity of illumination in lumen*

$Luminous\ Flux = I\omega$

$$A_1 = d_1^2\omega$$

$$Illumination, E_1 = \frac{I\omega}{A_1} = \frac{I\omega}{d_1^2\omega} = \frac{I}{d_1^2}$$



# Laws of Illumination

## ❖Lambert's Cosine Law

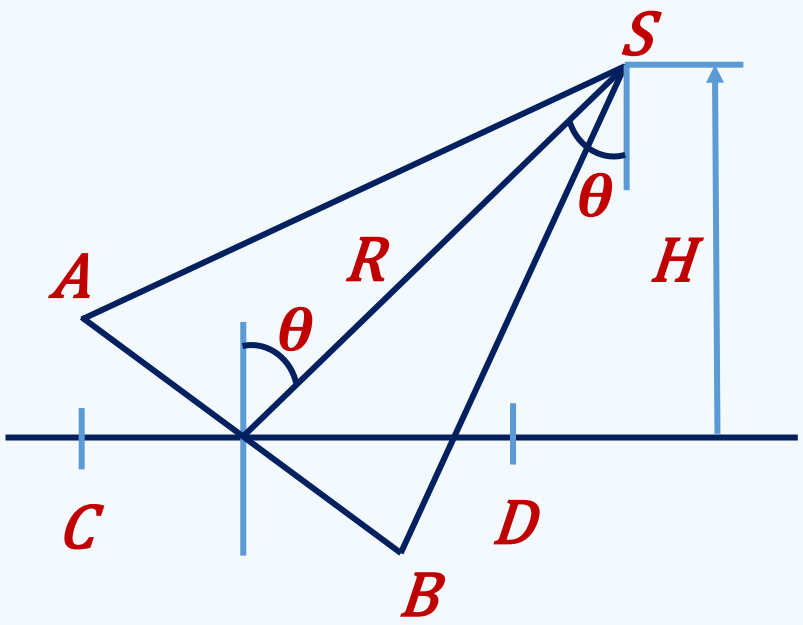
Illumination at any point on a surface is proportional to the cosine of angle between the normal at any point and the direction of luminous flux.

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

# Laws of Illumination

## ❖Lambert's Cosine Law

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



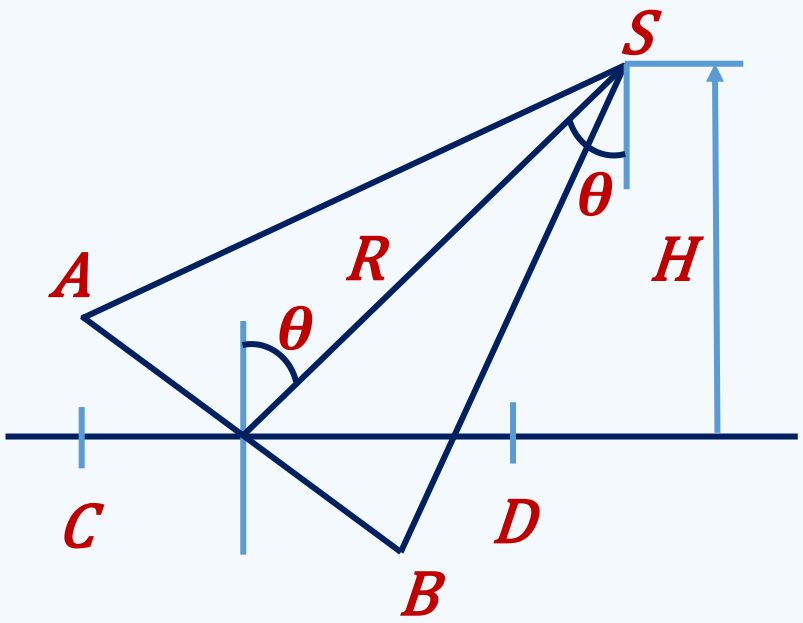

$$Illumination\ Surface\ AB = \frac{luminous\ flux}{Area\ of\ AB} = \frac{cp}{R^2}$$

$$Illumination\ Surface\ CD = \frac{luminous\ flux}{Area\ of\ AB} \times \cos\theta$$

$$= \frac{cp}{R^2} \times \cos\theta$$

# Laws of Illumination

## ❖Lambert's Cosine Law




$$\cos\theta = \frac{H}{R} \Rightarrow R = \frac{H}{\cos\theta}$$

$$Illumination\ Surface\ CD$$

$$= \frac{cp}{R^2} \times \cos\theta$$

$$= \frac{cp}{\frac{H^2}{\cos^2\theta}} \times \cos\theta$$

$$= \frac{cp}{H^2} \times \cos^3\theta$$

# Sources of Light

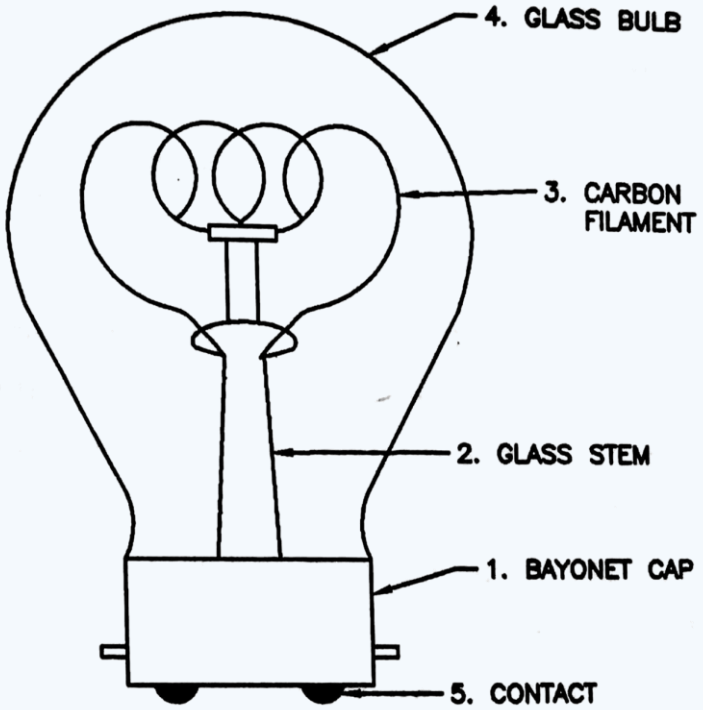
- Incandescent Lamp
- Discharge / Luminescent Lamp
- Metal Halide Lamp
- LED Lamp

# Incandescent Lamp

- Carbon Filament Lamp
- Metal Filament Lamp
- Halogen Lamp

# Incandescent Lamp

## ❖ Carbon Filament Lamp




(Fig. 1.10 Carban filament lamp)

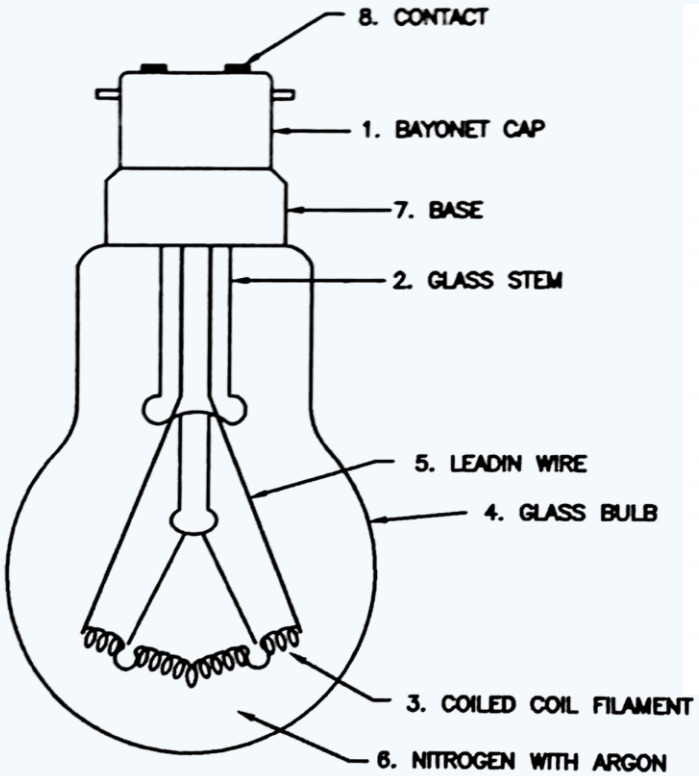
# Incandescent Lamp

## ❖ Carbon Filament Lamp

| Sr. No | Description | Value |
|---|---|---|
| 1 | Working Temperature | 1600 to 1800°C |
| 2 | Efficiency | 2 to 3.5 Lumen/Watt |
| 3 | Life | 800 Hour |

# Incandescent Lamp

- Metal Filament Lamp




(Fig. 1.11 Metal filament lamp)

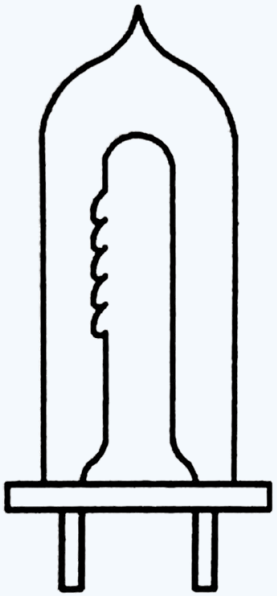
# Incandescent Lamp

- Metal Filament Lamp

| Sr. No | Description | Value |
|---|---|---|
| 1 | Working Temperature | 2000°C |
| 2 | Efficiency | 10 to 20 Lumen/Watt |
| 3 | Life | 800 Hour |

# Incandescent Lamp

- Halogen Lamp



(a)

(b)

(Fig. 1.12 Halogen lamps)

# Incandescent Lamp

## ❖ Halogen Lamp

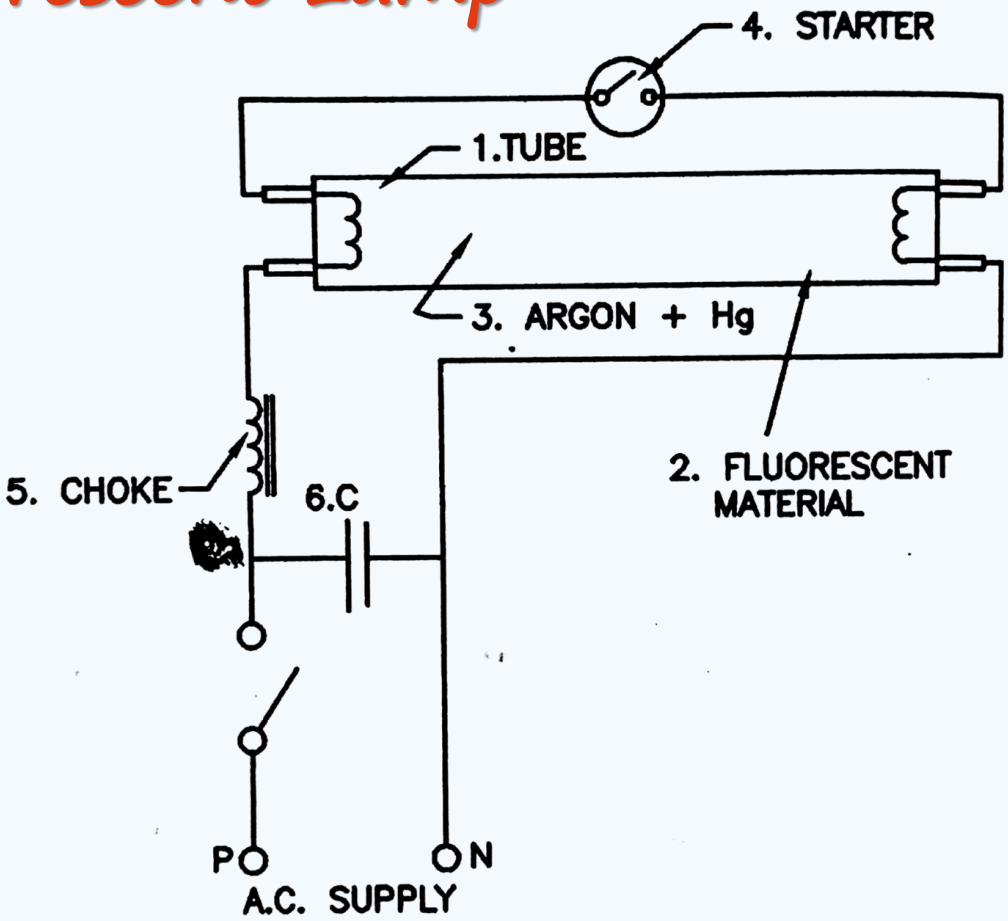
| Sr. No | Description | Value |
|---|---|---|
| 1 | Working Temperature | 540°C |
| 2 | Efficiency | 25 to 35 Lumen/Watt |
| 3 | Life | 2000 Hour |

# Discharge / Luminescent Lamp

- Fluorescent Lamp
- High Pressure Mercury Vapor Lamp
- Sodium Vapor Lamp
- Compact Fluorescent Lamp
- Neon Lamp

# Discharge / Luminescent Lamp

- Fluorescent Lamp

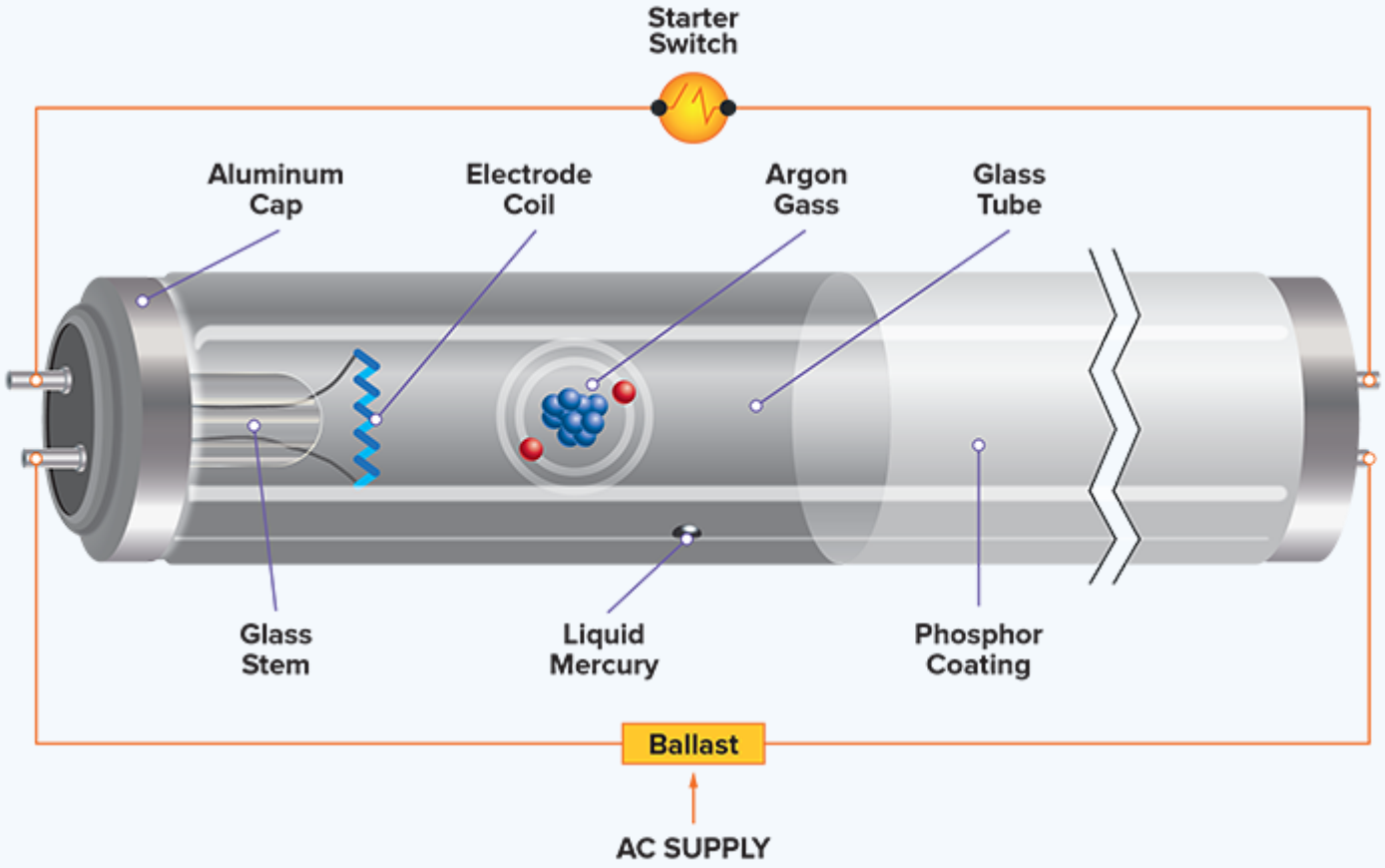





(Fig. 1.13 Fluorescent tube light circuit)

# Discharge / Luminescent Lamp

## ❖ Fluorescent Lamp



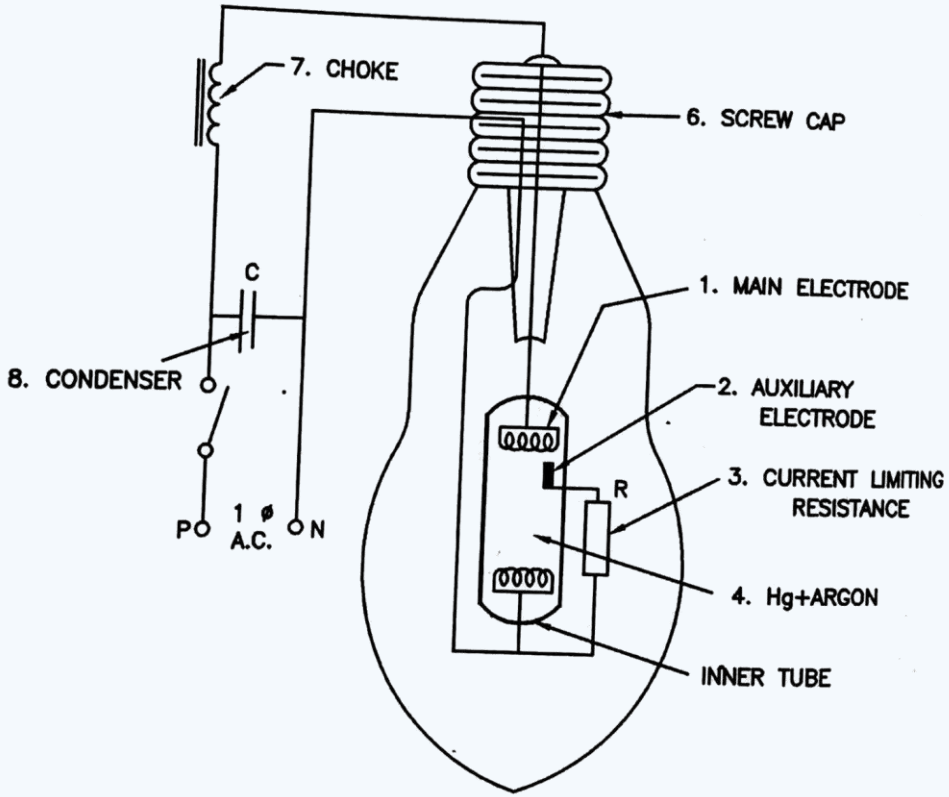
# Discharge / Luminescent Lamp

## ❖ Fluorescent Lamp

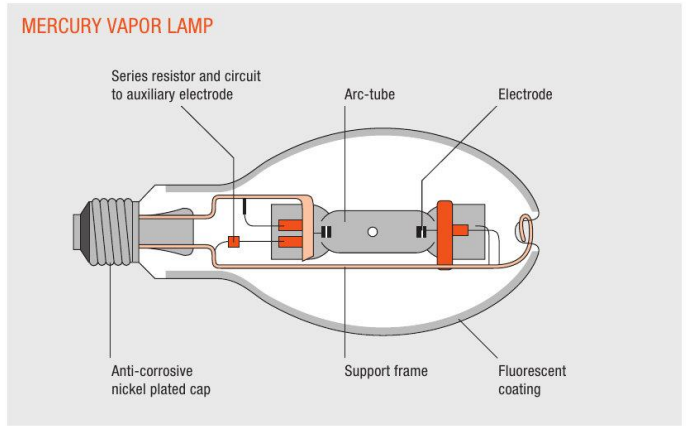
| Sr. No | Description | Value |
|---|---|---|
| 1 | Working Temperature | 40°C |
| 2 | Efficiency | 40 Lumen/Watt |
| 3 | Life | 4000 Hour |

# Discharge / Luminescent Lamp

## ❖ High Pressure Mercury Vapor Lamp




(Fig. 1.14 High pressure mercury vapour lamp)

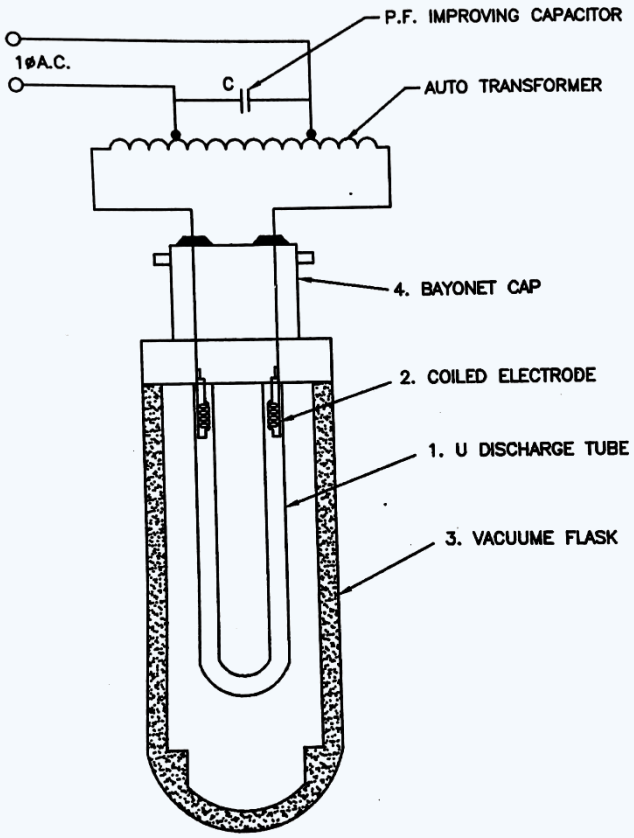
# Discharge / Luminescent Lamp

## ❖ High Pressure Mercury Vapor Lamp

| Sr. No | Description | Value |
|---|---|---|
| 1 | Working Temperature | 150°C |
| 2 | Efficiency | 30 to 60 Lumen/Watt |
| 3 | Life | 24000 Hour |

# Discharge / Luminescent Lamp

## ❖ Sodium Vapor Lamp




(Fig. 1.15 Sodium vapour lamp)

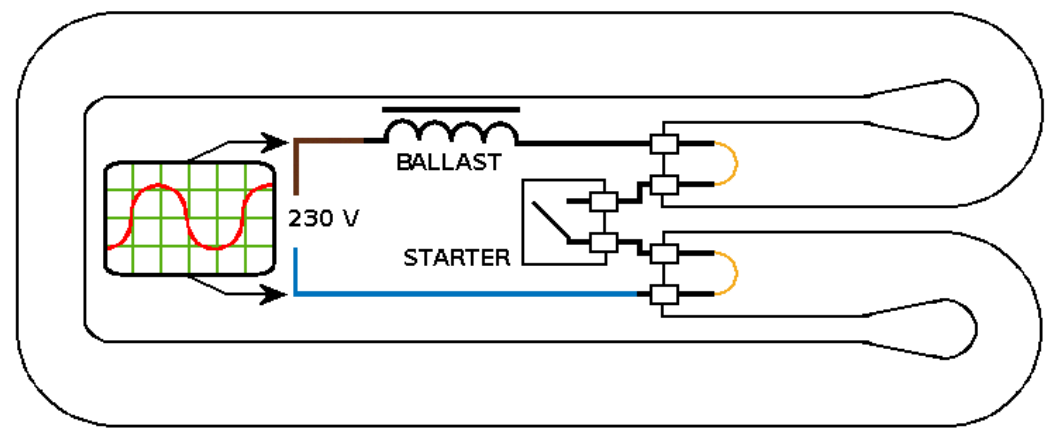
# Discharge / Luminescent Lamp

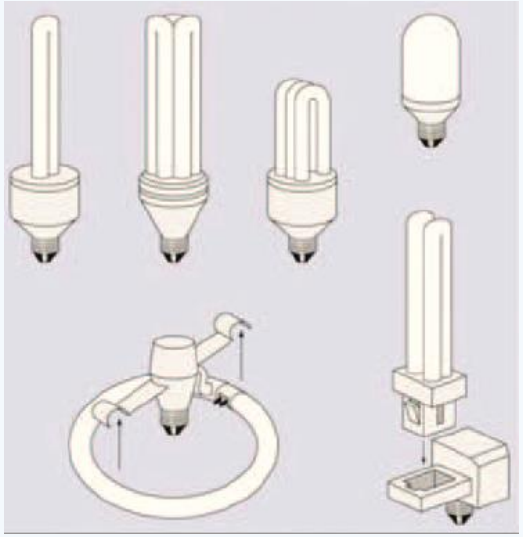
## ❖ Sodium Vapor Lamp

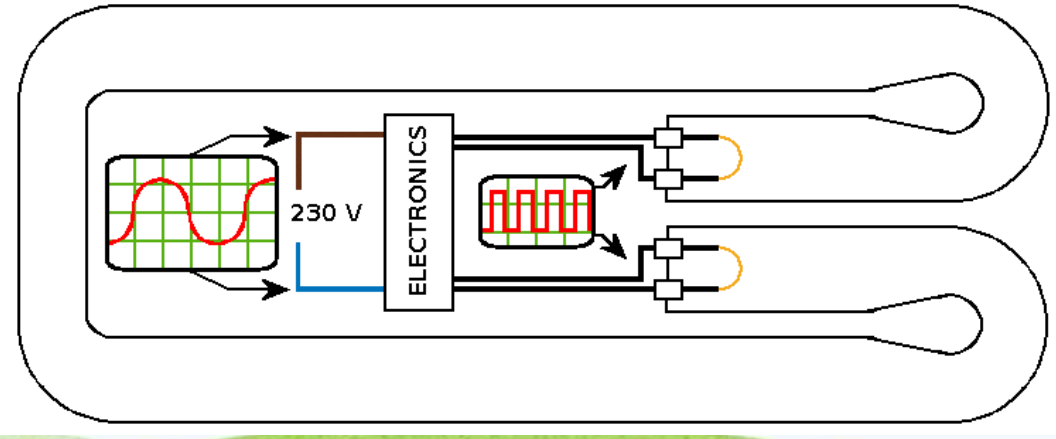
| Sr. No | Description | Value |
|---|---|---|
| 1 | Working Temperature | 700°C |
| 2 | Efficiency | 100 to 200 Lumen/Watt |
| 3 | Life | 18000 Hour |

# Discharge / Luminescent Lamp

## ❖ Compact Fluorescent Lamp





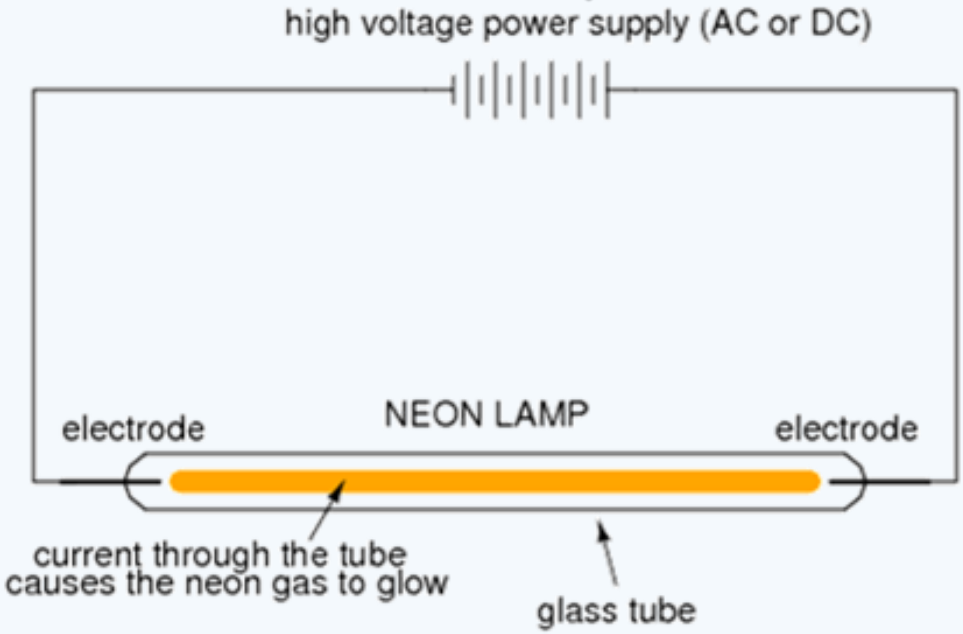

# Discharge / Luminescent Lamp

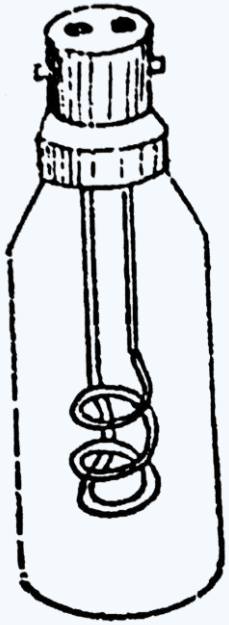
## ❖ Compact Fluorescent Lamp

| Sr. No | Description | Value |
|---|---|---|
| 1 | Working Temperature | 40°C |
| 2 | Efficiency | 50 Lumen/Watt |
| 3 | Life | 6000 to 15000 Hour |

# Discharge / Luminescent Lamp

## ❖ Neon Lamp

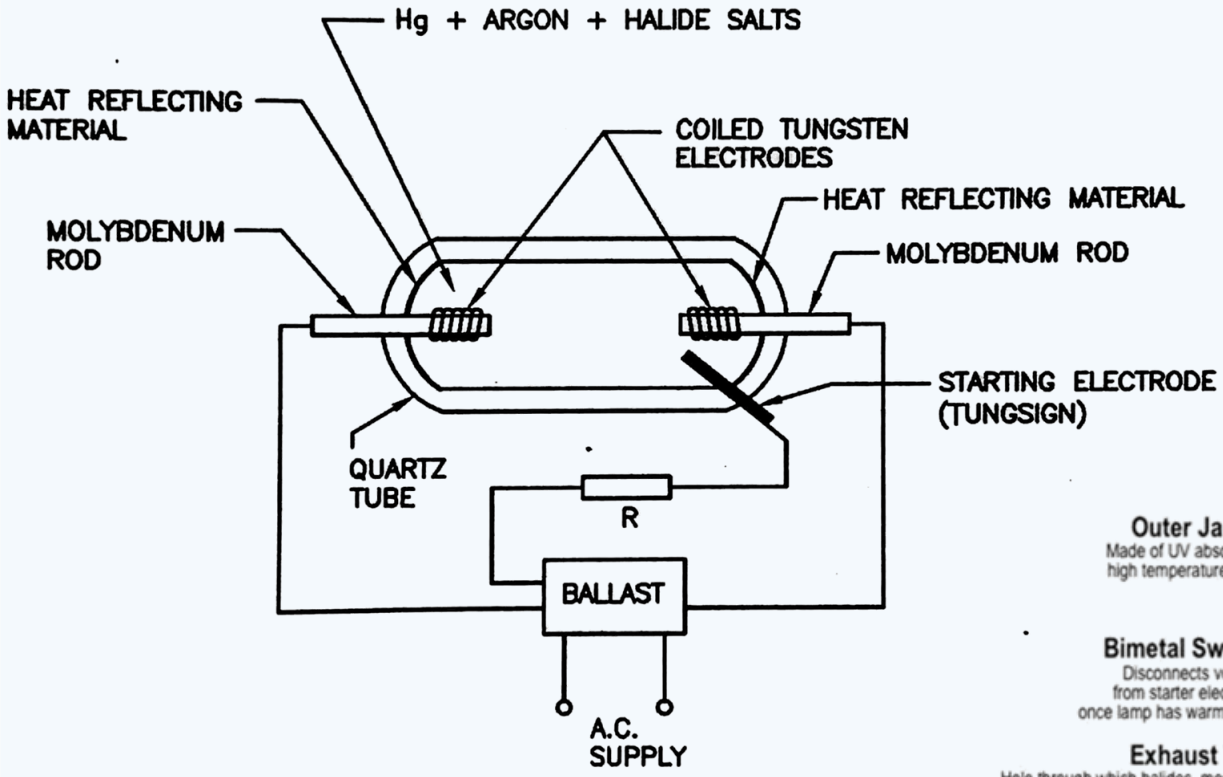


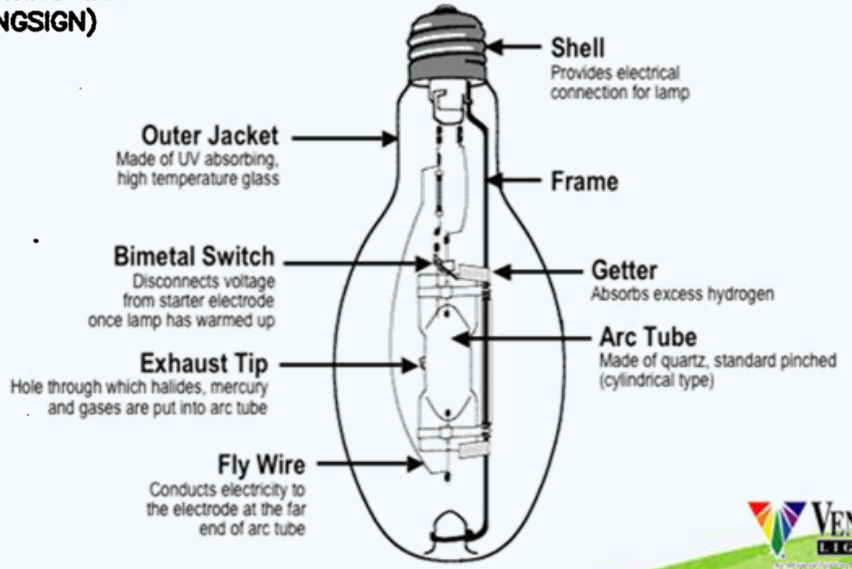
(Fig. 1.17 Neon lamp)


Neon lamp schematic symbol

# Metal Halide Lamp



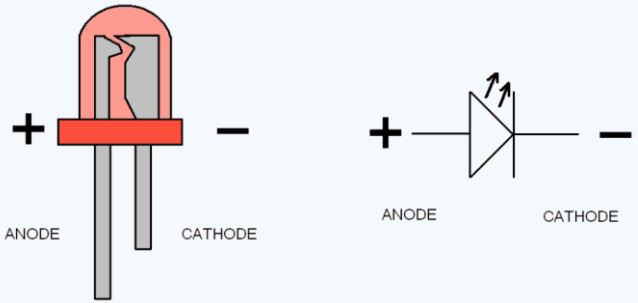

(Fig. 1.18 Discharge tube of metal halide lamp)



# Metal Halide Lamp

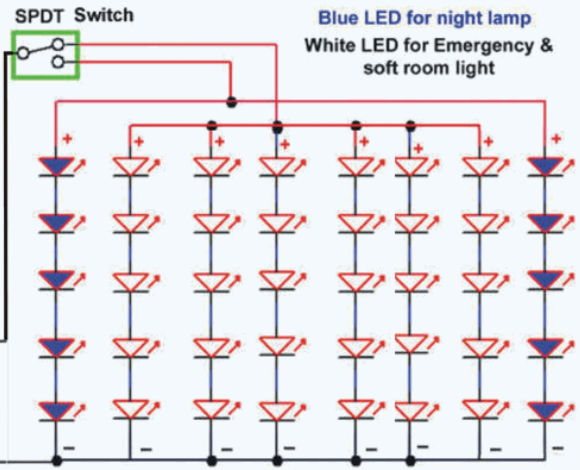
| Sr. No | Description | Value |
|---|---|---|
| 1 | Working Temperature | 1000 to 3000°C |
| 2 | Efficiency | 115 Lumen/Watt |
| 3 | Life | 10000 to 20000 Hour |

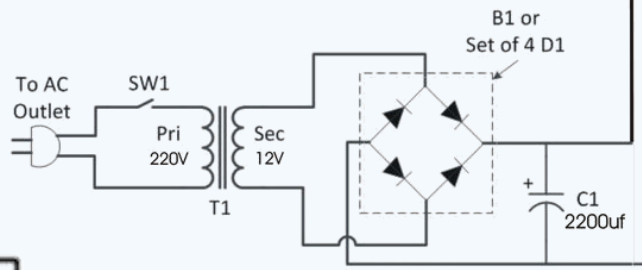
# Light Emitting Diode (LED) Lamp













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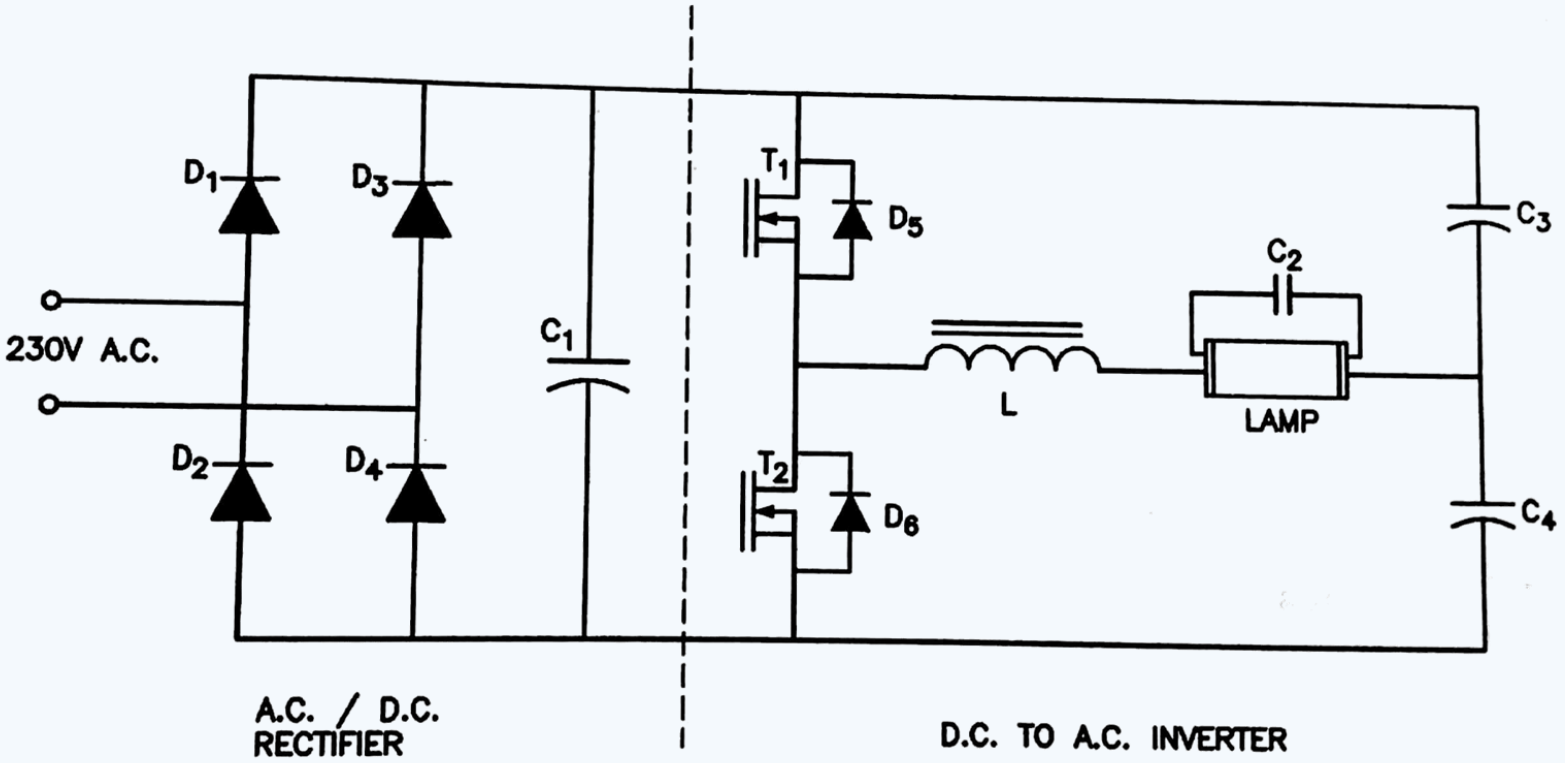
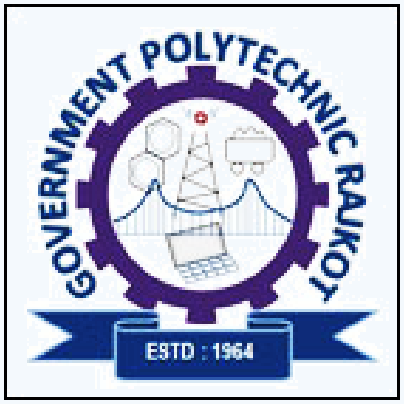
# Electronic Ballast




(Fig. 1.19 Electronic ballast circuit)

# Thank You

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