Distribution & Utilization of Electrical Power (4340902)

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Unit – 4
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)= $10^{-10}\ m$

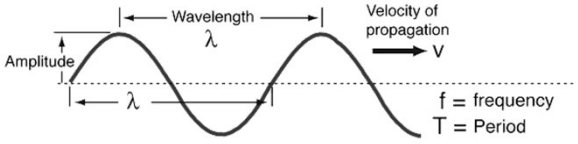
Relation : Frequency & Wavelength

$$v = f\lambda$$

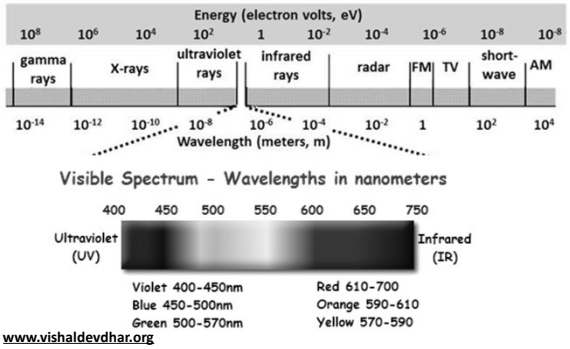
$f = Frequency$, Hz

$\lambda = Wavelength, m$

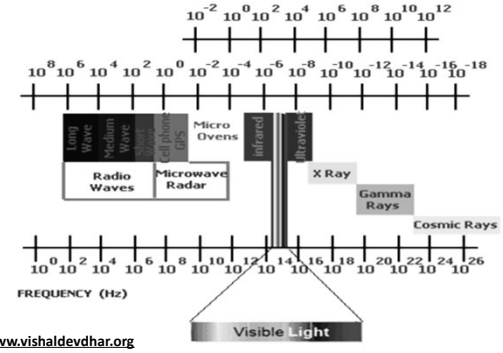
v =Velocity, m/Sec



Electromagnetic waves spectrum



Electromagnetic waves spectrum



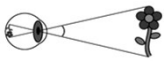
Terms related to Illumination

❖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/m² 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.

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

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.

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

Terms related to Illumination

❖Nit

One candle per square meter.

❖Stib

One candle per square centimeter.

❖Glare

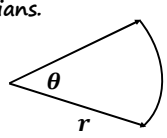
Brightness within the field of vision cause any kind of discomfort to eye fatigue.

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.

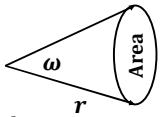


$$Plane\ Angle(\theta) = \frac{Arc}{Radius} = \frac{A}{r}\ radians$$

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

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

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

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

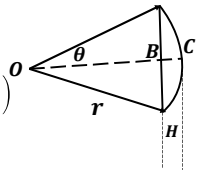
$$= \frac{2\pi r^2}{r^2}\left(1 - cos\frac{\theta}{2}\right)$$

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

$$H = OC - OB$$

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

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



Terms related to Illumination

❖Lamp Efficiency

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

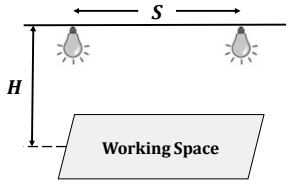
$$Lamp\ Efficiency = \frac{Lumens\ output\ by\ lamp}{Watt\ input\ to\ lamp}$$

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

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

Direct Lighting – 0.25 to 0.5

Indirect Lighting – 0.1 to 0.3

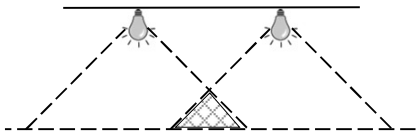
❖Depreciation Factor

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

DF = 0.4 to 0.8

Terms related to Illumination

❖Waste Light Factor



Overlapping

Terms related to Illumination

❖Absorption Factor

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

AF = 0.5 to 1

❖Reflection Factor

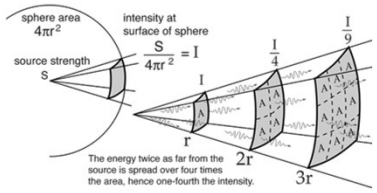
$$RF = \frac{Lumens\ Reflected}{Lumens\ Incident}$$

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

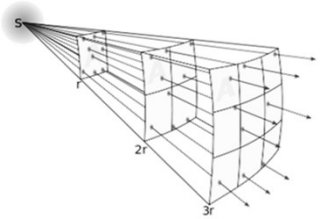
❖Law of Inverse Squares

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

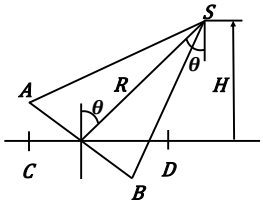
❖Lambert's Cosine Law

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



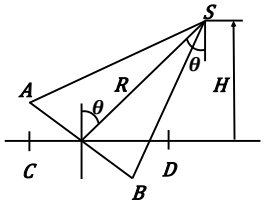
$$Illumination\ Surface\ AB = \frac{luminous\ flux}{Area\ of\ AB} = \frac{cp}{R^2}$$

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

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

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

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Incandescent Lamp

- ❖ Carbon Filament Lamp
- ❖ Metal Filament Lamp
- ❖ Halogen Lamp

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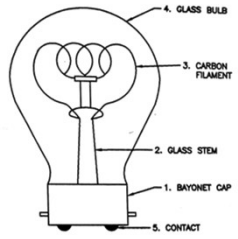
Incandescent Lamp

- ❖ Carbon Filament Lamp



(Fig. 1.10 Carban filament lamp)

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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

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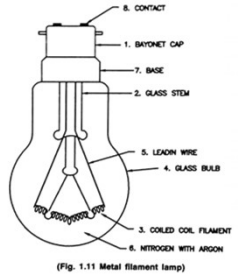
Incandescent Lamp

- ❖ Metal Filament Lamp



(Fig. 1.11 Metal filament lamp)

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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

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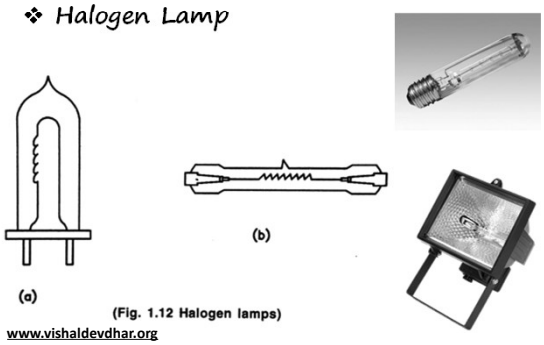
Incandescent Lamp

- Halogen Lamp



(Fig. 1.12 Halogen lamps)

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Incandescent Lamp

- Halogen Lamp

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

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Discharge / Luminescent Lamp

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

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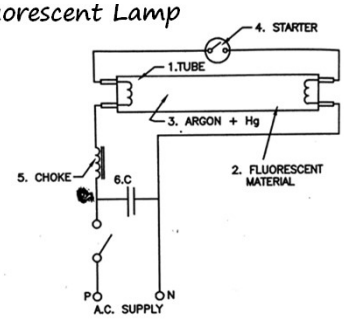
Discharge / Luminescent Lamp

- Fluorescent Lamp



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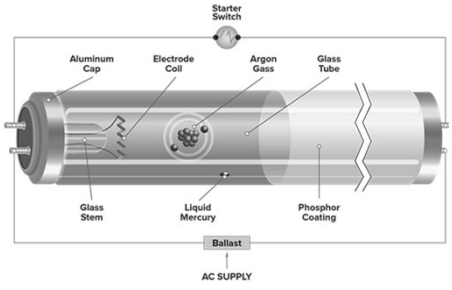
(Fig. 1.13 Fluorescent tube light circuit)

Discharge / Luminescent Lamp

- Fluorescent Lamp



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Discharge / Luminescent Lamp

- Fluorescent Lamp

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

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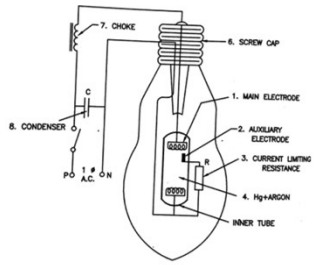
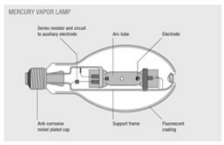
Discharge / Luminescent Lamp

❖ High Pressure Mercury Vapor Lamp





(Fig. 1.14 High pressure mercury vapour lamp)

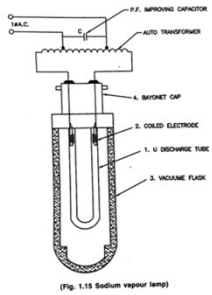
Discharge / Luminescent Lamp

❖ 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)

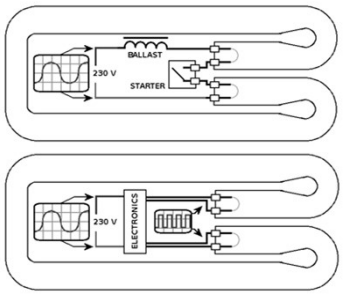
Discharge / Luminescent Lamp

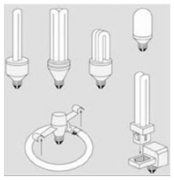
❖ Sodium Vapor Lamp

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





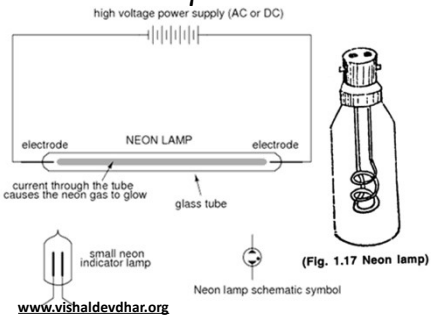
Discharge / Luminescent Lamp

❖ 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)

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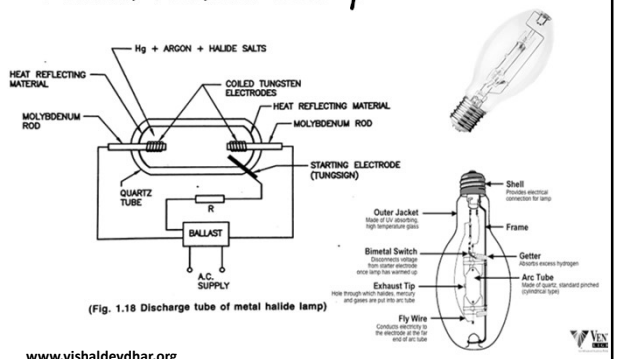
Metal Halide Lamp



(Fig. 1.18 Discharge tube of metal halide lamp)

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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

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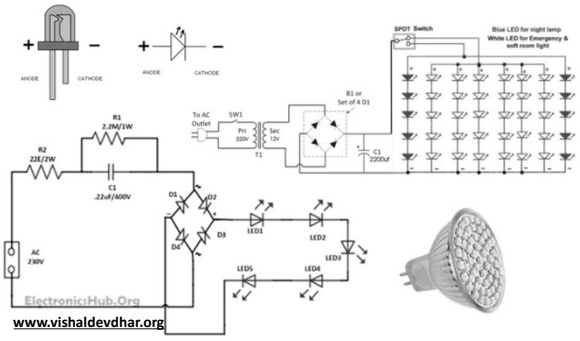
Light Emitting Diode (LED) Lamp



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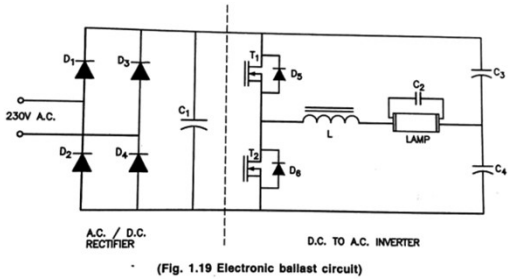
Electronic Ballast



(Fig. 1.19 Electronic ballast circuit)

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Thank You

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