01

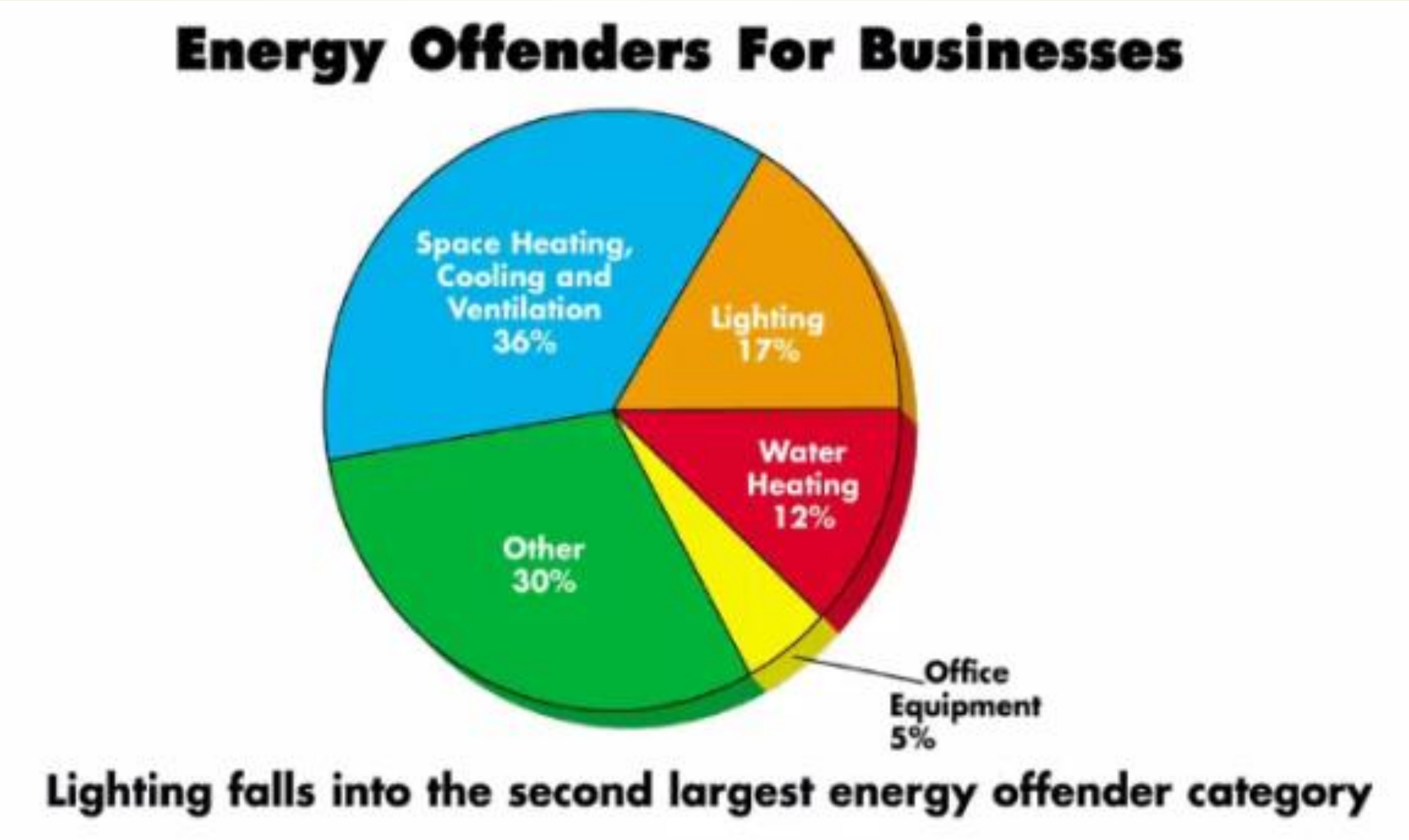
Illumination Engineering: EE366

MODULE 1

SYLLABUS:
MODULE 1

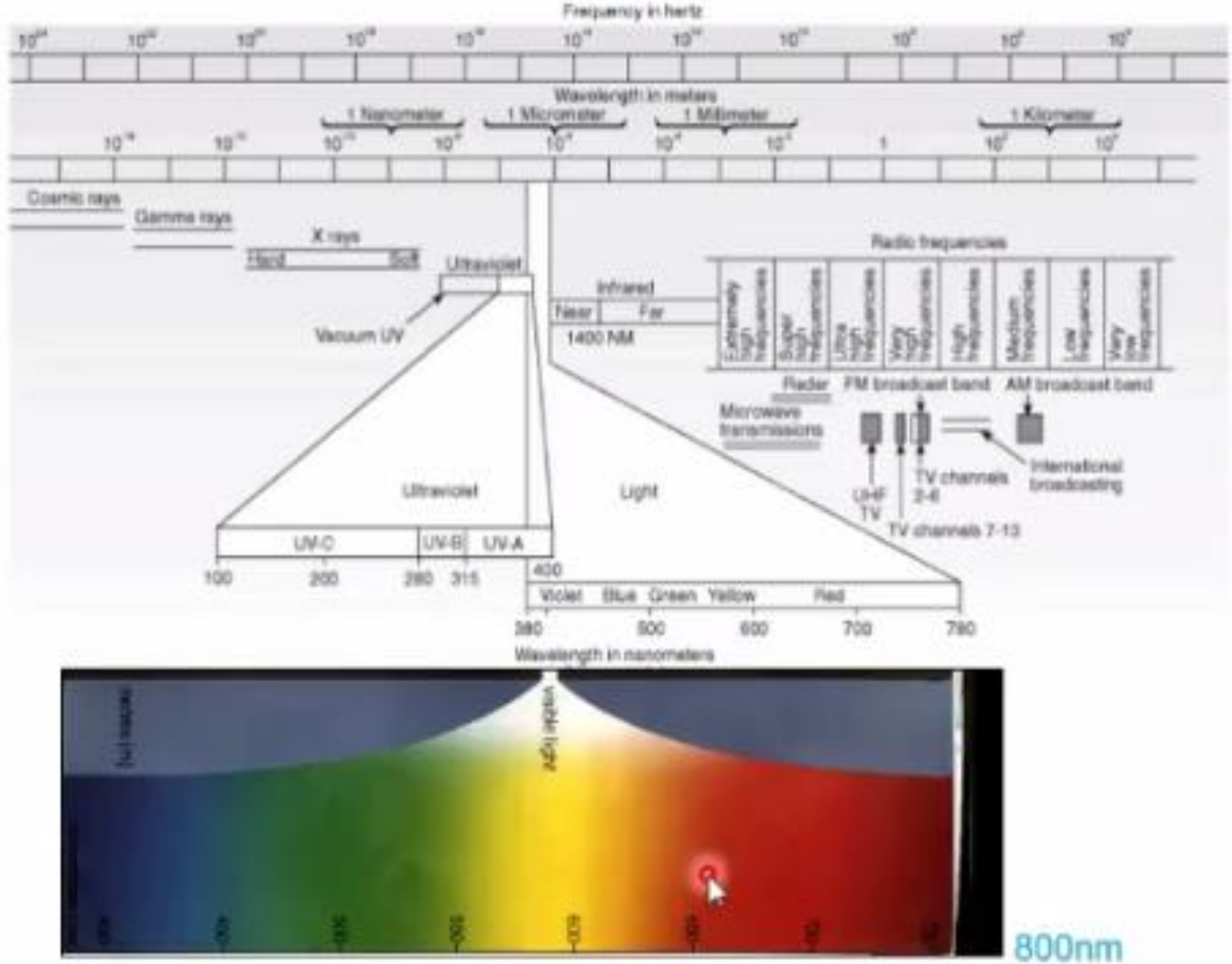
Introduction of Light : Types of illumination, Day lighting, Supplementary artificial lighting and total lighting, Quality of good lighting, Factors affecting the lighting-shadow, glare, reflection, Colour rendering and stroboscopic effect, Methods of artificial lighting, Lighting systems-direct, indirect, semi direct, semi indirect, Lighting scheme, General and localised .

Light is a form of Electromagnetic energy, radiated from a body which is capable of being perceived by the human eye.



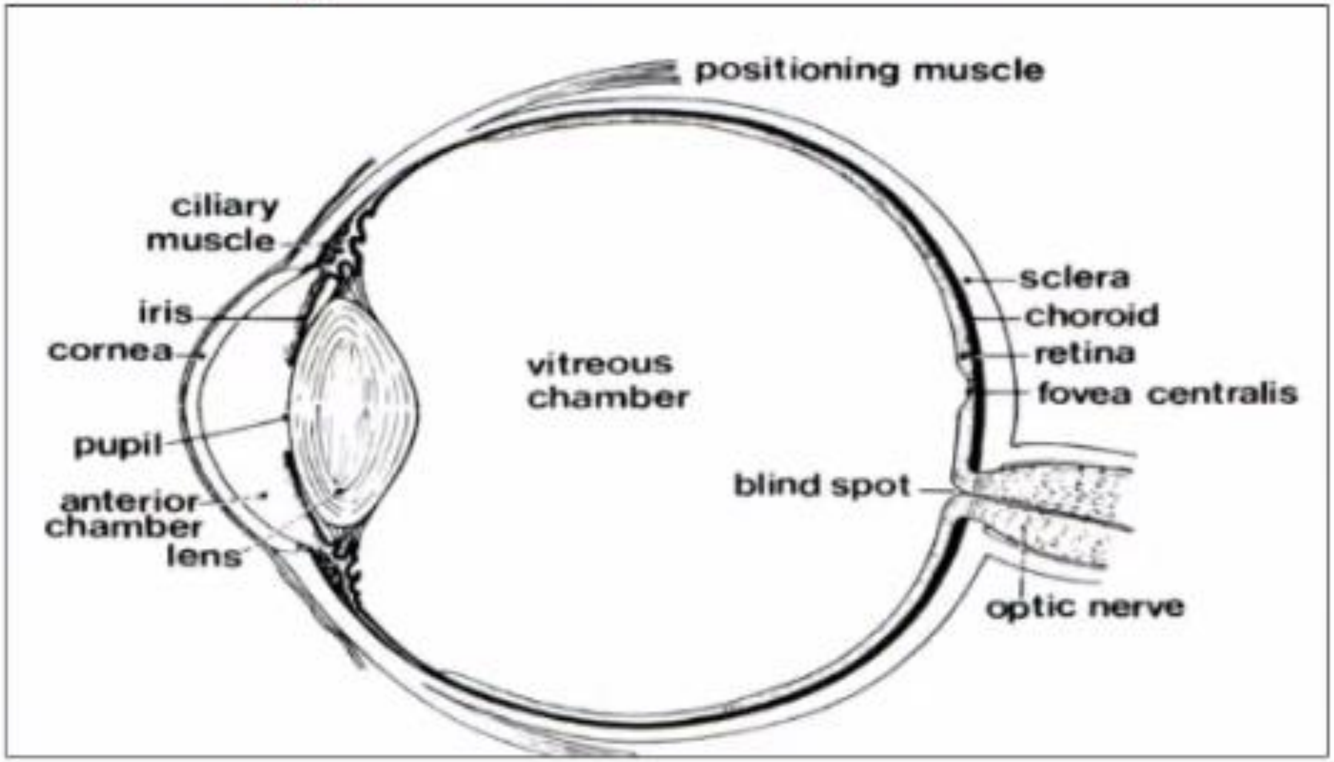
- Energy Consumption efficient
- Good Visual comfort

Electromagnetic spectrum



380nm 800nm

Human Eye is the Light Sensor



Vision is resultant of a process between 'Light' itself and 'Eye'

Both ,together, helps us to see the world around us

- https://www.youtube.com/watch?v=YcedXDN6a88

Illumination Engineering:

Deals with :

- Science & Economics
- Physiology of eye
- Peculiarities of our seeing process
- Psychological effects

Poor Lighting can cause:

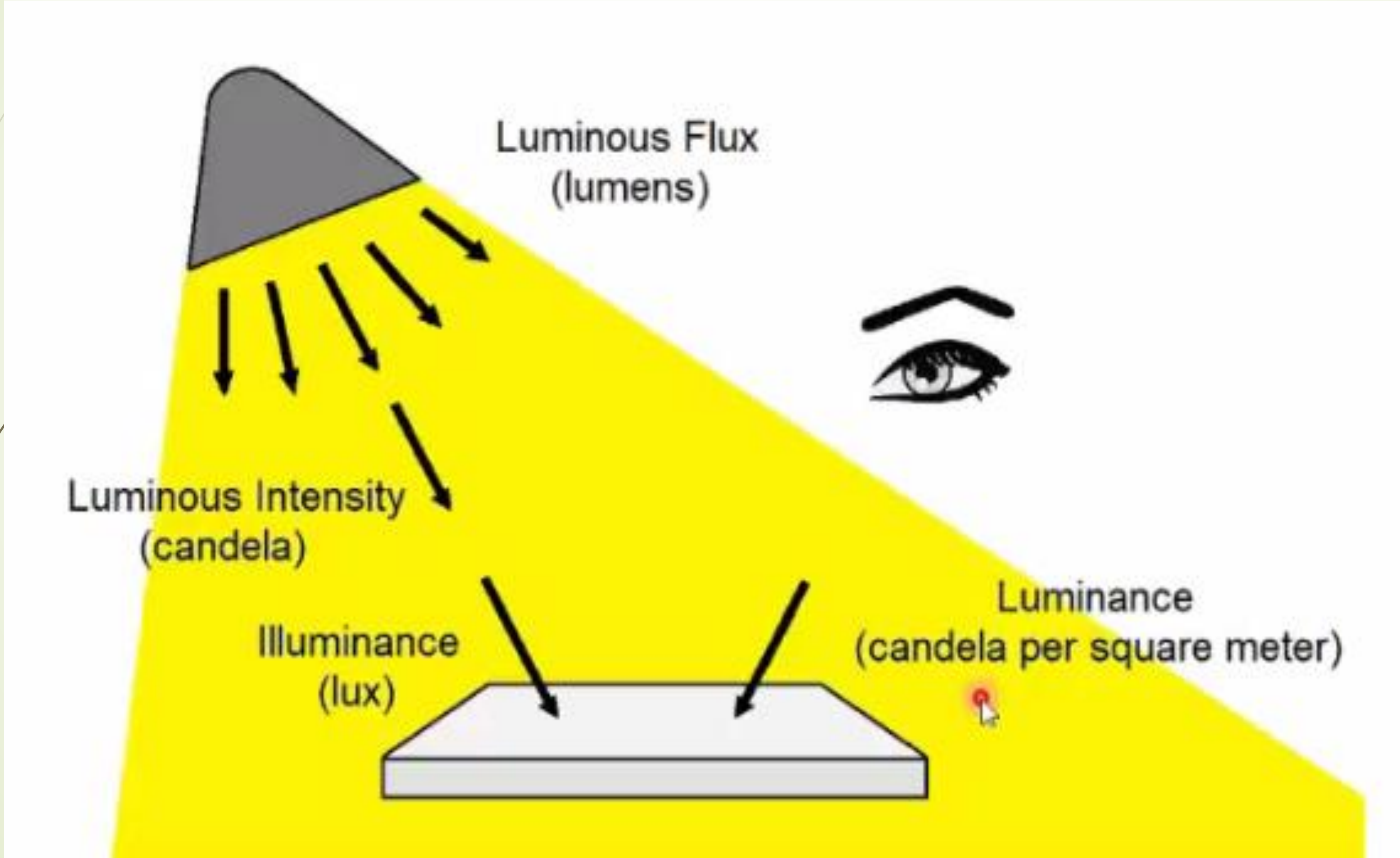
- Eye Strain
- Headache
- Accidents due to insufficient lighting
- Glare

For Good lighting system:

- Adequate illumination of suitable colour on the working surface
- Good maintenance
- Avoidance of hard shadows
- Avoidance of Glare.

Good illuminance ensures increased production, effectively of work & reduced accidents.

Fundamentals / Terms:



- Light:-
  - Electromagnetic energy
  - Radiated from a hot body

- Luminous Flux:-
  - The total quantity of light energy emitted per second
  - Measured in lumens

Conti…

- Luminous Intensity:-
  - Intensity of emission of luminous flux in specific direction.
  - Unit=Candela

- Illumination:-
  - Lights falls on any surface, the phenomenon is called Illumination.
  - Measured in $Lumens/m^2$

Lighting Schemes

1. Direct Lighting:-

- About 90% to 100% of the total light flux is made to fall directly upon the working plane (falls downwards) with the help of suitable reflectors.
- Most commonly used for internal lighting.
- Mainly used for Industry & general outdoor lighting.
- Disadvantage: Causes hard shadows and glare.

2. Semi-Direct Lighting

- 60%-90% of the total light flux is made to fall directly downwards with the help of semi-direct reflectors.
- Remaining light is used for illuminate ceilings and walls.
- It is used for general lighting where ceiling also should be illuminated
- Causes soothing brightness.

3.Indirect Lighting

- More than 90% of the total light flux is thrown upwards to the ceiling for diffused reflection by bowl reflectors.
- Causes soft, glare-free, diffused illumination.
- Used for decorative purposes in cinemas, hotels, theatres, etc.
- Advantage; It gives a glarefree diffused light flux with soft shadows.

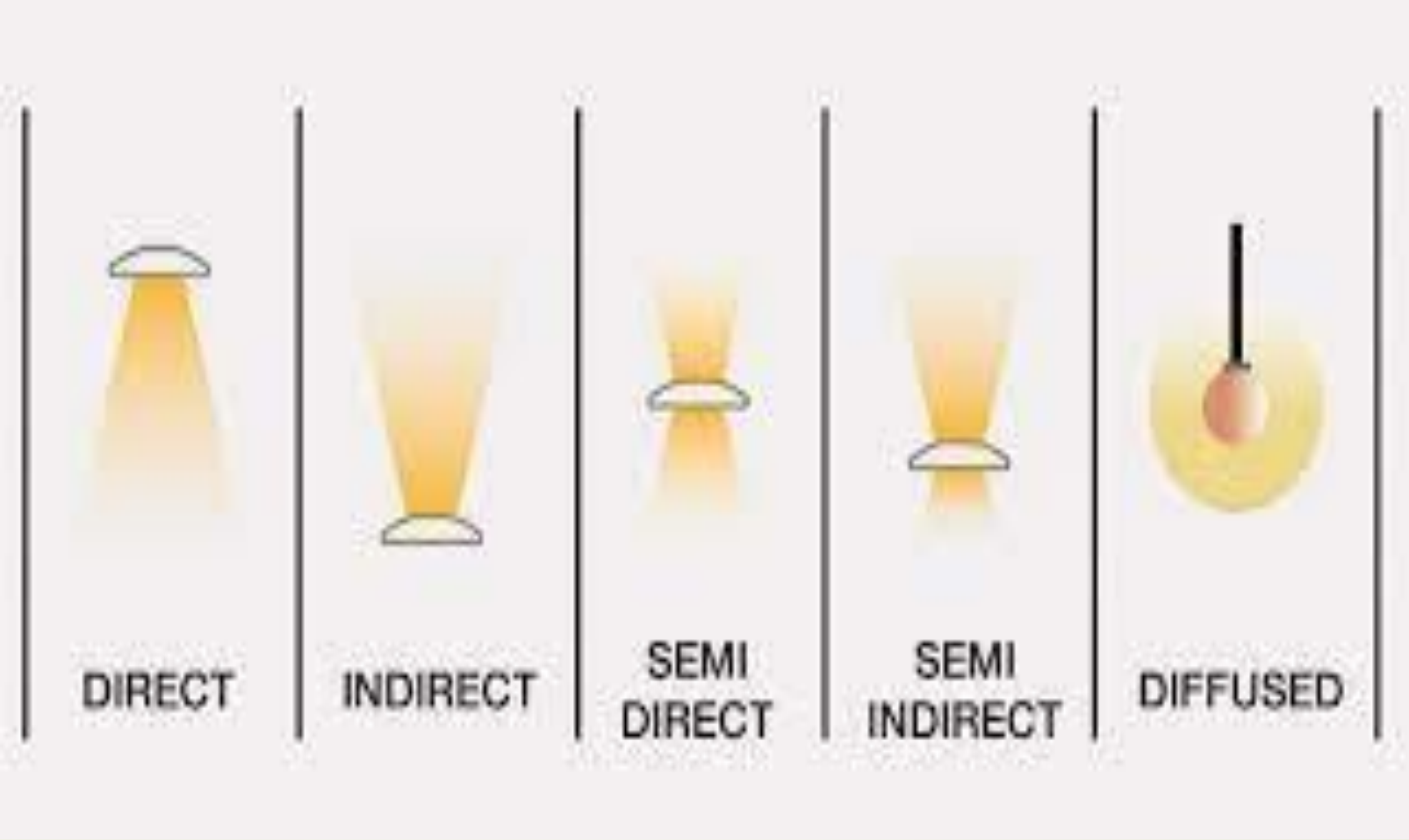
4. Semi-Indirect Lighting:-

- 60%-90% of the total light flux is thrown upwards to the ceiling for diffused reflection by using inverted reflectors.
- The remaining light reaches the work plane directly except for some absorption by the reflectors.
- Causes soft shadows and glare free lighting scheme.
- Used for indoor light decorations.

5. General Lighting

- In this method the bulb and the reflector are made of diffuse glass, so as to give uniform illumination in all direction.
- Causes diffused and glare-less lighting, same illumination in all directions.
- Eg: Wall lights, Ceiling lights, dimmers and lower wattage lights, fluorescent lights.

Lighting Schemes



DESIGN OF INDOOR LIGHTING SCHEMES

I. Adequate illumination
II. Uniform light distribution all over the working plane.
III. Light of suitable colour.
IV. Minimum hard shadow and glare

Factors affecting Lighting:

- Shadow
- Glare
- Reflection
- Stroboscopic effect
- Colour Rendering

Factors affecting Lighting:

1. Shadow

- A **shadow** is a dark (real image) area where light from a light source is blocked by an opaque object. It occupies all of the three-dimensional volume behind an object with light in front of it.

- *Characteristics:*

i) It depends on shape of the object. The shadow increases & decreases in the ratio same as the shape of the object.

ii) It depends on source of light whether it is plane, parallel rays or spherical.

iii) It depends on position of the object whether it is at infinite or finite directions.

iv) It depends on the position of source of light. If the source of light is kept closer to the object –the shadow will be smaller & if it is Farther then, shadow will be longer.

Factors affecting Lighting:

2. Glare

- A Glare is the loss of visual performance or discomfort produced by an intensity of light in the visual field greater than the intensity of light to which the eyes are adapted.
- Glare occurs when too much light enters your eye and interferes with your eye's ability to manage it.
- Glare can be distracting and even dangerous and can occur day or night in a number of ways.
- Glare may come directly from a light source or be reflected.
- *Two types of Glares:*

i) Discomfort Glare : Results in an instinctive desire to look away from a bright light source or difficulty while seeing a task.

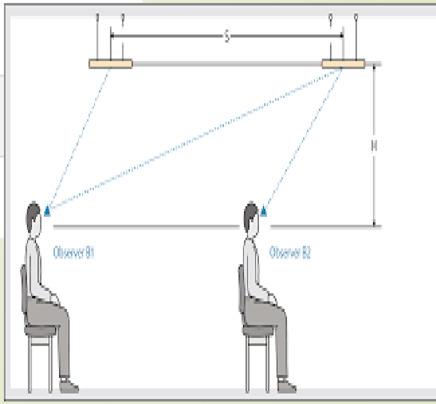
ii) Disability Glare : Caused by inter-reflection of light within the eyeball

Factors affecting Lighting:

2. Glare… https://www.youtube.com/watch?v=PwHX

- UGR: UGR (Unified Glare Rating) is a method of calculating glare from luminaires, light through windows and bright light sources.
- The UGR rating helps to determine how likely a luminaire is to cause discomfort to those around it. For example, the discomfort that a LED Panel will cause the workforce within an office. This classification ranges from 5 to 40, with low numbers indicating low glare.

UGR ≤ 16	Technical drawing
UGR ≤ 19	Reading, writing, training, meetings, computer-based work
UGR ≤ 22	Craft and light industries
UGR ≤ 25	Heavy industry
UGR ≤ 28	Railway platforms, foyers

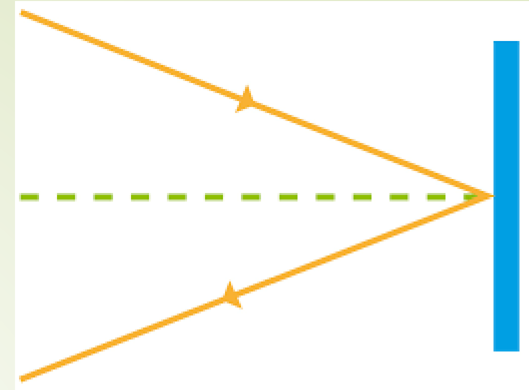


Factors affecting Lighting:

2. Glare:

- VCP:
- It is defined as the percentage of people that will find a certain scene (viewpoint and direction) comfortable with regard to visual glare.
- If VCP = 70%, then system is said to be glare fee.

Factors affecting Lighting:



3. REFLECTION:

- When a ray of light approaches a smooth polished surface

and the light ray bounces back, it is called the reflection of light.

- The incident light ray which lands upon the surface is said to be reflected off the surface. The ray that bounces back is called the reflected ray.
- **Reflection factor:**
  The ratio of the total amount of radiation, as of light, reflected by a surface to the total amount of radiation incident on the surface.
- Aluminum polished: 65 – 75
- Granite 20 – 25
- Marble, polished 30 – 70
- Plaster, light 40 – 45
- Plywood, rough 25 – 40
- Concrete, rough 20 – 30
- Brick, red 10 – 15
- Paint, white 75 – 85

Factors affecting Lighting:

4. Stroboscopic Effect:

- The **Stroboscopic Effect in Fluorescent lamp** is a phenomenon which causes running or moving equipment to appear stationary or appear to be operating slower than they actually are.

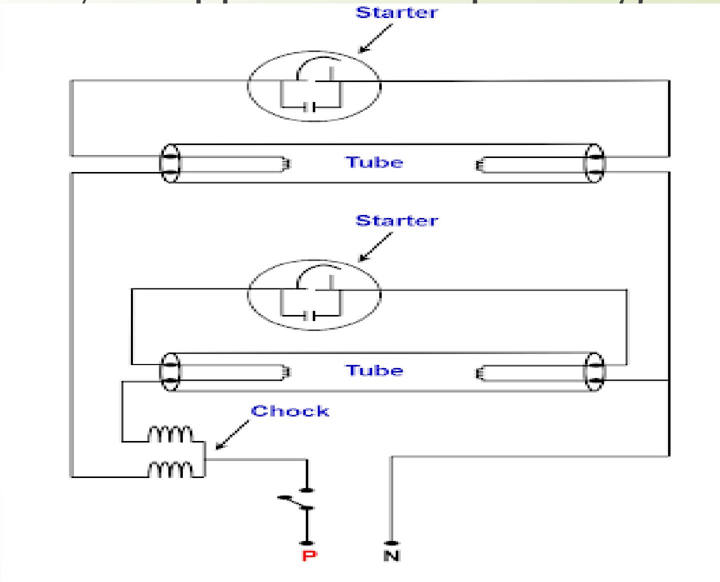
In an AC supply, the voltage drops 100 times a second to zero volts as the supply frequency is 50 Hz. When a Fluorescent lamp is operating with an AC supply, the light intensity drops 100 times a second. This flicker is not noticeable to the human eye due to the persistence of vision.

When a worker in a factory observes a running machine, say a flywheel under the illumination of a fluorescent light, the flywheel may appear to be stationary or to be operating at reduced speed. This can result in accidents and is highly dangerous.

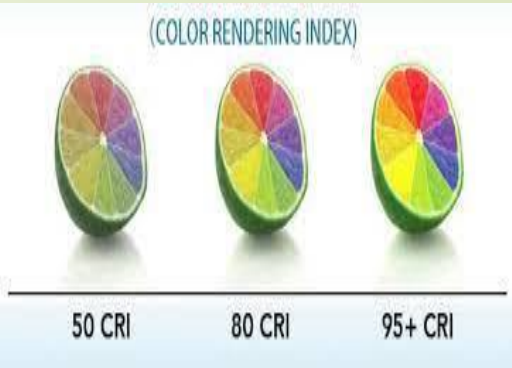
A sewing machine whose needle moves up and down may appear to be stationary and the operator can prick the fingers. These are some examples where the stroboscopic effect in the Fluorescent lamps can prove to be dangerous. When using fluorescent lamps around rotating or moving machinery, two lamps powered by two different phases should be used. This ensures that both the lamps do not flicker due to the zero crossing at the same time.

4. Stroboscopic Effect:

- The **Stroboscopic Effect in Fluorescent lamp** is a phenomenon which causes running or moving equipment to appear stationary or appear to be operating slower than they actually are.
- It can be eliminated by:
- 1) Using 3 phase supply for lighting System
- 2) Using frequency controllers for the supply
- 3) using Twin tubes



- Two lamps are connected parallel to the supply and the lamp is connect in series with a capacitor or choke. Therefore there exist a phase difference between 2 currents.



5. Colour Rendering:

- It describes how well the light render color in an object.
- Color Rendering is expressed as a rating from 0-100 on Color Rendering Index (CRI).
- How a light source makes the color of an object appear in human eye and how well the variations in color shades are reveated.
- Color Rendering relates to the object appear under a given light source. This measure is called CRI.
- Low CRI- Object color may appear unnatural
- High CRI- Object color may appear more natural
- Street Lighting- 2.2 (Sodium Vapor Light)
- Office- 62 (Fluorescent Light)
- Residential- 80-90 LED

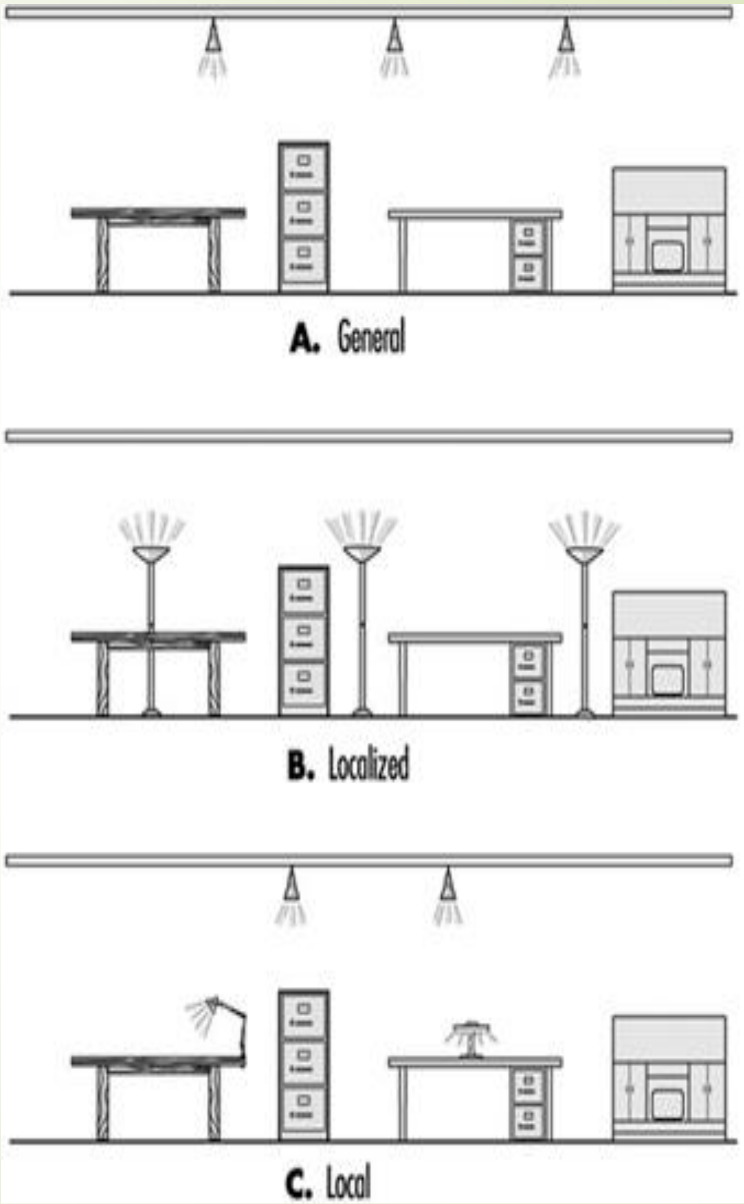
  95 Incandescent Light

  80-85 CFL

- https://www.khanacademy.org/computing/pixar/rendering/rendering1/v/overview-rendering

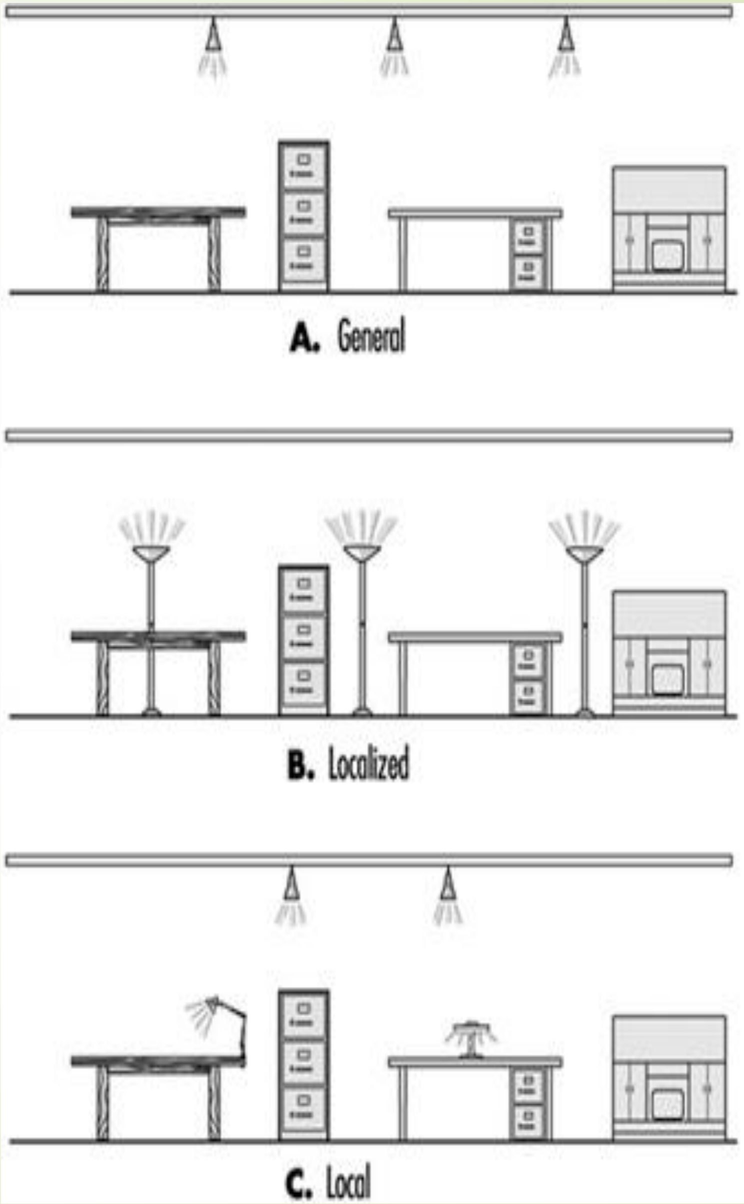
General and Localised Lighting

- The term '***general lighting***' or 'ambient lighting' refers to the background levels of light in a particular space. In the majority of workspaces the minimum level of general lighting is determined in line with best practice guides to ensure safety and enable everyday visual tasks to be performed comfortably and efficiently.
- ***Localized lighting*** systems provide illuminance on general work areas with a simultaneous reduced level of illuminance in adjacent areas.
- ***Local lighting*** systems provide illuminance for relatively small areas incorporating visual tasks. Such systems are normally complemented by a specified level of general lighting. Figure 1 illustrates the typical differences between the systems described.



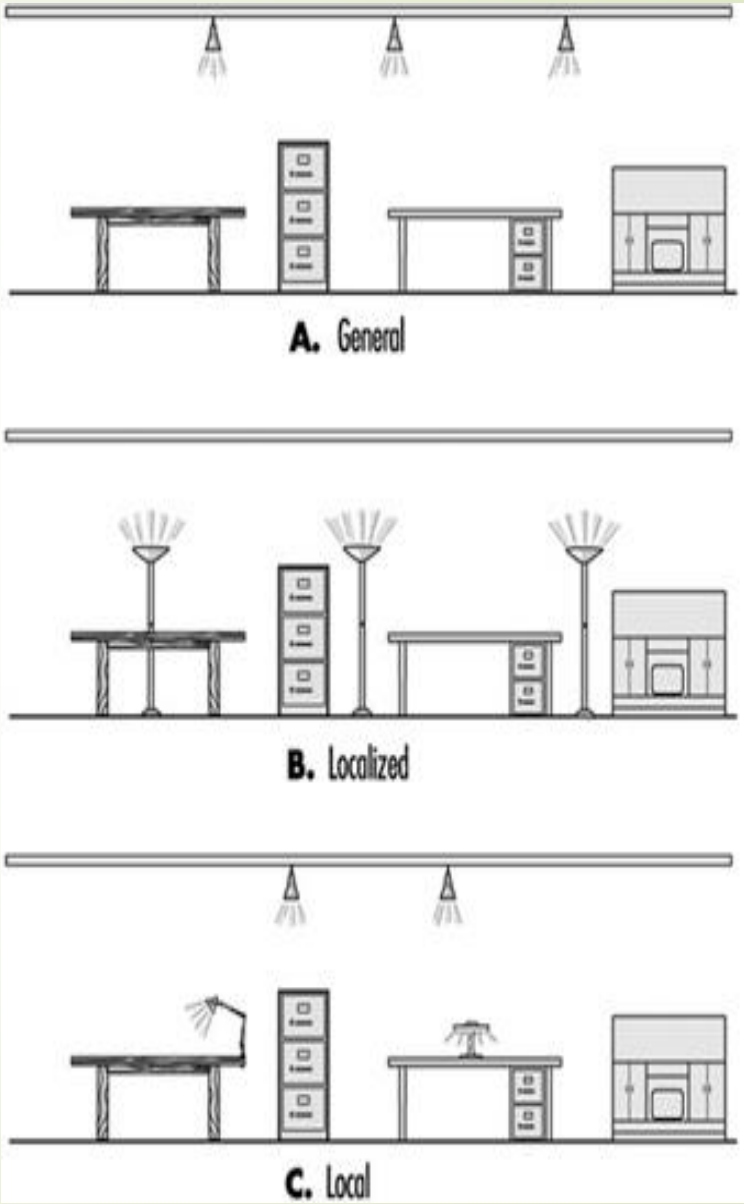
General and Localised Lighting

- ‘***General lighting***’ or ‘uniform lighting’:
- Lighting system which provides an approximately uniform illuminance on the horizontal working plane over the entire area are called general lighting systems.
- Simple to plan & install
- Adv: It permits complete flexibility oftask location
- Disadv: Energy is wasted illuminating the whole area to the level needed only for the most critical tasks.



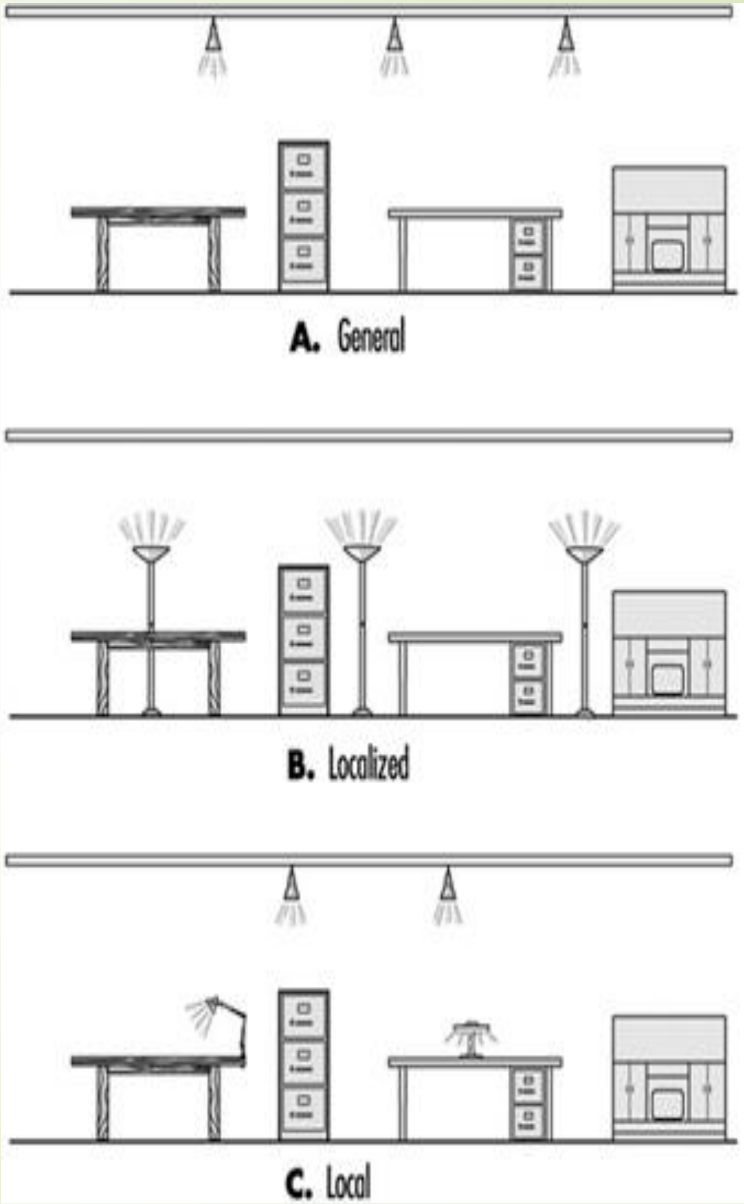
General and Localised Lighting

- ***Localized lighting*** systems
- It employ an arrangement of luminaries related to the position of tasks and workstations.
- They provide the required service illuminance on work areas together itha a lower level ofgeneral illumination for the space.
- Localised systems normally consumes less energy than general systems.



General and Localised Lighting

- ***Local lighting*** systems provides illumination only over the small area occupied by the task and its immediate surroundings.
- Also referred as task ambient lighting
- It is a very efficient system, particularly when high standards of task illuminance are required.
- It is normally provided by luminaires mounted on the workstation, providing a very flexible room layout. Such local units must be positioned carefully to minimize shadows, veiling reflections and glare.



Types of Lamps

Electric lamps :-

A. Incandescent lamps
B. Discharge lamps

Incandescent lamps:-

1. Vacuum lamps
2. Gas filled lamps

1. Vacuum lamps

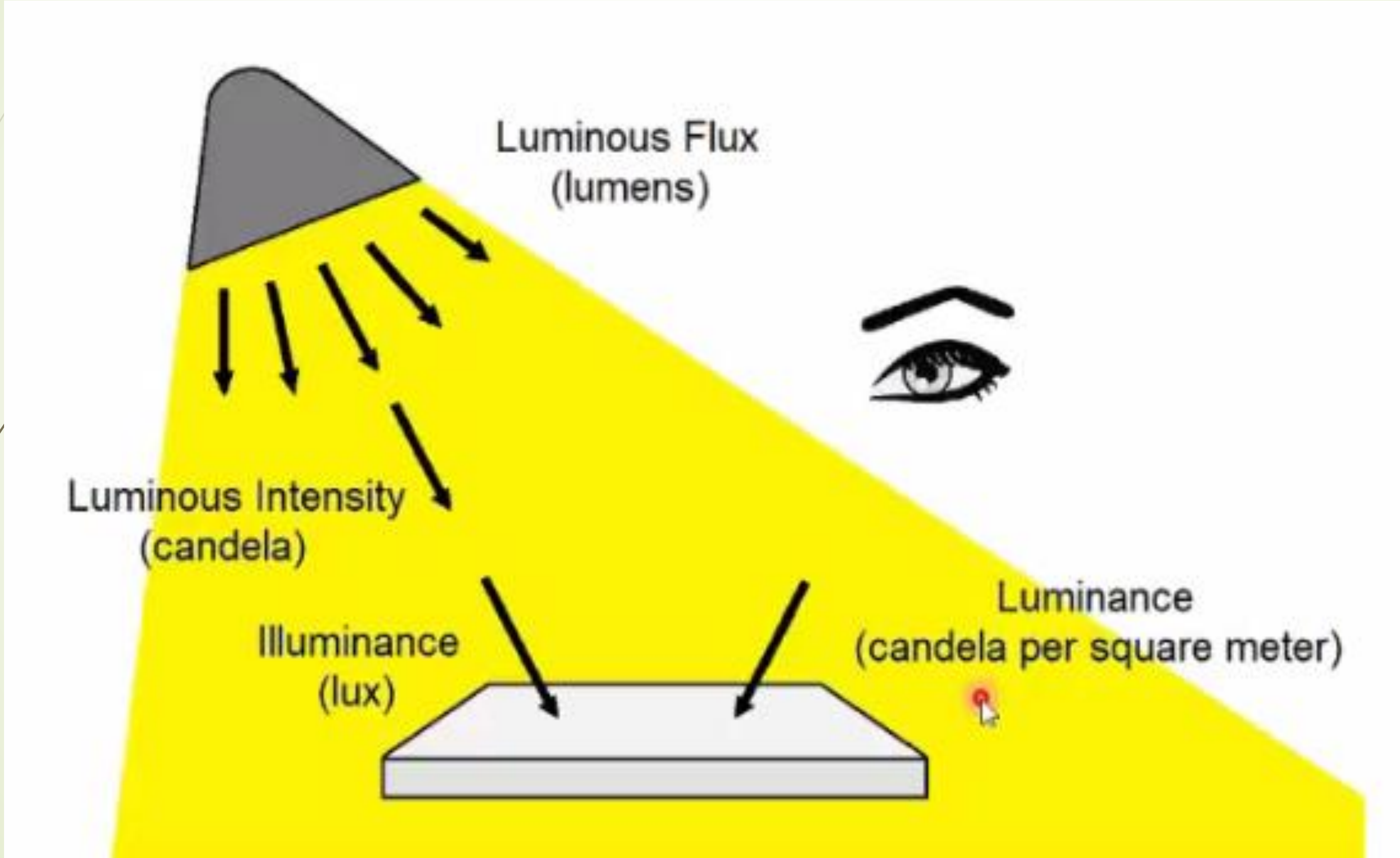
2. Gas filled Lamp

3. Halogen Lamp

4. Discharge Lamp

5. Fluorescent Lights

Fundamentals:



2-Measurement of Light

Module II

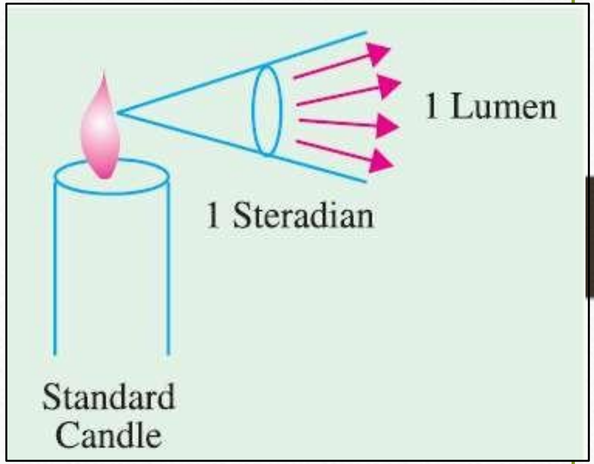
Candela

- Unit of luminous intensity of a source
- Defined as 1/60th of the luminous intensity per cm2 of a black body radiator at the temperature of solidification of platinum (2045 °K)
- A source of one candela (cd) emits one lumen per steradian
- Total flux emitted by it all round is $4\pi \times 1 = 4\pi$ lumen

Luminous Flux (F or ϕ)

- It is the light energy radiated out per second from the body in the form of luminous light waves.
- Unit of luminous flux is lumen (lm).
- Defined as the flux contained per unit solid angle of a source of one candela or standard candle.
- Since, it is a rate of flow of energy, it is a sort of power unit.
- Approximate relation between lumen and electric unit of power (watt) is given as

$$1 \text{ lumen} = 0.0016 \text{ watt (approx.)}$$



Lumen-hour

It is the quantity of light delivered in one hour by flux of one lumen.

It is similar to watt-hour (Wh)

Luminous Intensity (I) or Candle-power

- Candle power of a point source in any particular direction is given by the luminous flux radiated out per unit solid angle in that direction.
- It is solid angular flux density of a source in a specified direction.
- If $d\varphi$ is the luminous flux radiated out by a source within a solid angle of $d\omega$ steradian in any particular direction, then $I = {}^{d\varphi}/_{d\omega}$.
- If flux is measured in lumens and solid angle in steradian, then its unit is lumen/steradian (lm/sr) or candela (cd).
- If a source has an average luminous intensity of I lm/sr (or I candela), then total flux radiated by it all around is $\phi = I\omega = 4\pi I\ lumen$.

Luminous Intensity (I) or Candle-power

- The luminous intensity or candle power of a source is different in different directions.
- The average candle-power of a source is the average value of its candle power in all directions.
  - *Mean Spherical Candle-Power (M.S.C.P.).*
  - *Mean Hemispherical Candle-Power (M.H.S.C.P.).*

Mean Spherical Candle-Power (M.S.C.P.).

- Total flux (in lm) emitted in all directions in all planes divided by 4π.

$$MSCP = \frac{total\ flux\ in\ lumens}{4\pi}$$

Mean Hemispherical Candle-Power (M.H.S.C.P.).

- Total flux emitted in a hemisphere (usually the lower one) divided by the solid angle subtended at the point source by the hemisphere.

$$MSCP = \frac{flux\ emmitted\ in\ a\ hemisphere}{2\pi}$$

Reduction Factor

- The ratio, f = M.S.C.P./M.H.C.P. where M.H.C.P. is the mean horizontal candle power.
- Also referred to as spherical reduction factor.

Illuminance or Illumination (E)

- When the luminous flux falls on a surface, it is said to be illuminated. The illumination of a surface is measured by the normal luminous flux per unit area received by it.
- If $d\phi$ is the luminous flux incident normally on an area dA,

  then $E = {}^{d\phi}/_{dA}$ $or\ E = {}^{\phi}/_{A}$

- Unit
  - ${}^{lm}/_{m^2}$ $or\ metre - candle\ (m - cd)$

Lamp efficacy

- The ratio of the light output from a light source to the power consumed; measured in lumens per Watt (lm/W).
- $Lamp\ efficiency = \frac{Luminous\ flux}{Power\ Inout}$
- The higher the efficacy value of a lamp or lighting system, the more energy-efficient it is.

Coefficient of utilization or utilization factor

- Ratio of total number of lumens reaching the working plane to the total number of lumens emitting from source.

$$U.F. = \frac{\boldsymbol{Total\ lumens\ reaching\ the\ working\ plane}}{\boldsymbol{Total\ lumens\ emmiting\ from\ the\ source}}$$

Maintenance factor

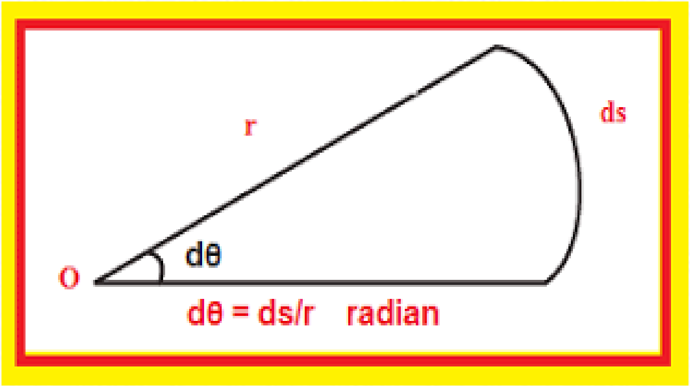
- Ratio of illumination under normal working conditions to the illumination when everything is clean.

$$U.F. = \frac{Total\ lumens\ reaching\ the\ working\ plane}{Total\ lumens\ emmiting\ from\ the\ source}$$

- Always less than 1, approx. 0.8
- Due to the accumulation of dust, dirt and smoke on the lamp, pump emits less light when they are clean.
- Improved by frequent cleaning of the lamp.

Plane Angle

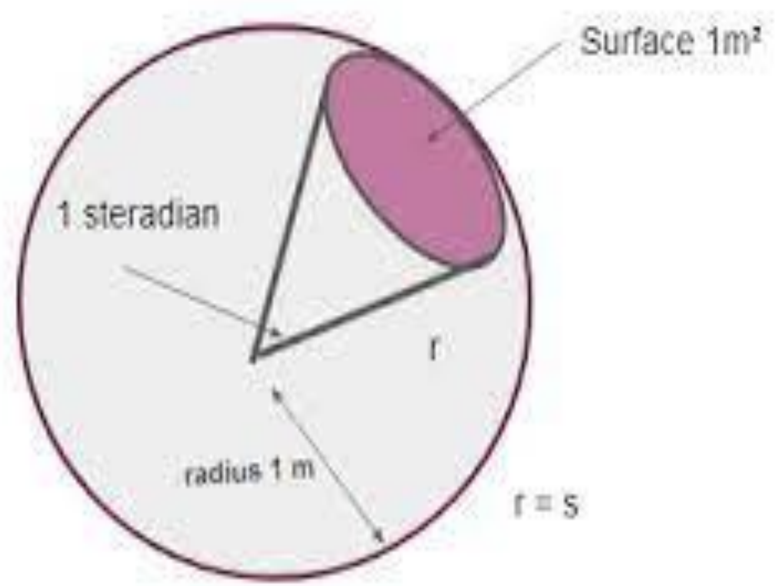
- A plane angle is the angle subtended at a point in a plane by two converging lines
- Denoted by the Greek letter ‘θ’ (theta)
- Usually measured in degrees or radians.
- $Plane\ angle, \theta = \frac{arc}{radius}$
- One radian is defined as the angle subtended by an arc of a circle whose length by an arc of a circle whose length is equals to the radius of the circle.



Solid Angle

- Solid angle is the angle subtended at a point in space by an area, i.e., the angle enclosed in the volume formed by numerous lines lying on the surface and meeting at the point
- Denoted by symbol 'ω'
- Measured in steradian.
- $SOlid\ angle, \omega = \frac{area}{radius^2}$
- Largest solod angle is subtended at the center of sphere,

$$\omega = \frac{area\ od\ sphere}{R^2} = \frac{4\pi r^2}{r^2} = 4\pi\ steredians$$



Steradian

Relationship between plane angle and solid angle

$$the\ solid\ angle, \omega = \frac{area}{(radius)^2}$$

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

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

Laws of Illumination or Illuminance

Laws of Illumination or Illuminance

- Assumption
  - *The source of illumination is a point source or*
  - *The source is sufficiently away from the surface to be regarded as a point source .*

Laws of Illumination or Illuminance

- E is directly proportional to the luminous intensity (I) of the source or $E \propto I$.

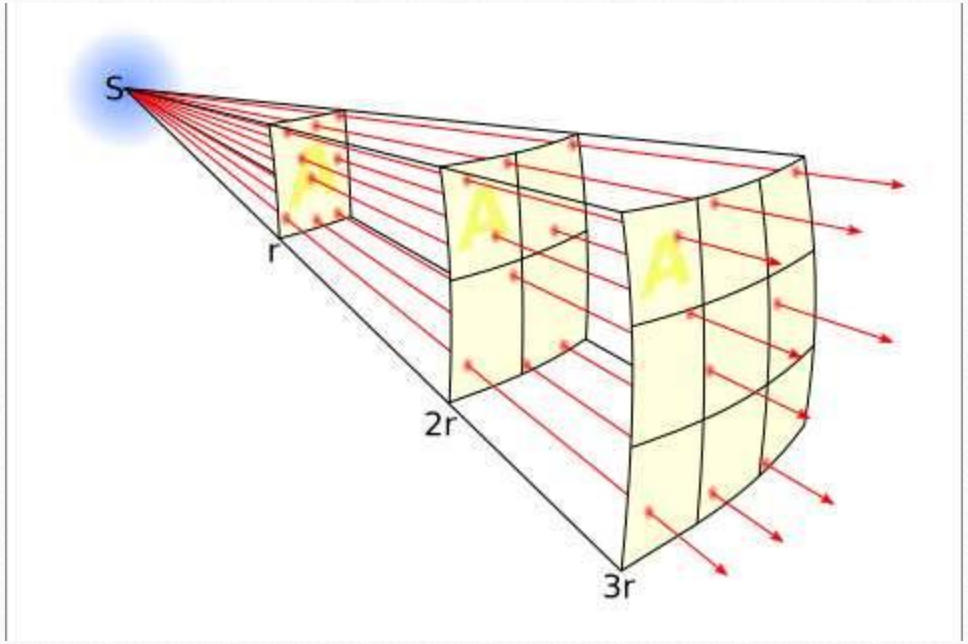
$$\mathrm{E} \propto I$$

- Inverse Square Law
- Lambert's Cosine Law

Inverse Square Law

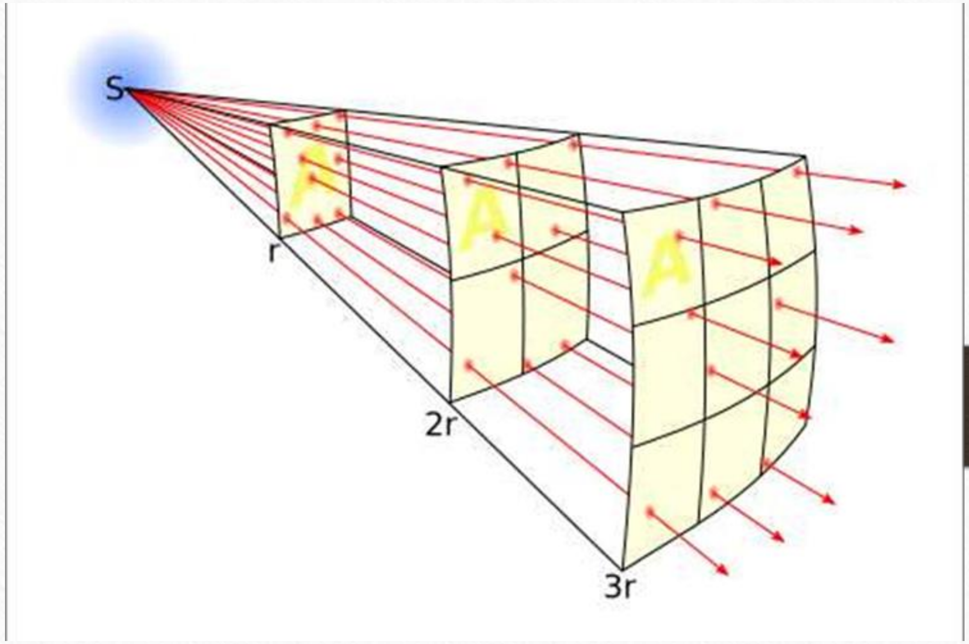
- The illumination of a surface is inversely proportional to the square of the distance of the surface from the source.

$$E \propto 1/r^2$$



Inverse Square Law

- The figure shows the portions of the surfaces of three spheres whose radii are in the ratio 1 : 2 : 3. All these portions subtends the same solid angle at the source and hence receive the same amount of total flux. However, since their areas are in the ratio of 1 : 4 : 9, their illuminations are in the ratio $1{:}\frac{1}{4}{:}\frac{1}{9}$.



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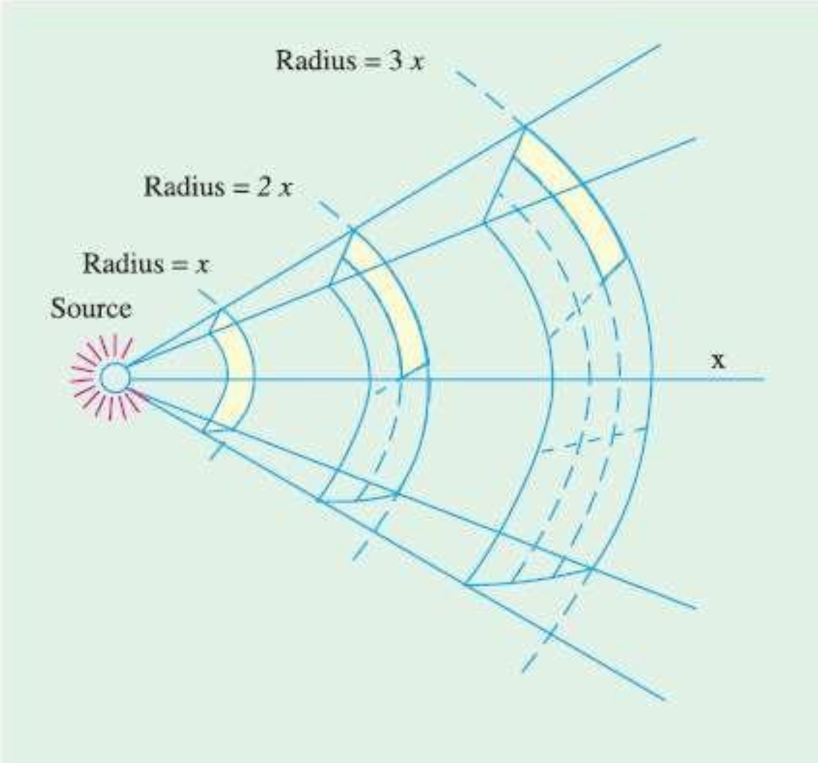
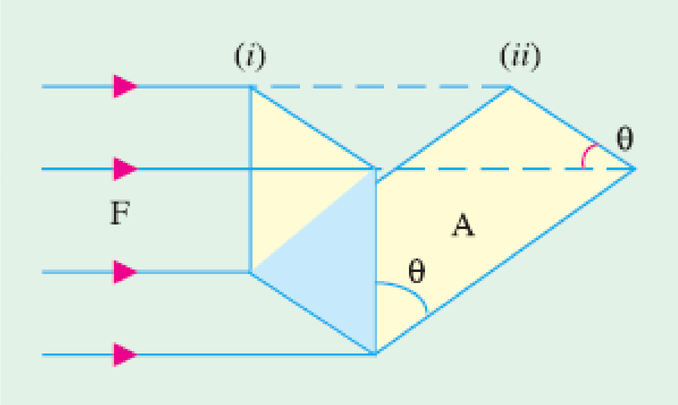


Lambert's Cosine Law



- According to this law, **E is directly proportional to the cosine of the angle made by the normal to the illuminated surface with the direction of the incident flux.**
- When in position 1, let ϕ be the flux incident on the surface of area A. When this surface is turned back through an angle θ, then the flux incident on it is $\phi \cos\theta$. Hence, illumination of the surface when in position 1 is $E_1 = \frac{\phi}{A}$

Lambert's Cosine Law

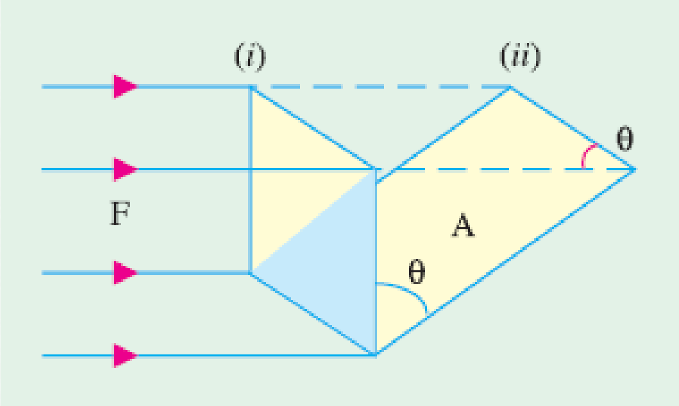
- In position 2, the Illumination

$$E_2 = \frac{\phi \cos\theta}{A}$$

$$\therefore E_2 = E_1 \cos\theta$$

- Combining all these factors together,

$E = \frac{I \ \cos\theta}{r^2}$. *The unit is* ${}^{lm}/_{m^2}$

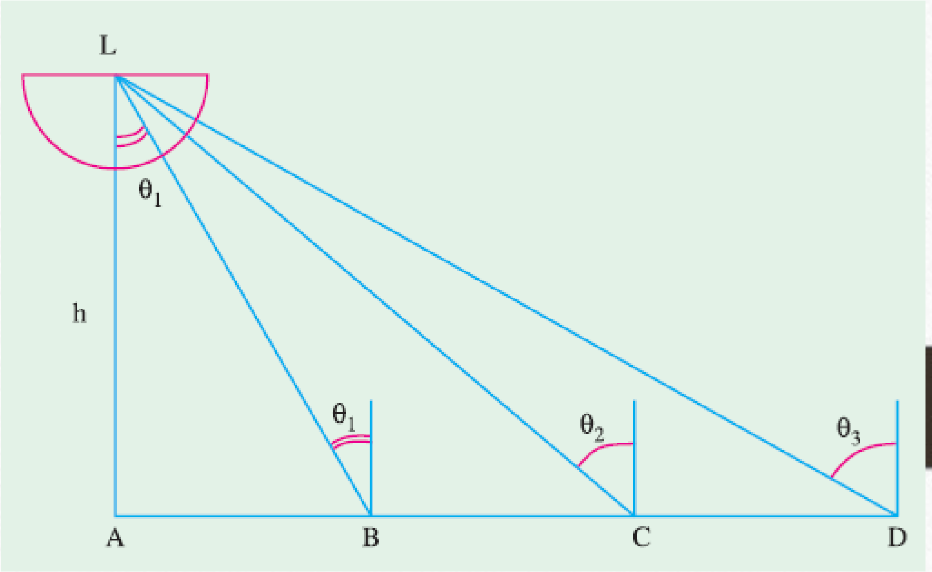


Illumination possible at a given point

- The determination of illumination possible at a given point provided, the position and the luminous intensity or candle power (in the given direction) of the source (or sources) by which it is illuminated, are known.

Illumination possible at a given point

- Consider a lamp of uniform luminous intensity suspended at a height *h* above the working plane.
- Let us consider the value of illumination at point A immediately below the lamp and at other points B,C,D etc., lying in the working plane at different distances from A.



Illumination possible at a given point

$E_A = \frac{I}{h^2}, \therefore \ \theta = 0 \ and \ \cos\theta = 1$

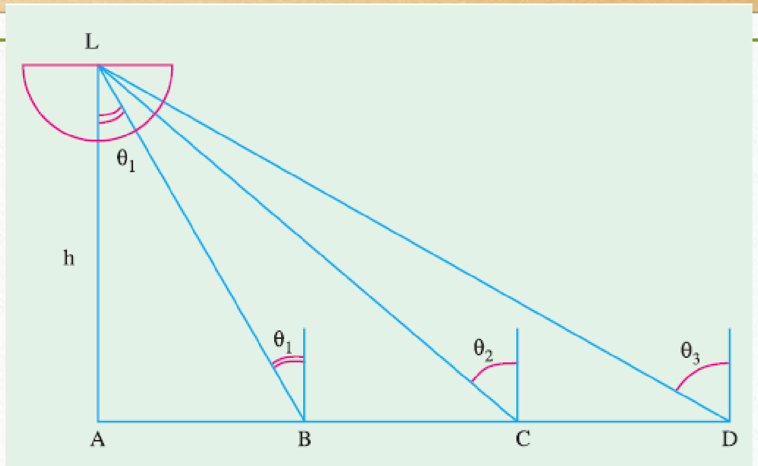
$E_B = \frac{I}{LB^2} \times \cos\theta_1, Since, \cos\theta_1 = {}^{h}/_{LB}$

$\therefore E_B = \frac{I}{LB^2} \times \frac{H}{LB} = I \times \frac{h}{LB^3} = \frac{I}{h^2} \times \frac{LB^3}{LB^3} = \frac{I}{h^2}\left(\frac{h}{LB}\right)^3$

$Now, \frac{I}{h^2} = E_A \ and \ \left(\frac{h}{LB}\right)^3 = \cos^3\theta_1$

$\therefore E_B = E_A \cos^3\theta_1$

$Similarly, E_C = E_A \cos^3\theta_2$ and $E_D = E_A \cos^3\theta_3$



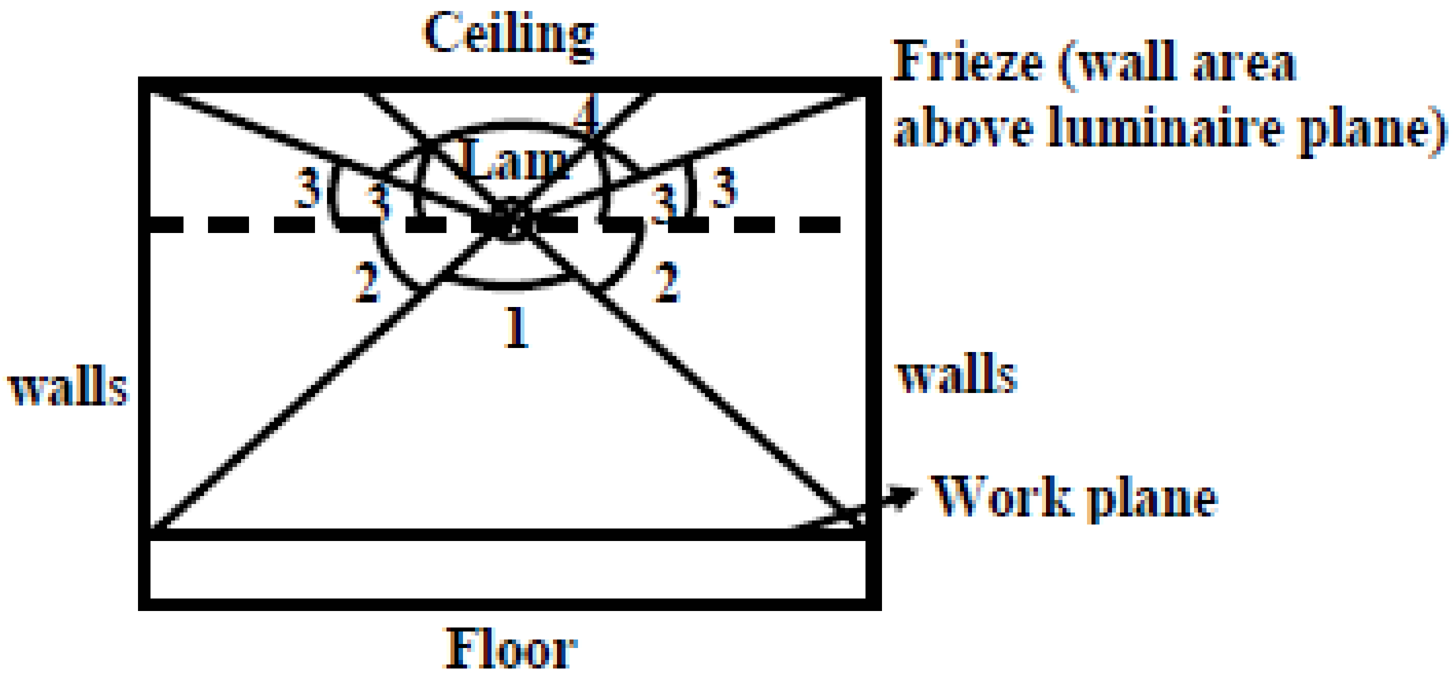
- Let us consider the value of illumination at point A immediately below the lamp and at other points B,C,D etc., lying in the working plane at different distances from A.

Horizontal Illuminance

- Specified as Average illuminance on the work plane while Sitting 0.75 – 0.9m above floor and while Standing 0.85 – 1.2m above floor.
- Horizontal Illumination is given by,

$$\boldsymbol{E = \frac{\varphi_{tot}}{A} U.F \times M}$$

Horizontal Illuminance - Schematic showing various zones in an interior of a room



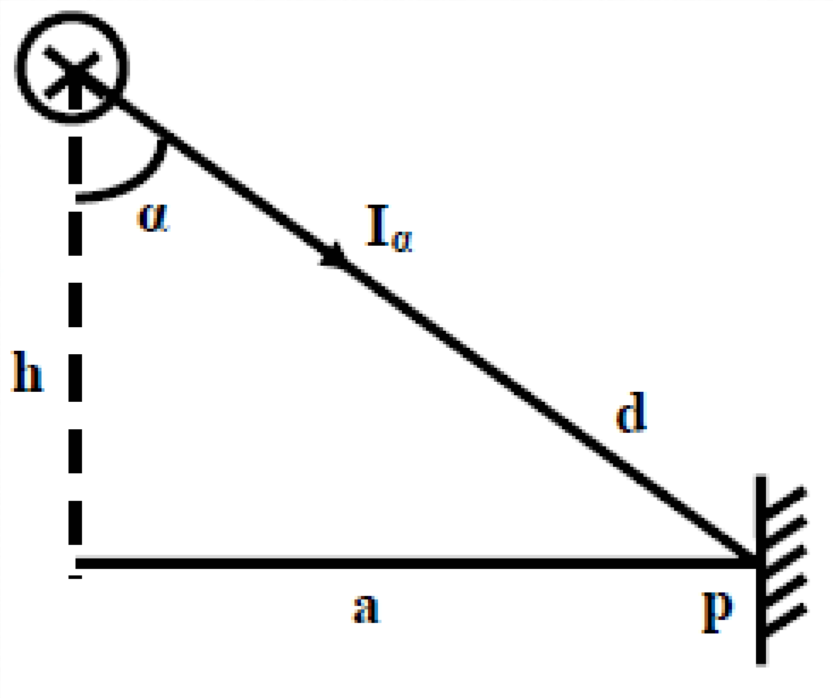
1 – work plane, 2 – wall area below the luminaire, 3 – on the frieze, 4 – ceiling

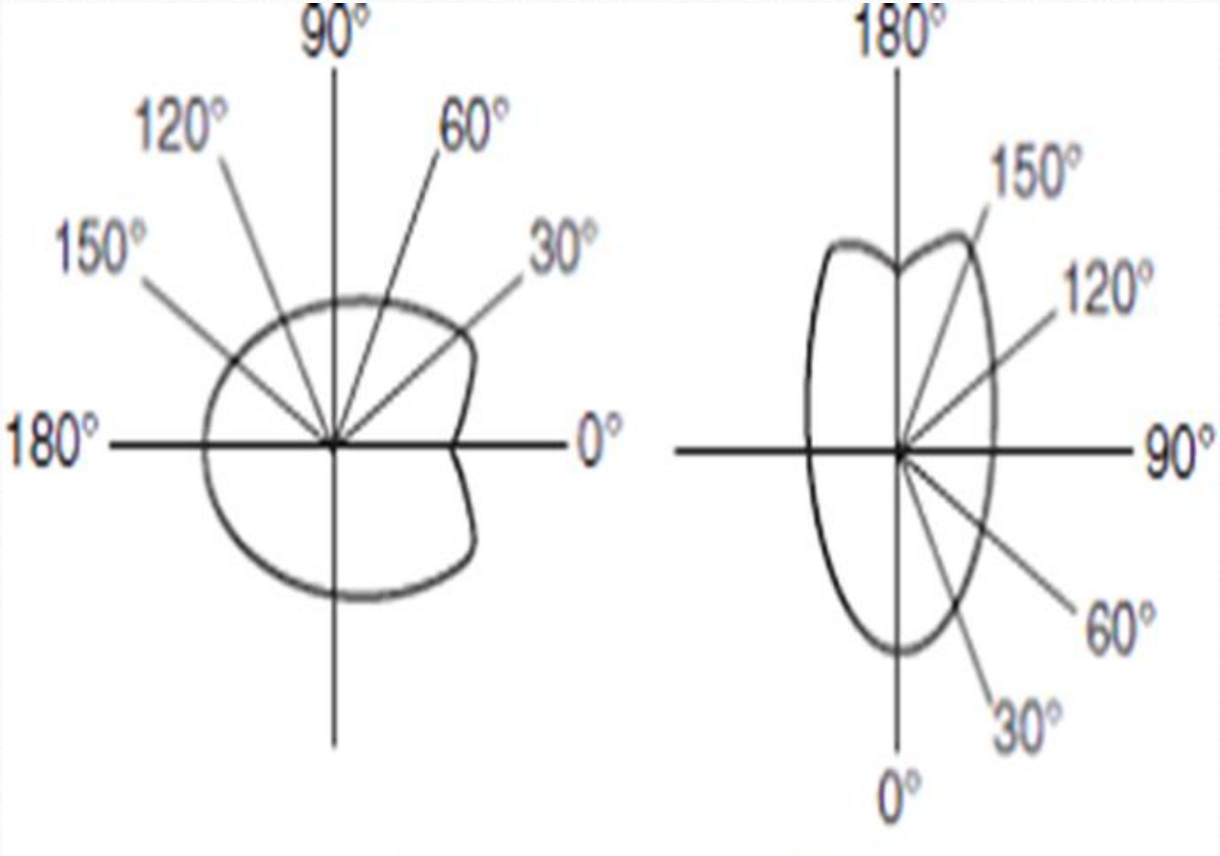
Vertical Illuminance

- Vertical Illuminance, becomes important in case of an Average wall, wall mounted object, black board – chalk board and wall display in a shop.
- Vertical Illumination is given by,
- $\boldsymbol{E = \frac{\varphi_{tot}}{A}\ (R)N_W\ \times M}$

The vertical illuminance at a point ‘P’

$$E_p = \frac{I_\alpha}{h^2} cos^2\alpha \ \sin\alpha$$





(a) Horizontal polar curves (b) Vertical polar curves

Polar Curves

Polar Curve

Represents the luminous intensity at different directions.

Horizontal polar Curve

- Luminous intensity over a horizontal plane above the vertical axis plotted against the angular position

Vertical polar Curve

- Luminous intensity over a vertical plane plotted against the angular position

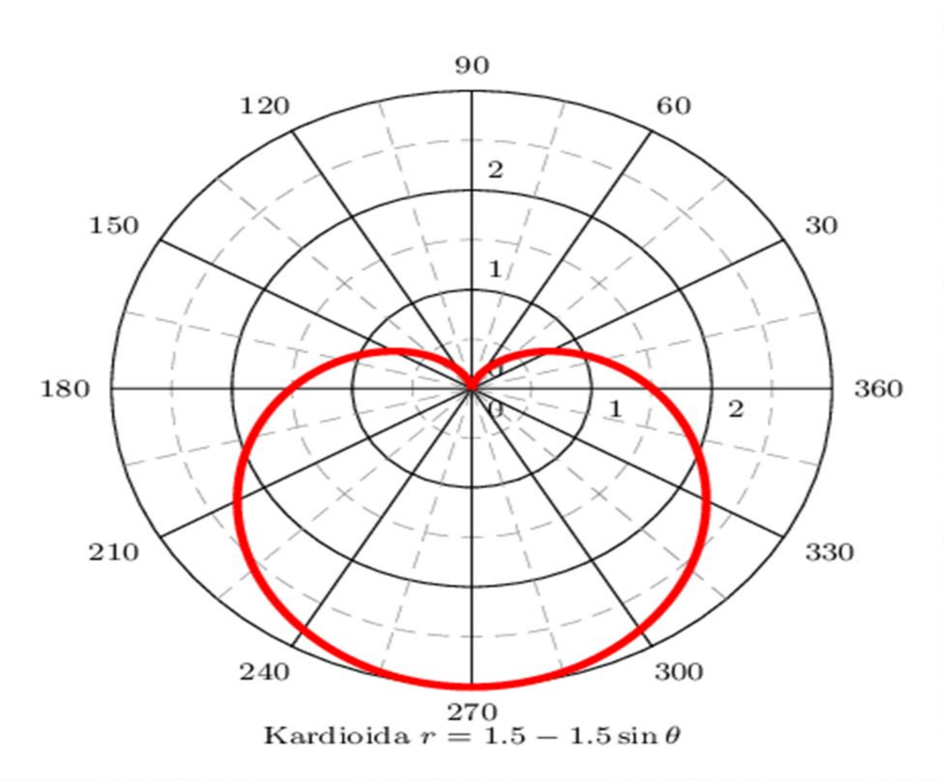
Purpose

- To find actual illumination
- To calculate MHCP & MSCP

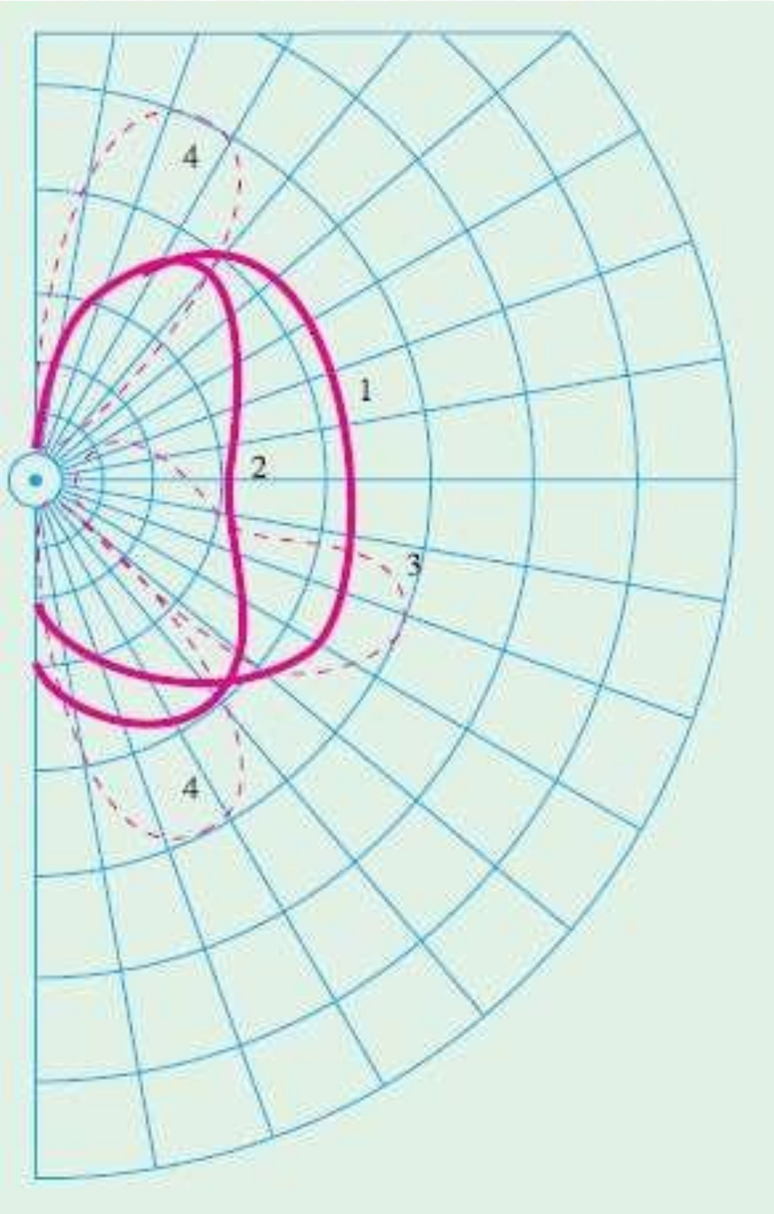
Polar Curves of C.P. Distribution

- The plot / locus of luminous intensity of a source in various directions plotted to scale along lines radiating from the centre of the source at corresponding angles,
- Elevations represent c.p. distribution in the vertical plane
- Plans represent c.p. distribution in horizontal plane.

C.P. distribution in a vertical plane



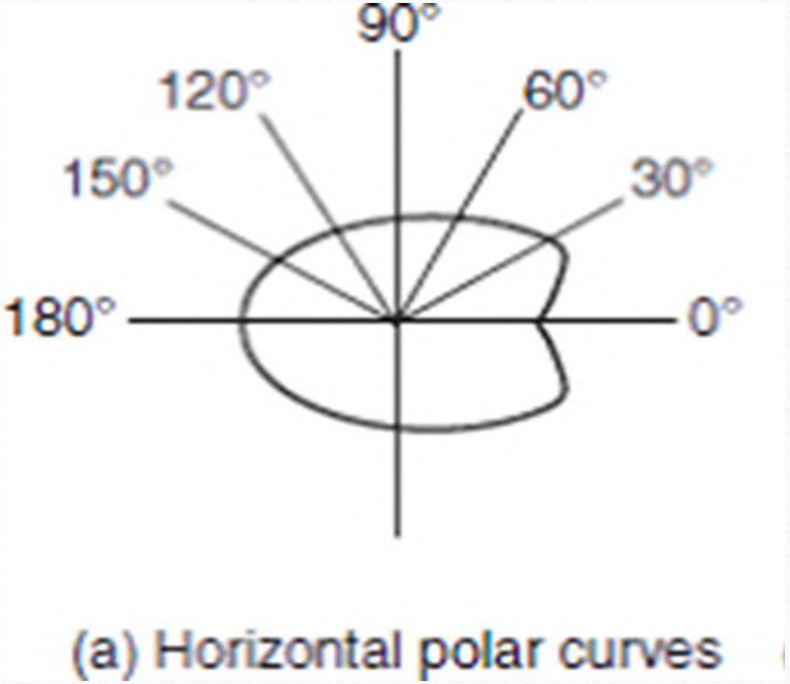
If the polar curve is symmetrical about the vertical axis, then it is sufficient to give only the polar curve within one semicircle in order to completely define the distribution of c.p.



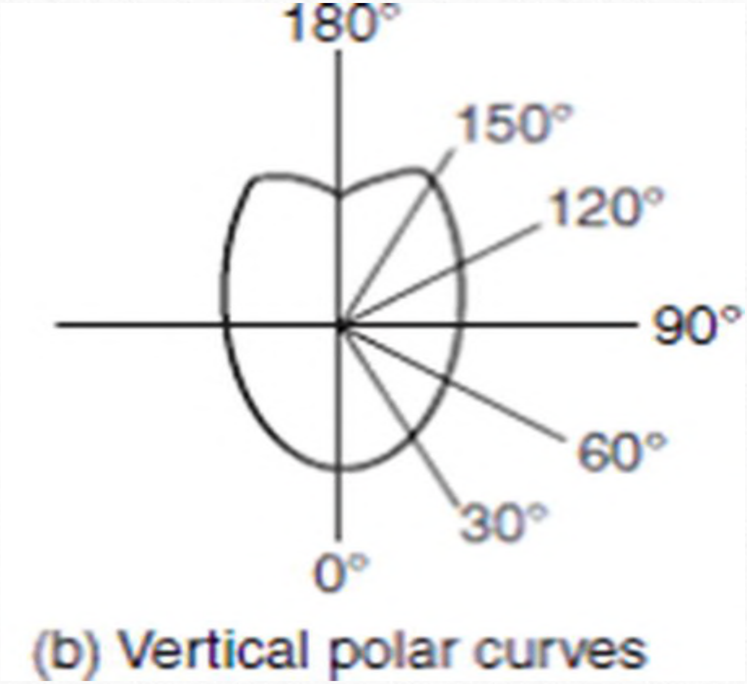
Use of Polar Curve

- Determine the MSCP
- Determine the actual illumination of a surface.

Determination of MSCP & MHCP from Polar Curve



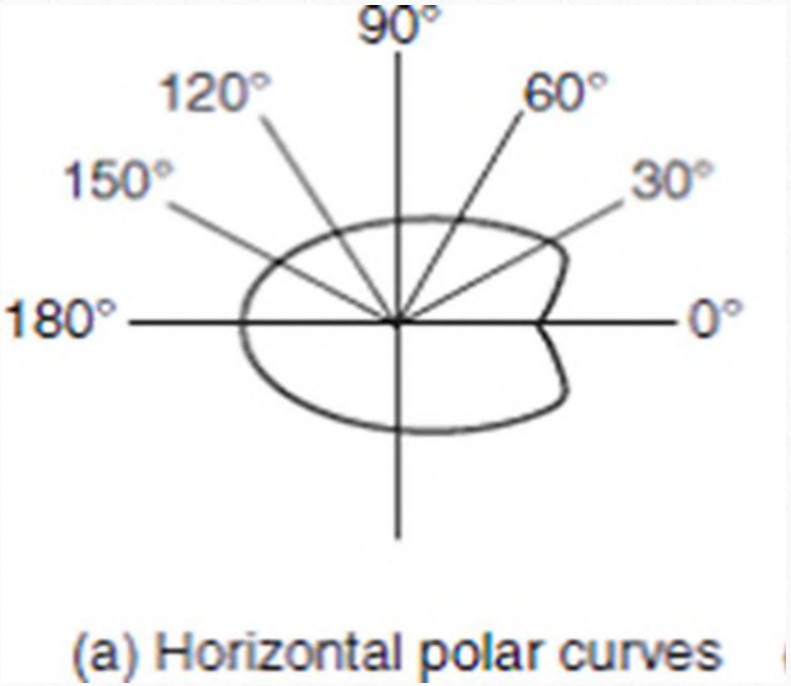
The polar distribution curve of a filament lamp in a horizontal plane



The polar curve represents the c.p. distribution in a vertical plane.

Determination of MHCP

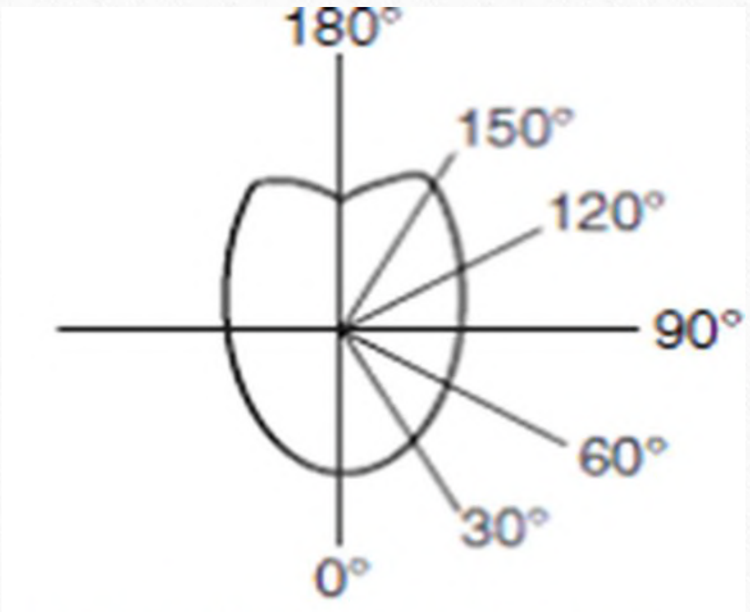
- The M.H.C.P. is taken as the mean of the readings.
- A more accurate result can be obtained by plotting candle power on an angular base along the rectangular axes and by determining the mean height of the curve by the mid-ordinate or by Simpson's rule.



The polar distribution curve of a filament lamp in a horizontal plane

Determination of MSCP

- The M.S.C.P. of the lamp can be obtained from the vertical polar curve by Rousseau's construction.



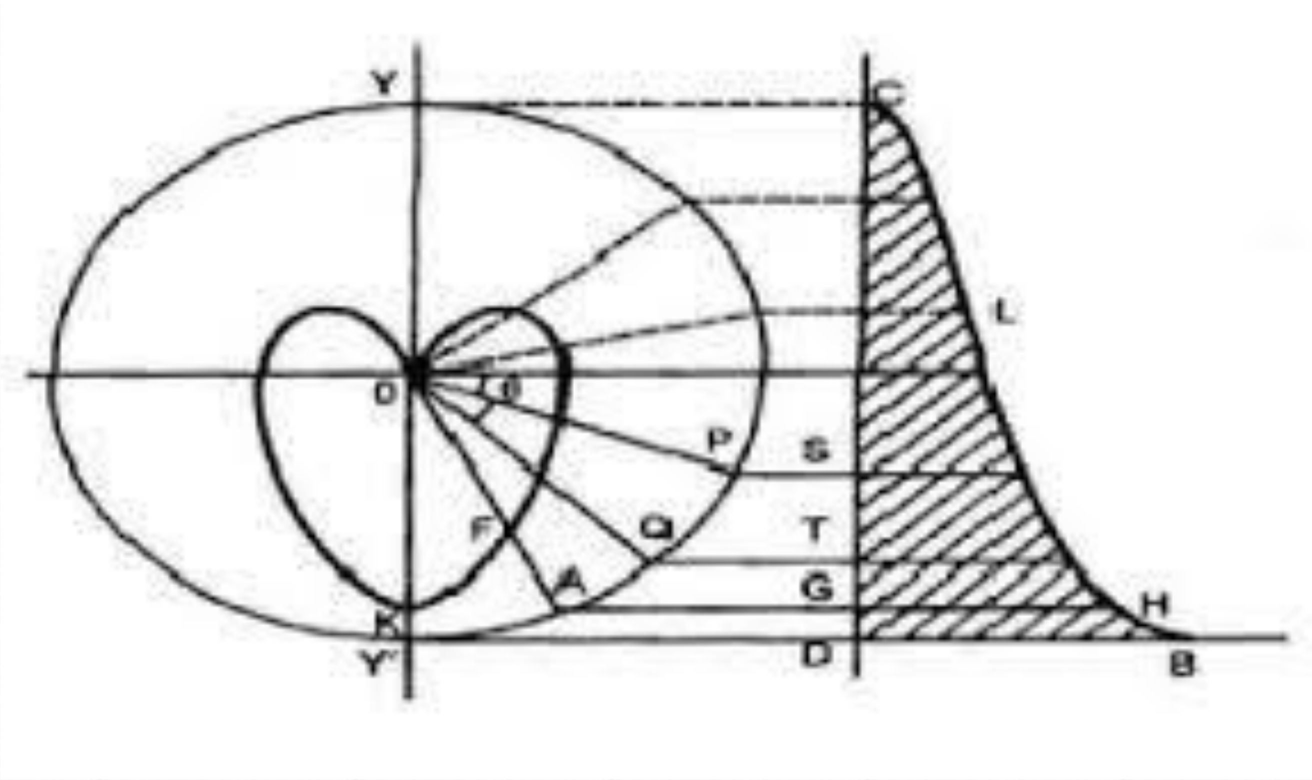
(b) Vertical polar curves

The polar curve represents the c.p. distribution in a vertical plane.

Determination of MSCP

$$MSCP = \frac{area\ of\ Rosseau\ figure}{length\ of\ the\ base}$$

$$= \frac{\textbf{Area CSTGDBHC}}{\textbf{Length CD}}$$



CD=YY'
DB=OK
GH=OF

The curve obtained by joining the ends of these ordinates is known as ***Rousseau Curve.***

Spherical Reduction Factor (f)

- Ratio of MSCP and MHCP

- For each filament lamp this is a definite value.

$$Spherical\ Reductin\ Factor, f = \frac{MSCP}{MHCP}$$

$$\therefore MSCP = f \times MHCP$$

Spherical Reduction Factor (f)

- Typical values of Spherical Reduction Factor (*f*) are :
  - *Ordinary vacuum-type tungsten lamp having zig-zag filament 0.76 – 0.78*
  - *Gas-filled tungsten lamp with filament in the form of broad shallow V's 0.85 – 0.94*
  - *Gas-filled tungsten lamp with filament in the shape of a horizontal ring 1.0 – 1.2*

MODULE 3

Design of Interior Lighting

3- SYLLABUS

III	Design of Interior Lighting : Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilisation and factors affecting it, Illumination required for various work planes, Space to mounting height ratio, Types of fixtures and relative terms used for interior illumination such as DLOR and ULOR, Selection of lamp and luminance, Selection of utilisation factor, reflection factor and maintenance factor Determination of Lamp Lumen output taking into account voltage and temperature variations, Calculation of wattage of each lamp and no of lamps needed, Layout of lamp luminaire, Calculation of space to mounting height ratio, Indian standard recommendation and standard practices for illumination levels in various areas, Special feature for entrance, staircase, Corridor lighting and industrial building	8	15%

• ***Maintenance Factor* / Depreciation Factor**

- Ratio of illumination under normal working conditions to the illumination when everything in clean or when the luminaire is installed.
- Always less than 1
- Due to the accumulation of dust, dirt and smoke on the lamps, lamps emit less light than they emit when clean.
- Frequent cleaning will improve the maintenance factor.
- Greater if the lamp fittings are cleaned regularly (0.8)
- If much dust is accumulated, it is 0.6
- **As a rule of thumb, 0.8 is chosen as a Maintenance factor.**

Quick Consideration of Maintenance factor

Room Classification	Lamp Maintenance Factor	Maintenance Factor for dirty lamp	Total Maintenance Factor
Very clean	0.09	0.85	0.9
Clean	0.9	0.9	0.8
Average	0.9	0.8	0.7
Dirty	0.9	0.7	0.6

Environment Activity or Task Area

Very Clean	Clean rooms, semiconductor plants, hospital clinical areas, computer centers
Clean	Offices, schools, hospital wards
Normal dirty	Shops, laboratories, restaurants, warehouses, assembly areas, workshops Steelworks, chemical works, foundries, welding, polishing, woodwork

Quick Consideration of Maintenance Factor

Enclosed fixture, clean room	0.80
Average conditions	0.70
Open fixture or dirty room	0.60

Utilization Factor / Coefficient of Utilization

- Ratio of the total number of lumens reaching the working plane to the total number of lumens emitting from the source
- Indicates the effectiveness of the lighting scheme.
- Depends on
  - Mounting height of the lamps- utilization factor decreases with increase in mounting height of lamps
  - Area to be Illuminated – for a given height, proportion of direct light becomes more and more if floor area increases i.e.., utilization factor increases with increase in area to be illuminated.
  - Type of lighting-more for direct lighting and low for indirect lighting
  - Colors of surroundings – more for light colors and less f or dark colors. Its value range from 0.25 to 0.5 for direct lighting and 0.1 to 0.25 for indirect lighting

Uniformity Ratio

- Ratio of maximum-to-minimum illumination levels
- IESNA# recommendation is 15:1, for parking lot. This means there can be 15 times more illumination when measured in one area of the parking lot compared to another.

IESNA: Illuminating Engineering Society of North America

- # *Direct Ratio*

- Proportion of the total downward flux from the luminaires which falls directly on the working plane.

• *<u>REFLECTION FACTOR</u>*

- The ratio of luminous flux leaving the surface to the luminous flux incident on it.

- Value will be always less than 1

• *Room Index*

- Measure of the angular size of the room
- Ratio of the sum of the plan areas of the F (Floor Cavity) and C surfaces (Ceiling Cavity) to the area of the W (Wall) surface.
- For rectangular rooms the room index is given by:

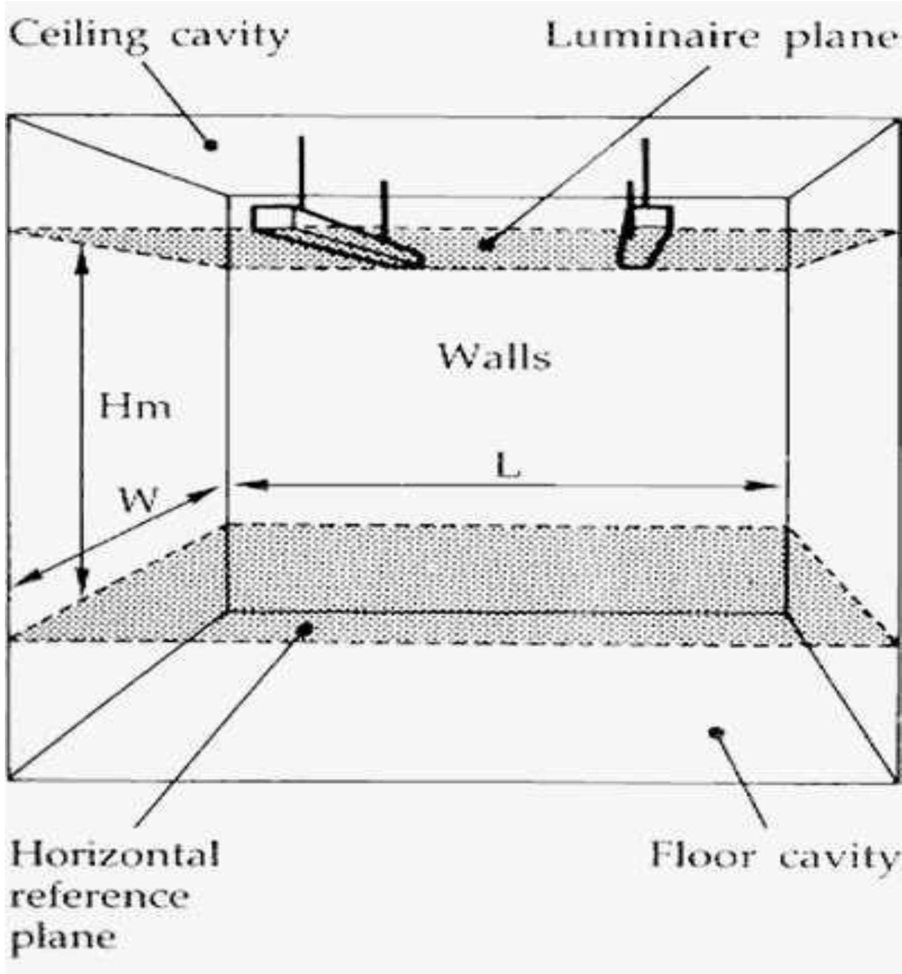
$$RI = \frac{L \times W}{(L + W)H_m}$$

Where:

L – the length of the room

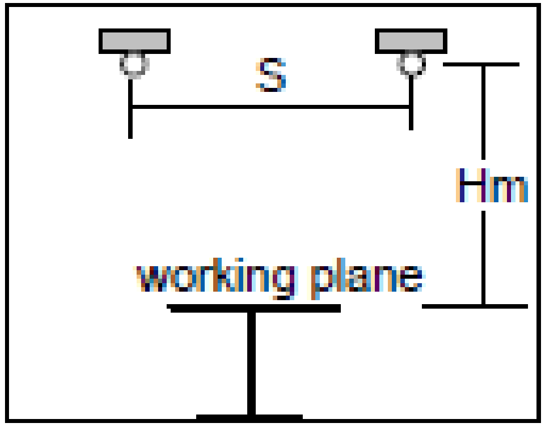
W – the width of the room

H_M – the height of the luminaire plane above the horizontal reference plane.



Space to Mounting Height Ratio (SHR)

- Ratio of distance between the adjacent luminaires (Center to center) to their height above the working plane



$$SHR = \frac{1}{H_m}\sqrt{\frac{A}{N}}$$

Where, H_M - Mounting Height
A – Total floor area
N- number of luminaires

- Maximum Spacing to Height Ratio
  - Luminaire spacing shall not exceed the maximum (provided by manufacturer) to endure uniformity.

Light Loss Factor

- Ratio of the illuminance produced by the lighting installation at the some specified time to the illuminance produced by the same installation when new
- Allows for the effects such as decrease in light output caused by
  - the fall in lamp luminous flux with hours of use,
  - the deposition of dirt on luminaire
  - reflectance of room surfaces over time.

LLMF – lamp lumen maintenance factor

LMF – Luminaire maintenance factor

RSMF – room surface maintenance factor.

• *Lamp Lumen Maintenance Factor (LLMF)*

- Proportion of initial light output of a lamp produced after a set time to those produced when new.
- Allows for the decline in the lumen output from a lamp with age.
- Determined by
  - Consulting the lamp manufacturer's catalog for a lumen depreciation chart.
  - Dividing the maintained lumens by the initial lamps.

Lamp Lumen Maintenance Factor (LLMF)

Lamp Type	Operating Hours				
	4000 Hr.	**6000 Hr.**	**8000 Hr.**	**10000 Hr.**	**12000 Hr.**
High Pressure Sodium	0.98	0.97	0.94	0.91	0.9
Metal Halide	0.82	0.78	0.76	0.74	0.73
High Pressure Mercury	0.87	0.83	0.8	0.78	0.76
Low Pressure Sodium	0.98	0.96	0.93	0.9	0.87
Tubular Fluorescent	0.95	0.94	0.93	0.92	0.91
Compact Fluorescent	**0.91**	0.88	0.86	0.85	0.84

• *Luminaire Maintenance Factor*

- Proportion of light output from a luminaire after a set time to the initial output from a lamp after a set time.
- Constitutes the greatest loss in light output
- Mainly due to the accumulation of atmospheric dirt.
- Factors determine LMF
  - Type of luminaire
  - Atmospheric conditions
  - Maintenance level.

Luminar Maintenance Factor (LMF)

Type of Distribution	Environment Condition	Expose Time					
		1 Year	2 Year	3 Year	4 Year	5 Year	6 Year
Open Distribution	Very Clean	0.96	0.94	0.92	0.9	0.88	0.87
	Clean	0.93	0.89	0.85	0.82	0.79	0.77
	Normal	0.89	0.84	0.79	0.75	0.7	0.67
	Dirty	0.83	0.78	0.73	0.69	0.65	0.62
Direct Distribution	Very Clean	0.95	0.92	0.89	0.86	0.84	0.82
	Clean	**0.9**	0.84	0.79	0.74	0.7	0.67
	Normal	0.86	0.8	0.74	0.69	0.64	0.6
	Dirty	0.83	0.75	0.68	0.62	0.57	0.53
Closed Distribution	Very Clean	0.94	0.91	0.89	0.87	0.86	0.85
	Clean	0.88	0.83	0.79	0.75	0.72	0.7
	Normal	0.82	0.77	0.73	0.69	0.65	0.62
	Dirty	0.77	0.71	0.66	0.61	0.57	0.53
Indirect-Distribution	Very Clean	0.93	0.88	0.85	0.82	0.79	0.77
	Clean	0.86	0.77	0.7	0.64	0.59	0.55
	Normal	0.81	0.66	0.55	0.48	0.43	0.4
	Dirty	0.74	0.57	0.45	0.38	0.33	0.3

Room Surface Maintenance Factor

- The proportion of the illuminance provided by the lighting installation in a room after a set time compared with that occurred when the room was clean.
- Takes into account the dirt accumulates on room surfaces and reduces surface reflectance.

Room Surface Maintenance Factor (Annual Clean) – RSMF

Type of Room	1 Year Room Clean		3 Year Room Clean	
	Direct Luminaires	Direct /Indirect Luminaires	Direct Luminaires	Direct /Indirect Luminaires
Very Clean	0.97	0.96	0.97	0.95
Clean	**0.95**	0.91	0.94	0.91
Normal	0.91	0.84	0.9	0.83
Dirty	0.86	0.75	0.86	0.75

Light Output Ratio of Luminaire

- Light Output Ratio (LOR)
  - A measure of light received outside the lamp
  - In other words it is the measure of amount of light lust inside the lamp/luminaire

- $LOR = \frac{Total\ Output\ of\ Luminaire}{Light\ Output\ of\ Lamp}$

- Downward Light Output Ratio (DLOR)

$$DLOR = \frac{Downward\ light\ output\ of\ luminaire}{Light\ output\ of\ Lamp}$$

- Upward Light Output Ratio (ULOR)

$$ULOR = \frac{UPard\ light\ output\ of\ luminaire}{Light\ output\ of\ Lamp}$$

$$\boldsymbol{LOR = DLOR + ULOR}$$

1Q : The total, upward and downward lamp output from a lamp are 1000lm, 300lm and 500lm respectively. Calculate LOR, ULOT, DLOR

Amount of light absorbed in luminaire = 100-80 = 20%

A greater DLOR means a higher UF (Utilization Factor)

Selection of Utilization Factor w.r.t. Room Reflectance and Room Index

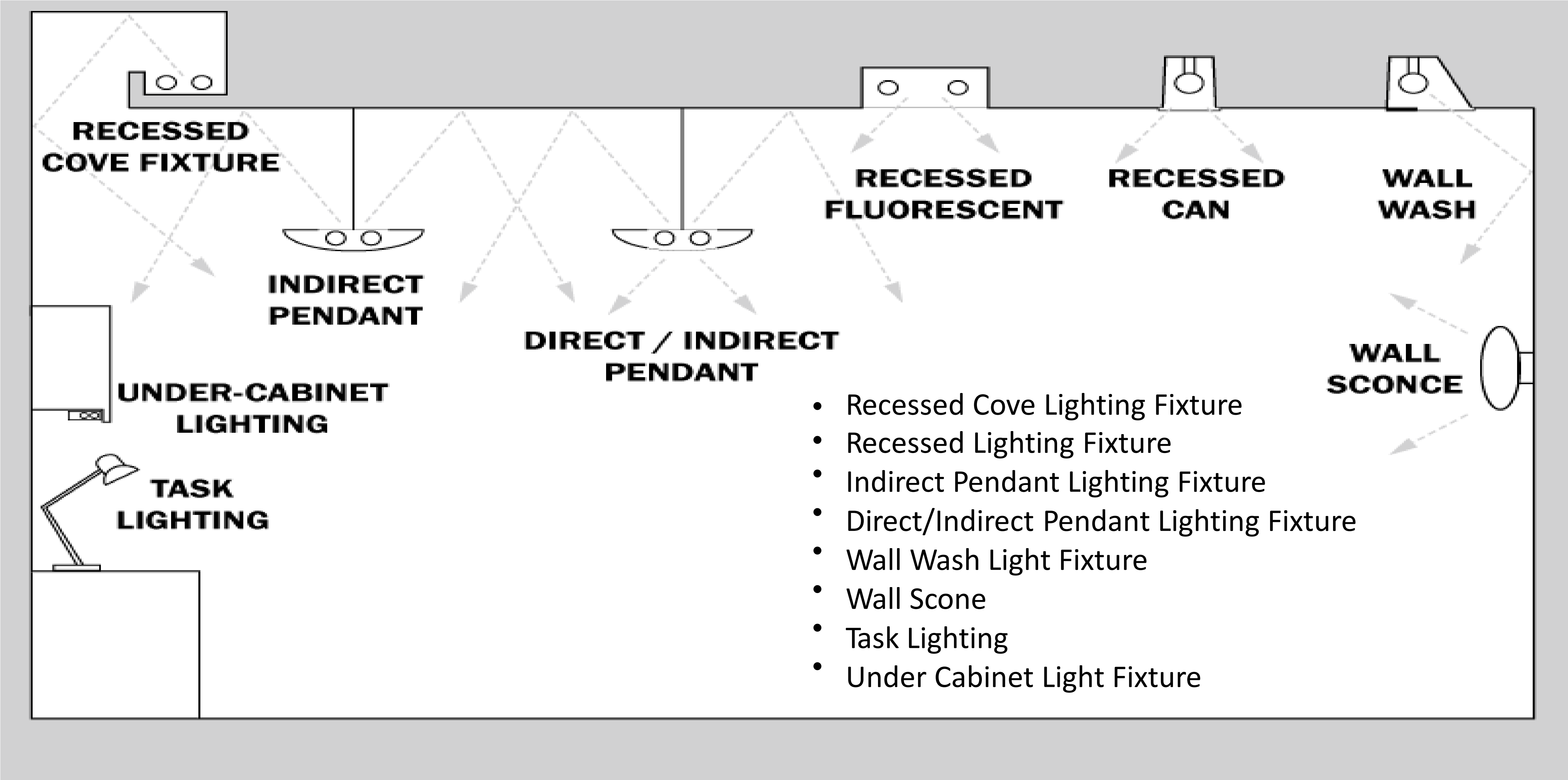
Utilization factor											
Room Reflectance			**Room Index**								
Ceiling	**Wall**	**Floor**	**0.75**	**1**	**1.25**	**1.5**	**2**	**2.5**	**3**	**4**	**5**
0.7	0.5	0.2	0.43	0.49	0.55	0.6	**0.66**	0.71	0.75	0.8	0.83
0.7	0.3	0.2	0.35	0.41	0.47	0.52	0.59	0.65	0.69	0.75	0.78
0.7	0.1	0.2	0.29	0.35	0.41	0.46	0.53	0.59	0.63	0.7	0.74
0.5	0.5	0.2	0.38	0.44	0.49	0.53	0.59	0.63	0.66	0.7	0.73
0.5	0.3	0.2	0.31	0.37	0.42	0.46	0.53	0.58	0.61	0.66	0.7
0.5	0.1	0.2	0.27	0.32	0.37	0.41	0.48	0.53	0.57	0.62	0.66
0.3	0.5	0.2	0.3	0.37	0.41	0.45	0.52	0.57	0.6	0.65	0.69
0.3	0.3	0.2	0.28	0.33	0.38	0.41	0.47	0.51	0.54	0.59	0.62
0.3	0.1	0.2	0.24	0.29	0.34	0.37	0.43	0.48	0.51	0.56	0.59
0	0	0	0.19	0.23	0.27	0.3	0.35	0.39	0.42	0.46	0.48

Selection of Lamp and Luminance

Types of Fixtures - Interior Lighting

- Recessed Cove Lighting Fixture
- Recessed Lighting Fixture
- Indirect Pendant Lighting Fixture
- Direct/Indirect Pendant Lighting Fixture
- Wall Wash Light Fixture
- Wall Scone
- Task Lighting
- Under Cabinet Light Fixture

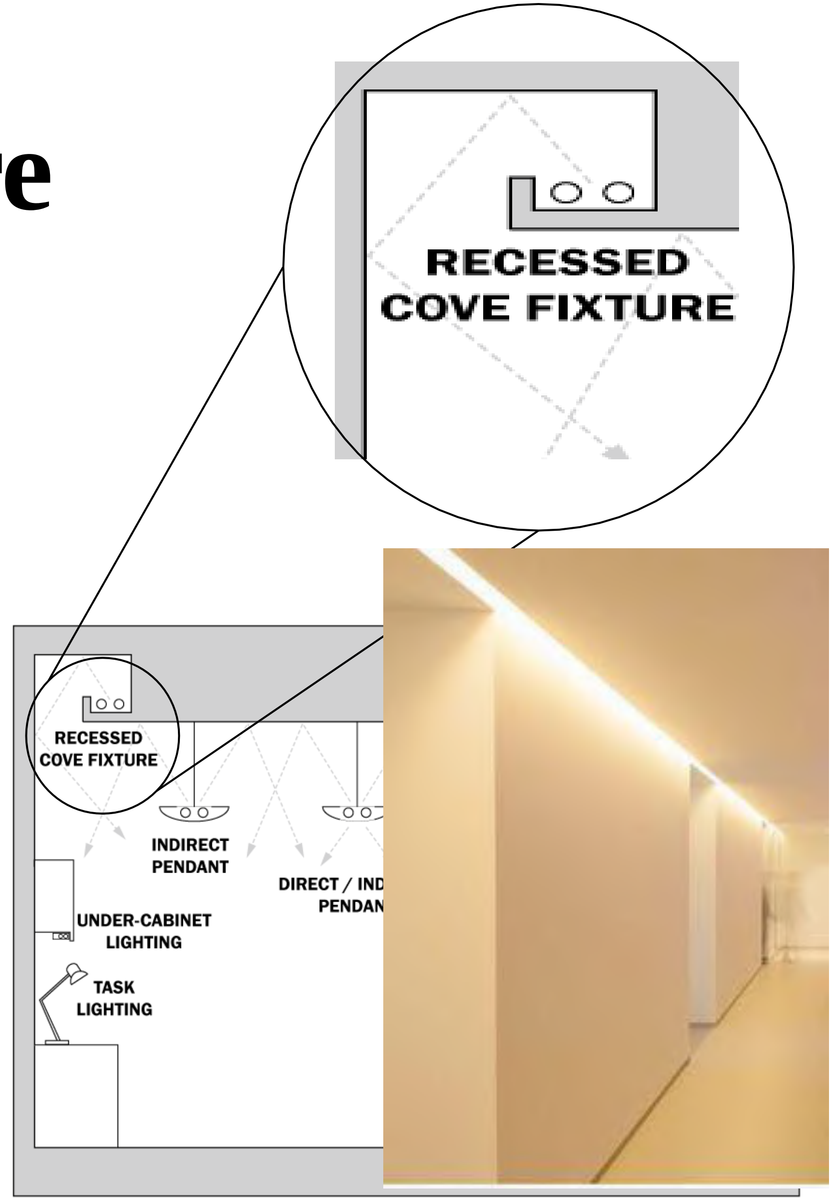
Types of Fixtures in Interior Lighting



- Recessed Cove Lighting Fixture
- Recessed Lighting Fixture
- Indirect Pendant Lighting Fixture
- Direct/Indirect Pendant Lighting Fixture
- Wall Wash Light Fixture
- Wall Scone
- Task Lighting
- Under Cabinet Light Fixture

1.Recessed #Cove Lighting Fixture

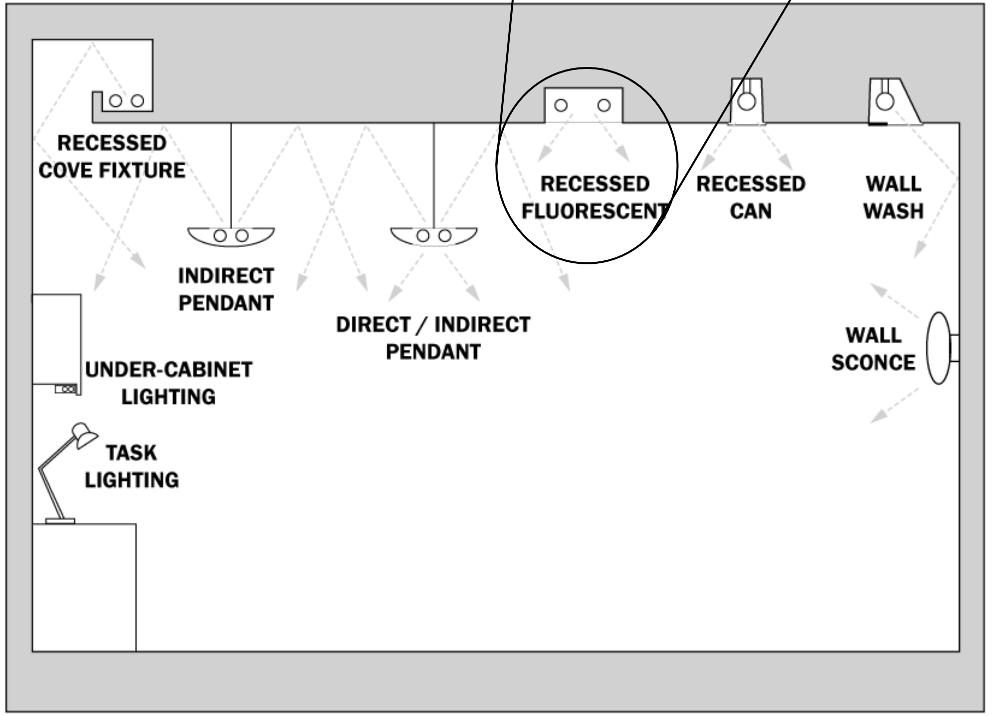
- Mounted in a light cove, which is built above the ceiling at the intersection of the ceiling and the wall.
- Directs the light toward the wall.
- It is important that trim at the edge of the cove is tall enough to hide the lighting fixture otherwise the lamp may be visible, which is unappealing.



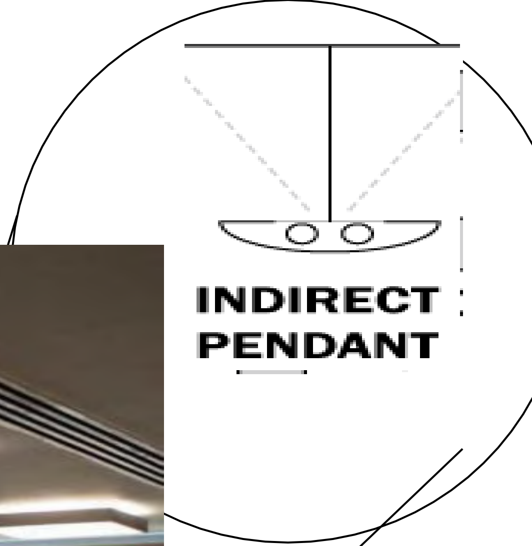
#Cove - a concave arch or arched moulding, especially one formed at the junction of a wall with a ceiling.

2.Recessed Lighting Fixture

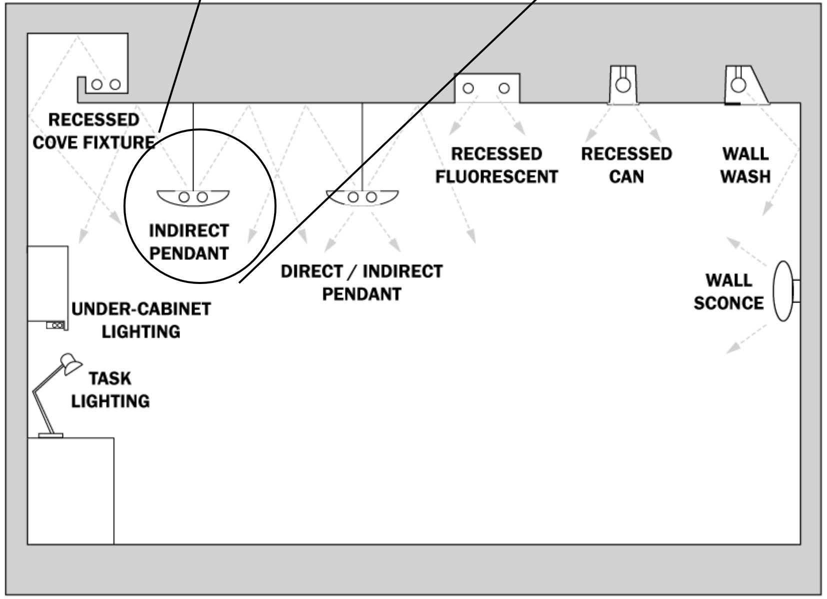
- Most common fixtures used in commercial and institutional construction.
- Fixtures are sized to work with common ceiling tile sizes.
- While fluorescent lamps have been most popular in the past, many facilities are shifting to LED fixtures because they last longer and require less maintenance.



3. Indirect Pendant Lighting Fixture

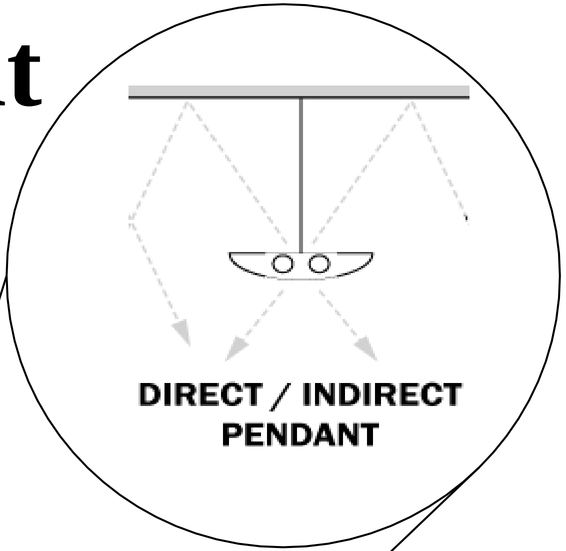


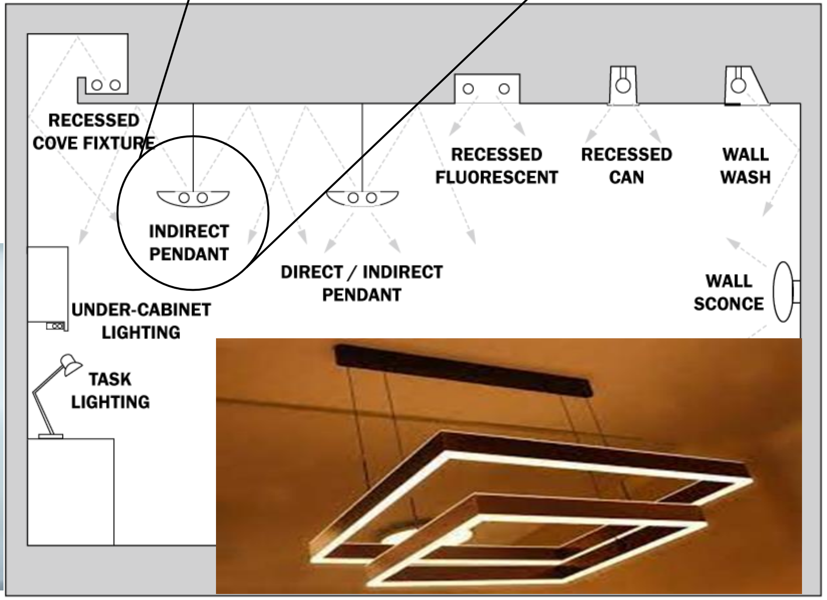
- Hang from the ceiling and are usually suspended from cables.
- The lamp is completely hidden from below and a reflector directs all of the light up toward the ceiling.
- This type of fixture offers a softer and more even distribution of light within the space.
- best used for general lighting
- not appropriate for task lighting.
- The ceiling color should be light so that it reflects as much light as possible.



4. Direct / Indirect Lighting Fixture Pendant

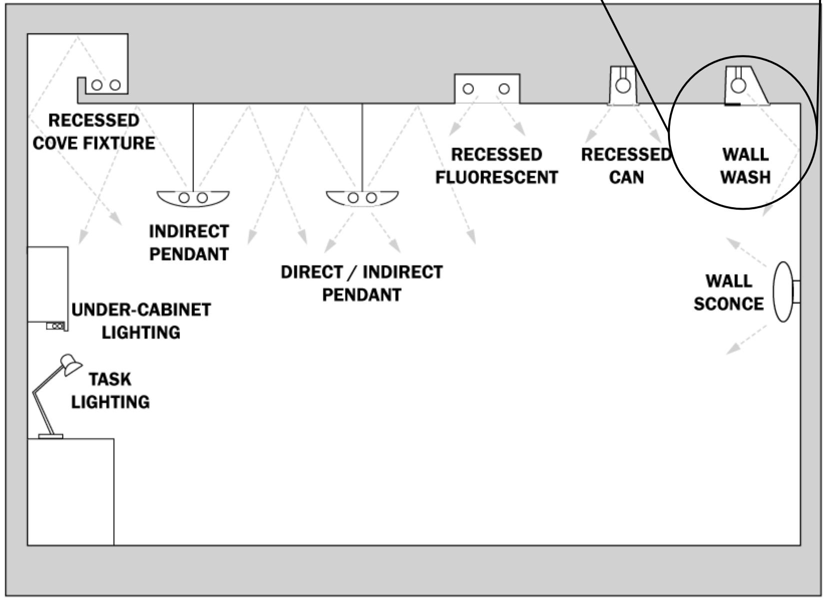
- hangs from the ceiling, but it directs light up and down.
- used a lot in offices where general lighting is required, but there is also a need for task lighting immediately below the fixture.
- designed in variations that distribute differing amounts of light up and down so that a designer has control over the light distribution.





5.Wall Wash Light Fixture

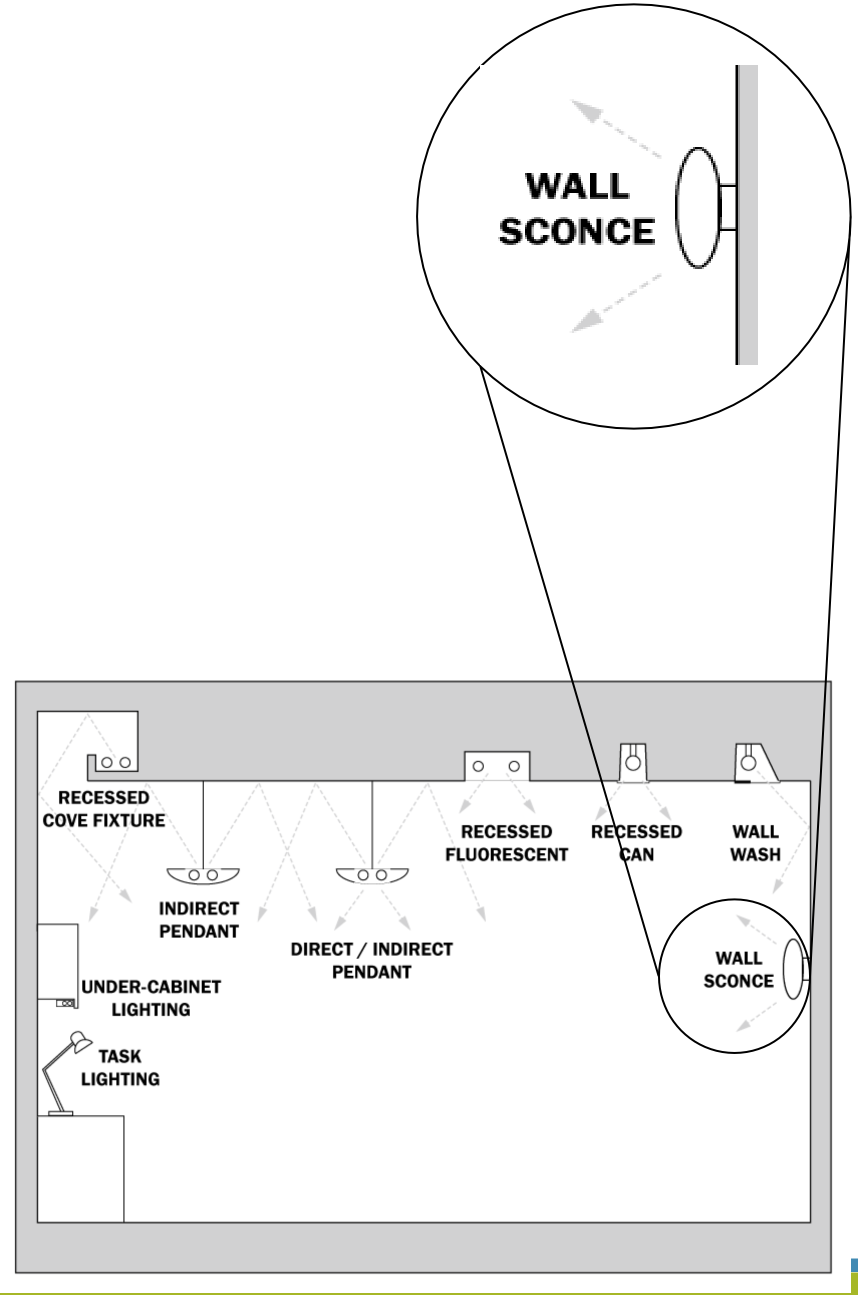
- Wall wash fixtures are recessed lights with reflectors that direct the light toward the wall.
- Most often used to highlight art, signage, or other items on a wall.



6. Wall Sconce

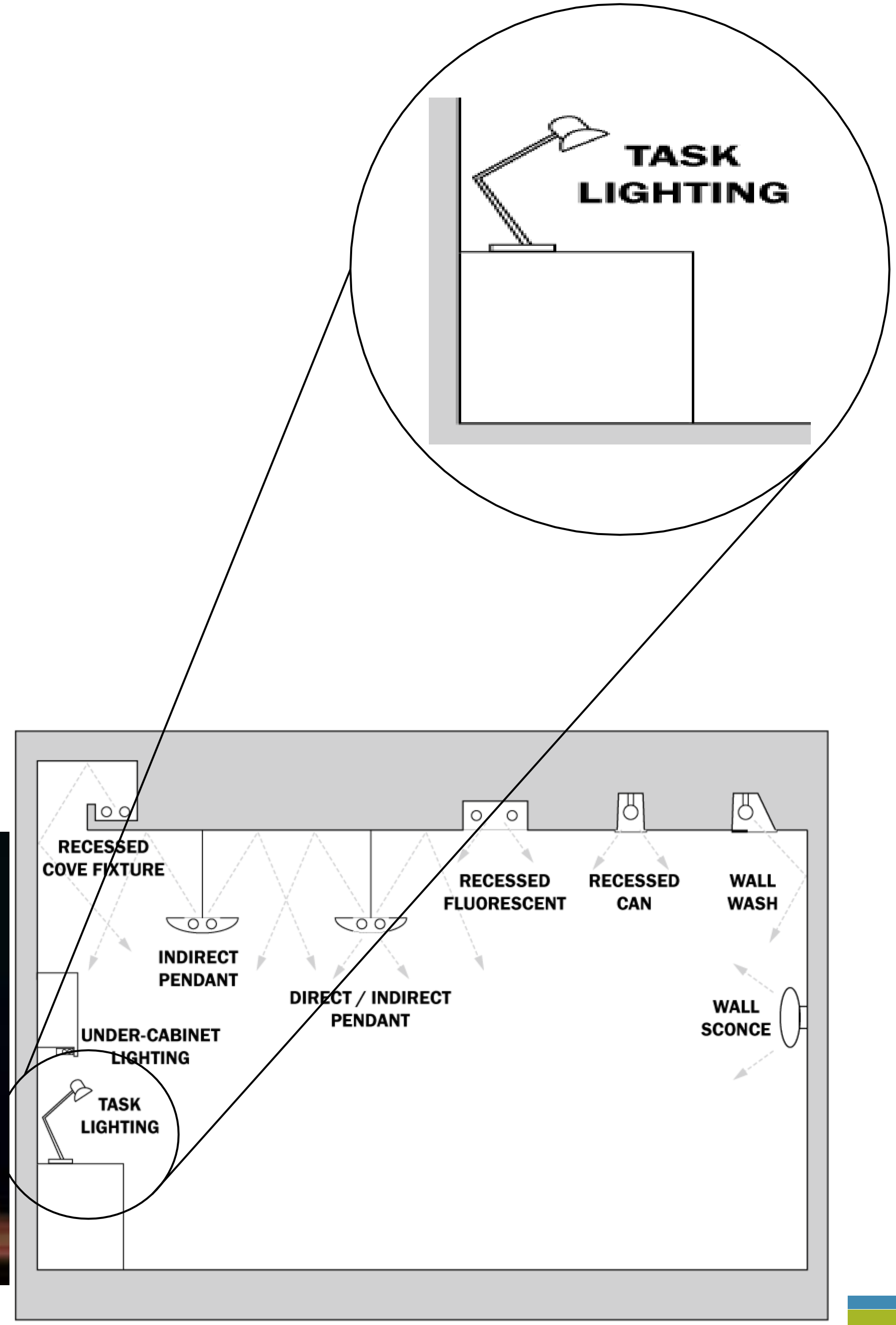
- A wall sconce is a decorative fixture that is mounted to a wall.
- Provide general room lighting, but are mostly decorative.



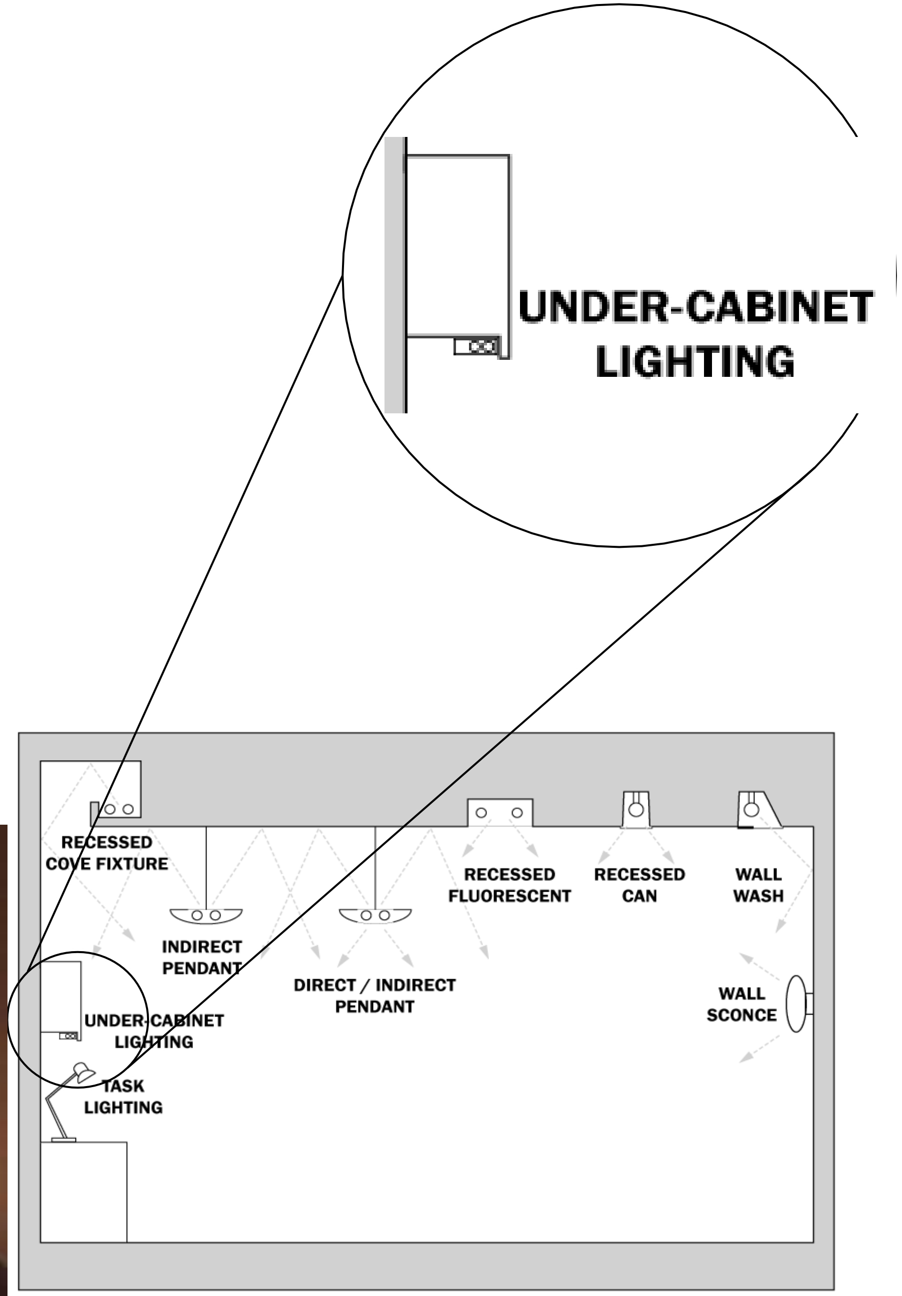
7. Task Lighting

- Generic description for lights that are used to illuminate specific tasks or work that is being done.
- Can be lamps, lights mounted to desks, under cabinet lights, or any lighting that helps people see their work better.



8.Under Cabinet Light Fixture

- Lights are often mounted below cabinets so that tasks on the counter below can be seen easily.
- Found in homes and offices
- Generally controlled from a nearby switch or a switch on the light fixture.



Lighting Calculations

<u>1. Point-by-point method</u>

2.Average Lumen Method

Lighting Calculations – Point by Point Method

- Simple but a number of assumptions must be made in the calculations.
- This method is true only for point source.
- For luminaries with asymmetrical Candle Power distribution, the CP distribution curve of the required vertical angle must be used.
- Application of rows of florescent lamps (linear source) will be unsuitable.
- Application of this method for interior lighting with number of luminaires will necessitate the use of computers, since contribution of luminaire at each location must be analyzed for all points in the room

Lighting Calculations – Point by Point Method

- This method does not take into account surface inter reflectance
- Consequently, this method is most suited for large areas, especially outdoor lighting where a few luminaires are involved and where no surface reflectance are to be accounted
- It can also be used effectively in interior where task lighting is to be calculated on a surface lighted by a few luminaires and where the room has negligible surface reflectance

Lighting Calculations

2. Average Lumen Method

Lighting Calculations – Average Lumen Method

- This method offers a much more simplified way of calculating an average uniform illuminance level on a plane in interiors
- In many applications complete information regarding the task location or the type of activities may not be readily available
- In such cases it is necessary to provide an average uniform lighting throughout the room
- This method takes into account the effects of surface reflectance and offers a simplified and accurate method of quantity evaluation for interiors

Lighting Calculations – Average Lumen Method

- This method is developed from the basic definition of Lux – **One lux is the illuminance on a surface of one square metre having a light flux on one lumen.**

$$\frac{}{A}$$

Where
L – luminous flux in lumens
A – Area in sq. metre

Lighting Calculations – Average Lumen Method

- Considering the Utilization Factor (UF) and Light Loss Factor (LLF)

$$\frac{\qquad \times \qquad}{A}$$

Where
L – luminous flux in lumens
A – Area in sq. metre
UF – Utilization Factor
LLF – Light Loss Factor

Lighting Calculations – Average Lumen Method

- In case of more than one light source in a room, the expression is modified as,

Where
N – Number of Luminaire
�� - Initial Lumen output per luminaire
L – luminous flux in lumens
A – Area in sq. metre

Lighting Calculations – Average Lumen Method

- From the above, it is obvious that for a given level of illuminance and area, the only means of reducing the number of luminaires is by using the highest values of Ln, UF and LLF The lower the number of luminaires the less the power consumption
- A lighting designer must, therefore look at all aspects of luminaire selection to determine which will offer the highest values of three critical factors, viz Ln, UF and LLF.

Lighting Calculations – Average Lumen Method

- The only way of obtaining maximum lumen is the proper selection of light source
- The largest lumen producing source appears to be the immediate choice
- But this should not be the only criterion Colour rendering, lumen maintenance, life and cost are some of the other features that also have to be considered

Lighting Calculations – Average Lumen Method

- The surface reflectance and room proportions will have marked effect on CU values
- Ceiling reflectance has the most significant effect on CU values with luminaires that produce light upwards, indirect and direct indirect type of luminaires fall in this category
- Wall reflectance has significant effect on almost all luminaires, and particularly for luminaires with wide spread distribution
- Floor reflectance has least effect on CU values, since most tasks are located above work plane

Lumen Method Calculation

Lumen Method Calculation

- Based on the fundamental lighting calculations
- Average Illumination on a horizontal working plane,

Where,

E – average illumination over the horizontal working plane.

n – number of lamps in each luminaire

N-Number of luminaire

F – lighting design lumens per lamp, i.e.. Initial bare lamp luminous

UF – utilization factor

LLF – light loss factor

A - area of the horizontal working plane.

LIGHTING DESIGN BY LAMP LUMEN METHOD

Steps - LAMP LUMEN METHOD

1. Find required lux level
2. Select luminaire
3. Determine room index
4. Determine Number of Fixtures

Where,
N = number of lamps required. (nXN)
E = illuminance level required (lux)
A = area at working plane height (m2)
F = average luminous flux from each lamp (lm)
UF = utilization factor,
MF = maintenance factor,

5. Determine Minimum spacing between luminaire

Minimum spacing = SHR * Hm

Where,
Hm= Mounting height
= Space to height ratio.

Contd.....Steps - LAMP LUMEN METHOD

6. Determine Number of required rows of luminaire along width of the room

   $$\text{Number of required rows} = \frac{\text{width of the room}}{\text{Minimum spacing}}$$

7. Determine Number of luminaire in each row

   $$\textit{Number of luminaire in each row} = \frac{\textit{Total luminaire}}{\textit{Number of rows}}$$

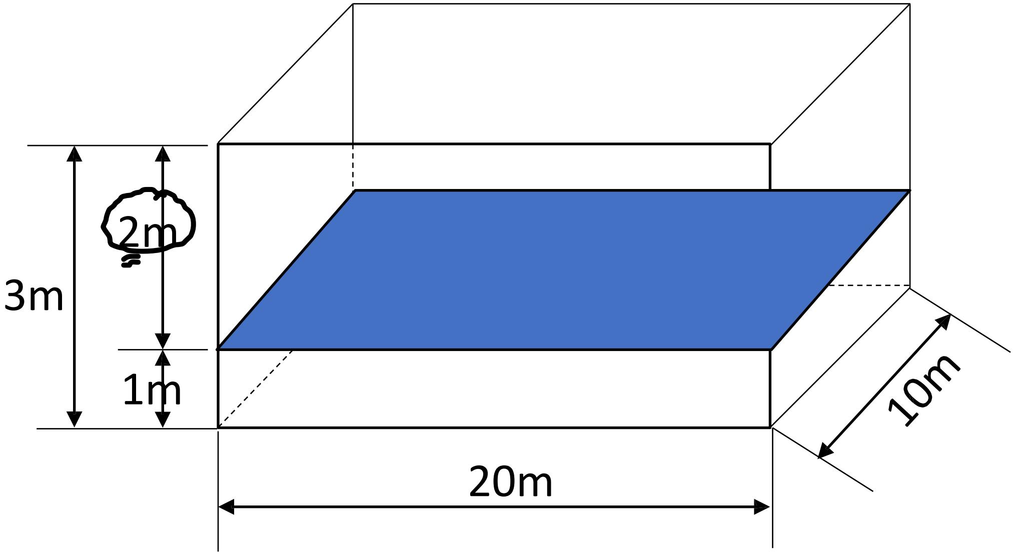
8. Axial spacing along luminaire

   $$\textit{Axial spacing} = \frac{\textit{Length of the room}}{\textit{Number of luminaire in each row}}$$

9. Transverse spacing between luminaire

   $$\textit{Transverse spacing} = \frac{\textit{Width of the room}}{\textit{Number of luminaire in each row}}$$

. 1Q. An office has dimension 20x10x3m. Ceiling to desk height is 2m.Area to be illuminated to a general is 250 lux using twin lamp 32 watt CFL Luminaire with a SHR of 1.25. Each lamp has an initial output of 85 lumen per watt. Maintenance factor is 0.63, Utilization factor is 0.69. Design a lighting system for this office.



Steps :

1. Required lux = 250 lux (given).
2. Select luminaire
   - Twin lamp 32W CFL luminaire (given).
3. Room Index Calculations:

$$RI = \frac{(l \times w)}{(l+w)H_m} = \frac{20 \times 10}{(20+10)2} = 3.33$$

$l = 20$, $b = 10$, $h = 3m$, $H_m = 2m$.

$E = 250$ lux, $SHR = 1.25$.

$M.f = 0.63$, $U.f = 0.69$.

4. Number of luminaire, $N = \frac{E \times A}{F \times UF \times MF}$ $= \frac{250 \times l \times w}{85 \times 32 \times 2 \times 0.69 \times 0.63}$

$F = \text{Efficacy} \times W$

$F = 85 \times 32 \times 2$. (Twin)

$= 21.14 \sim \underline{21}$ luminaire

5. Minimum Spacing b/w luminaire,

$SHR = \frac{\text{Spacing}}{H_m}$.

$\text{Spacing} = SHR \times H_m$

$= 1.25 \times 2 = \underline{2.5\,m}$.

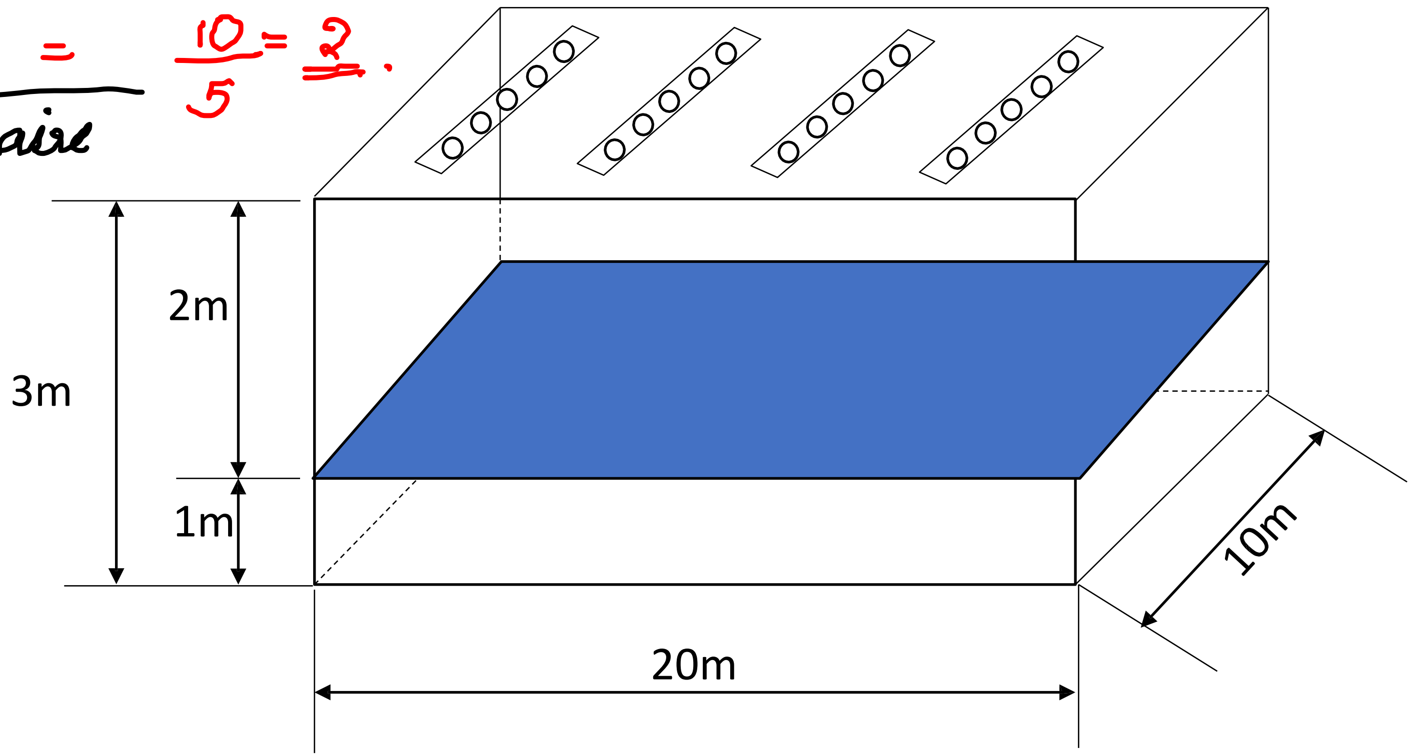
6. No. of rqd rows along the width of the room,

$= \frac{\text{Width}}{\text{Spacing}} = \frac{10}{2.5} = \underline{4}$.

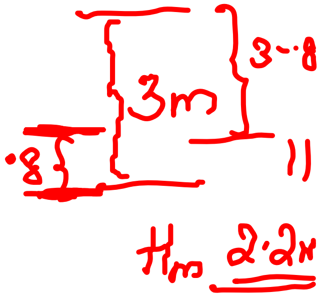
7. Number of luminaire in each row = $\frac{\text{Total luminaire}}{\text{Number of rows}} = \frac{21}{4} = 5.2 \approx 5$.

8. Axial Spacing = $\frac{\text{Length}}{\text{No. of luminaire in each row}} = \frac{20}{5} = 4$.

9. Transverse Spacing = $\frac{\text{Width}}{\text{No. of Luminaire}} = \frac{10}{5} = 2$.



. 2Q. The office measures 10*7 m with a floor to ceiling height of 3m. The working plane height is 0.8m. Office is being used for general office duties including some computer use. Determine number of luminaires required in this office



Room index	0.75	1.0	1.25	1.5	2.0	2.5	3.0	4.0	5.0
Room reflectances C W F									
70 - 50 - 20	0.36	0.42	0.47	0.51	0.56	0.60	0.63	0.66	0.69
30	0.31	0.36	0.42	0.46	0.52	0.56	0.59	0.63	0.66
10	0.27	0.32	0.37	0.41	0.47	0.52	0.55	0.60	0.63
50 - 50 - 20	0.33	0.38	0.43	0.46	0.51	0.54	0.57	0.60	0.62
30	0.29	0.34	0.38	0.42	0.51	0.51	0.53	0.57	0.59
10	0.25	0.30	0.35	0.38	0.44	0.48	0.50	0.54	0.57
30 - 50 - 20	0.31	0.35	0.39	0.42	0.46	0.49	0.51	0.54	0.55
30	0.27	0.31	0.35	0.38	0.43	0.46	0.48	0.52	0.54
10	0.23	0.28	0.32	0.35	0.40	0.44	0.46	0.50	0.52
0 - 0 - 0	0.20	0.24	0.28	0.30	0.34	0.37	0.39	0.42	0.44

1. Recommended lux level for office = 300 ~ 500lux(standard) ∴ E = 500 lux
2. Luminaire selection:Fluorescent lamp or LED

3. Room Index, $R.I = \frac{l \times w}{(l+w)H_m} = \frac{10 \times 7}{(10+7)\,2.2} = 1.87$

From the table, for a room index of 1.87, the utilization factor will be 0.54 , M.F = 0.8, Consider

Considering, reflection factor as 70% Ceiling, 50% Walls, & 20% Floor

UF = 0.54

$\frac{.51 + .56}{2}$

Room index	0.75	1.0	1.25	1.5	2.0	2.5	3.0	4.0	5.0
Room reflectances C W F									
70 - 50 - 20	0.36	0.42	0.47	0.51	0.56	0.60	0.63	0.66	0.69

From the Table : Average of 0.51 & 0.56 as 1.87 lies between 1.5 & 2.0

4. Number of Luminaires required =

$$= \frac{E \times A}{f \times Uf \times Mf} = \frac{500 \times 10 \times 7}{2600 \times .54 \times .8} = 31 \text{ luminaire}$$

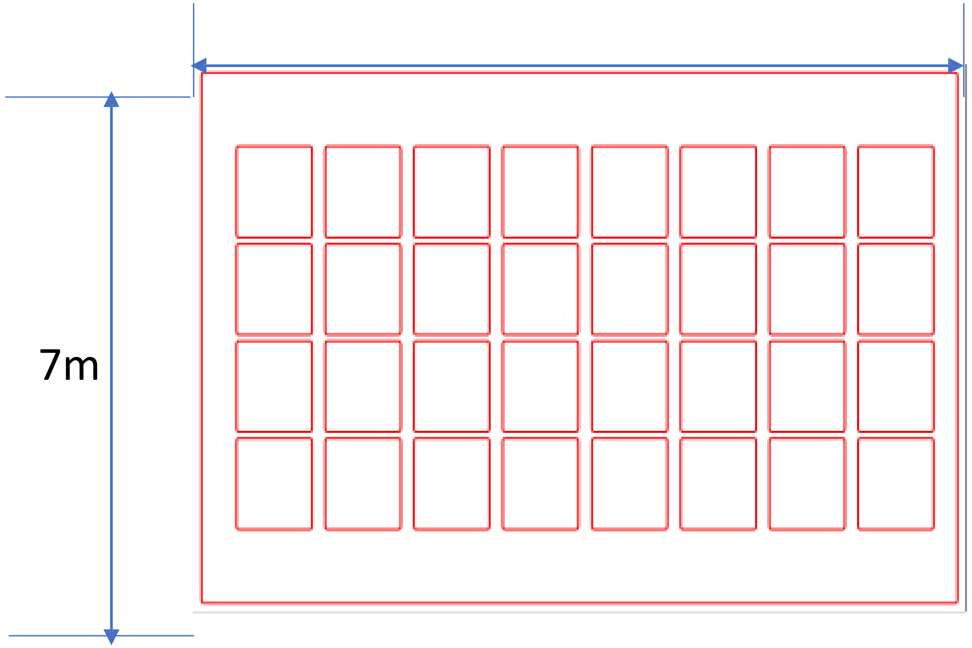
Assume:

1. Maintenance Factor = 0.8, that that the office is clean and the luminaires are well maintained.
2. LED lights of 30W providing 2600lumen output, F = 2600

Given 1.25 consider

5. Spacing = SHR × Hm

$$= 1.25 \times 2.2 = 2.75$$



6. No. of rows $= \frac{\text{Width}}{\text{Spacing}} = \frac{7}{2.75} \approx 3$

7. No. of luminaire in each $= \frac{N}{\text{No. of rows}} = \frac{31}{3} = 10$

31 luminaries are arranges in a 4X8 array,
3 rows of luminaries with each row containing 10 lamp

.3Q. An office 10X5m requires an illumination level of 300lux (E_{s}) on the working plane. It is proposed to use 40Watt fluorescent fittings having a rated output of 2440lumens each. Design the lighting scheme.

1. Rqd illum = 300 (given).
2. Luminaire : 40W fluroscent, F = 2440 lumens
3. Hm is not given, $RI = \frac{l \times w}{(l+w) H_m}$
4. $N = \frac{E \times A}{f \times Uf \times MF} =$ (M.F = 0.8, U.f = 0.5).

$= \frac{300 \times 10 \times 5}{2440 \times 0.8 \times 0.5} = 15.39 \sim 15$ luminaire.

.4Q. Design an illumination system for an office of 150 sq. Ft. area, need to have a specific lamp that has 2440 lumens to achieve 40 lux.

• Rqd lux = 40 lux. $A = 150$, $Uf = 0.5$, $M.f = 0.8$

• $N = \frac{E \times A}{f \times Uf \times Mf} = \frac{40 \times 150}{2440 \times 0.5 \times 0.8} \approx 6.14 \approx$ 6 lumai.

6 fittings of 40W fluorescent lamps

6 numbers of single lamp luminaire

3 numbers of double (Twin.) lamp luminaire

2 numbers of three lamp luminaire

A drawing hall 40mx25mx6m is to be illuminated with metal filament gas filled lamps to an average illumination of 90lm/m^2 on a working plane 1m above the floor. Estimate suitable number, size and mounting height of lamps. Sketch the spacing layout. Assume CU=0.5, DF=1.2 and space-height ratio =1.2. (10)

Size of lamps:	200W	300W	500W
Luminous efficiency: (in lm/W)	16	18	20

$A = 40 \times 25$, $h = 6m$

$h_m = 6 - 1 = 5m$.

$C.U = UF = 0.5$

$DF = MF = LLF = 1.2$

$SHR = 1.2$

Design

1. Rqd lux = 90 lux.
2. Select luminaire
   Metal filament gas filled lamps of 200W, 300W, 500W.
3. $RI = \frac{l \times w}{(l + w) h_m} = \frac{40 \times 25}{(40+25) 5} = 3$.

4. No of luminaire $N = \frac{E \times A}{f \times UF \times MF}$

- Gross lumen Rqd (GLR) = $\frac{A \times E \times DF}{UF} = \frac{90 \times 40 \times 25 \times 1.2}{0.5} = 216000$

W: 200W   300   500 W

Efficacy: $\times$ 16 $\times$ 18 $\times$ 20

- Total lumens = 3200   5400   10,000

- No. of luminaire = $\frac{GLR}{\text{Total lumens}}$

- for 200W, $N = \frac{216000}{3200} = 68$ lamps
- 300W, $N = \frac{216000}{5400} = 40$ lamps
- 500W, $N = \frac{216000}{10000} = 22$ lamps ✓ More Suitable.

$SHR = \frac{1}{h_m}\sqrt{\frac{A}{N}}$

$1.2 = \frac{1}{5}\sqrt{\frac{40 \times 25}{N}}$

$N = 27$ lamps.

6. No. of rows = $\frac{Width}{Spacing} = \frac{25}{6} = 4$ rows.

7. No. of luminaire in each row = $\frac{N}{rows} = \frac{22}{4} = 5$ lamps in each row.

8. Axial Spacing = $\frac{Length}{N} = \frac{40}{22} = 2\,m$

9. Transverse Spacing = $\frac{Width}{N} = \frac{25}{22} = 1.2\,m$

Design Layout

draw Layout here.

The Kinfra apparel park provides space area of 40 m long, 20 m wide and 8 m in height to a textile company. The luminaires are suspended 1.5 m below ceiling level. The sewing machines are placed 1 m high from the floor level. Calculate the minimum number of luminaires which must be installed to conform a recommend SHR (Space height ratio) of 1.5 : 1. Clearly show the layout of the luminaires.

(10 marks)

Entrance Lighting

- Entryway to home gives guests their first impression of interior space.
- Chandeliers, ceiling fixtures, recessed lighting, table lamps, variety of light fixtures.
- Considering the scale of the entryway along with any furniture, artworks or mirrors that you might want to highlight.
- Select fixtures that complement the architecture and design of your home while casting the right glow.

Entrance Lighting

- Avoid potlights/downlights, which can create high contrast shadows.
- Use accent lighting on artwork.
- Consider using tracks lighting to create a wall wash.
- A pendant light near the door can create a welcoming area.
- Make sure switches are easily accessible.
- Use LEDs and CFLs to save money, as these lights are on for extended periods of time.

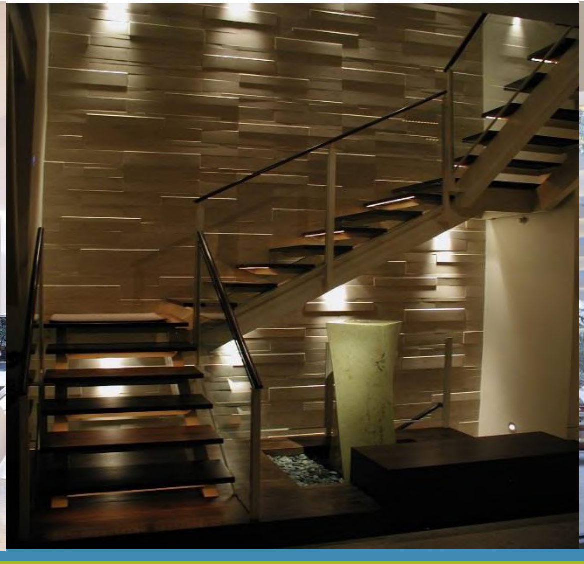
Staircase lighting

- Stairs, are the most functional yet the most ignored part of our homes.
- A well-lit stairway can be more than just a beautiful piece to look at, it serves as a safety feature while still bringing your interiors together and making it look cohesive.
- Wall light, Recessed light, Strip light, Pendant lights




Staircase Lighting

- Staircase lightening- functional and can add creative lighting.
- Problematic areas into an instant highlight with the perfect nighttime landscape.
- Adding lights in the steps is about adding highlights in décor, and is also a security measure.
- It can be as simple as adding lights on every step.
- Safety is first and for that case, therefore the lighting should show the separation between steps.
- Following are some Staircase Lighting Design:

Corridor Lighting

- Corridor lights provides wide light and makes the corridor look attractive.
- Provide economic and efficient solution by using intelligent light management system.
- Relatively high brightness is required
- All entry points are covered and there is complete coverage.
- Using ‘corridor hold’ to link illumination levels to occupancy in adjacent areas
- Whether lights should be off or at a set-back level when unoccupied.
- Availability of natural light – switch off, hold off or regulate the luminaires accordingly.



Module 4
Street / Road Lighting

Street Light Design

- Design of street lighting such that people can safely continue their travels on the road.
- Provide sufficient light for people to see important objects required for traversing the road
- Reducing the risk of night-time accidents
- Assisting in the protection of buildings/property (discouraging vandalism)
- Discouraging crime
- Creating a secure environment for habitation

Basic Features of Street Light Luminaires

- Mounted horizontally and have fixed vertical aiming.
- Have particular intensity distributions which are desired to light long narrow horizontal stripes on one side of the luminaire, while minimizing the intensities on the other side of the luminaire.
- The intensity distributions up and down the narrow strip are generally the same.
- Any fixed aimed luminaire which does not have this type of intensity distribution is called an area luminaire.

Main Objectives of Street Lighting Design Scheme

- Perfect visual sensation for safety
- Illuminated environment for quick movement of the vehicles
- Clear view of objects for comfortable movement of the road users.

Lamps Used in Street Lighting

- High pressure sodium lamp
- Metal Halide Lamps
- Low pressure sodium lamps
- Incandescent Lamp (not recommended)
- LED





Main Factors in the Street Lighting Design Scheme

- Luminance Level Should be Proper
- Luminance Uniformity must be Achieved
- Degree of Glare Llimitation is always taken into Design Scheme
- Lamp Spectra for Visual Sharpness depends on the Proper Luminaries
- Effectiveness of Visual Guidance

Luminance Level Should be Proper

- Luminance always influences the contrast sensitivity of the obstructions with respect to the back ground. If the street is brighter, then darker surroundings makes the car driver adapted, unless the driver will be unable to perceive the objects in the surroundings. As per CIE, 5m away from the road on both sides will be lit by Illuminance level at least 50% of that on the road.

Luminance Uniformity must be Achieved

- To provide visual comfort to the viewer’s eyes, enough luminous uniformity is needed. Luminous uniformity means the ratio between minimum luminance level to average luminance level, i.e.

$$U_0 = \frac{L_{min}}{L_{max}}$$

- It is termed as longitudinal uniformity ratio as it is measured along the line passing through the viewers position in the middle of the traffic facing the traffic flow.

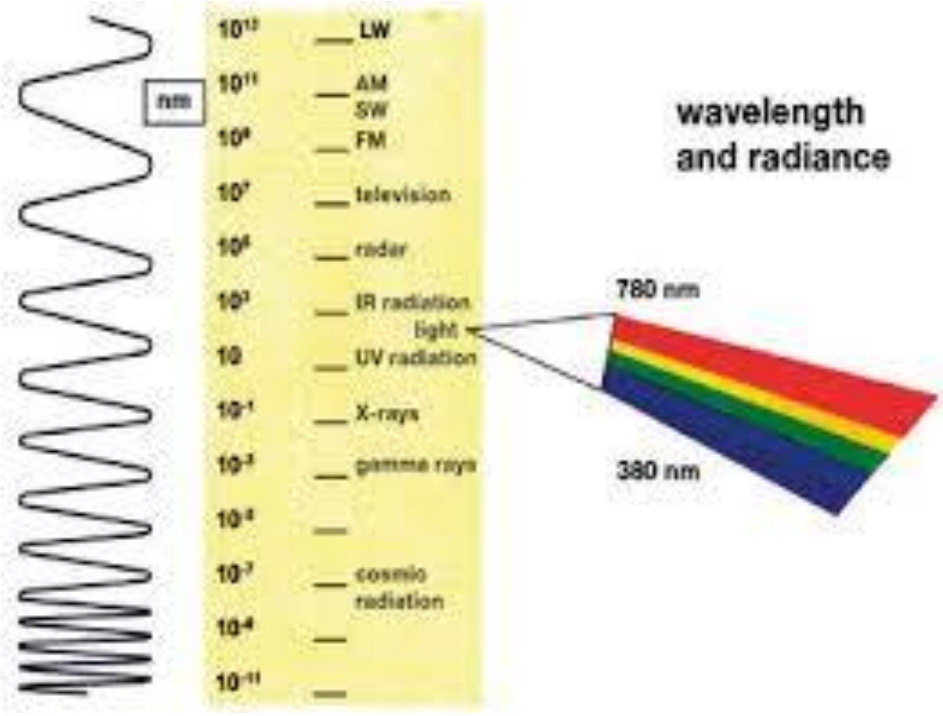
Degree of Glare Limitation is always taken into Design Scheme

- Glare means visual discomfort due to high luminance.
- 2 types of glare created by the street light luminaires,
- 1st disability glare
- 2nd discomfort glare.
- Disability glare is not a strong factor, rather discomfort glare is a common factor due to unplanned street lighting scheme.



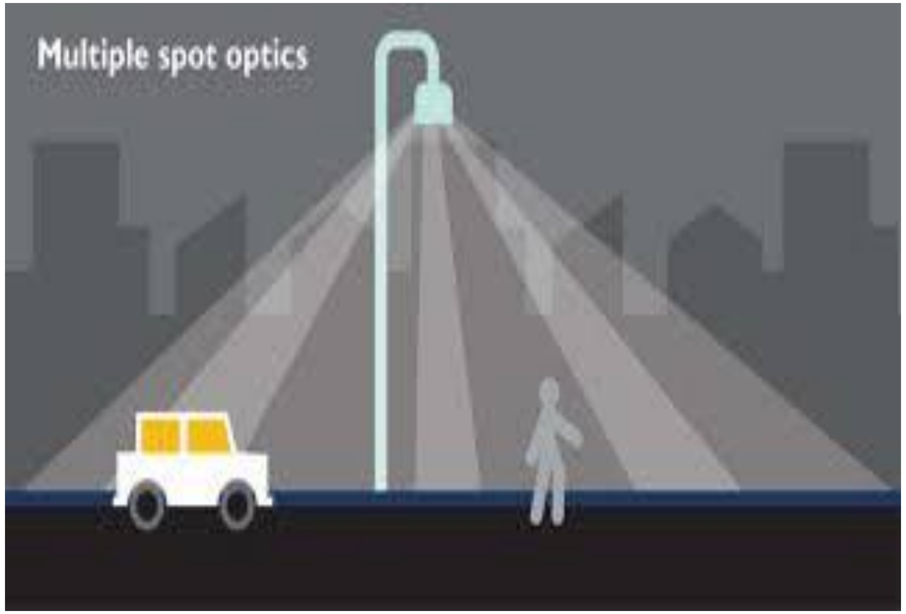

Lamp Spectra for Visual Sharpness depends on the Proper Luminaries

- It is very much essential to make an object as per its size and dimension.



Effectiveness of Visual Guidance is alsoan important factor

- It helps a viewer to guess how far another object is from his position.



Types of Road to Implement Various Street Lighting Design Schemes

- As per CIE 12 roads are broadly classified into five types.
  - Type A of Street Lighting Design
  - Type B of Street Lighting Design
  - Type C of Street Lighting Design
  - Type D of Street Lighting Design
  - Type E of Street Lighting Design

- ***Type A of Street Lighting Design***

    - Heavy and high speed traffic.
    - The roads are separated with the separators.
    - No crossing is allowed.
    - Controlled access
    - As the example: express ways.

- ***Type B of Street Lighting Design***

- Heavy and high speed traffic.
- Separate road for slow traffic movement or pedestrians.
- As the example: Trunk road.

- *<u>Type C of Street Lighting Design</u>*

- Heavy mixed traffic with moderate speed.
- Rural and urban roads.
- As the examples: Ring Road or Radial Road.

- *<u>Type D of Street Lighting Design</u>*

- Slow traffic and pedestrians' purpose.
- Road in the city or shopping center.
- As the example: Shopping streets.

- ***Type E of Street Lighting Design***

- Mixed Traffic with limited speed.
- Connector road between residential areas.
- As the example: Local street.

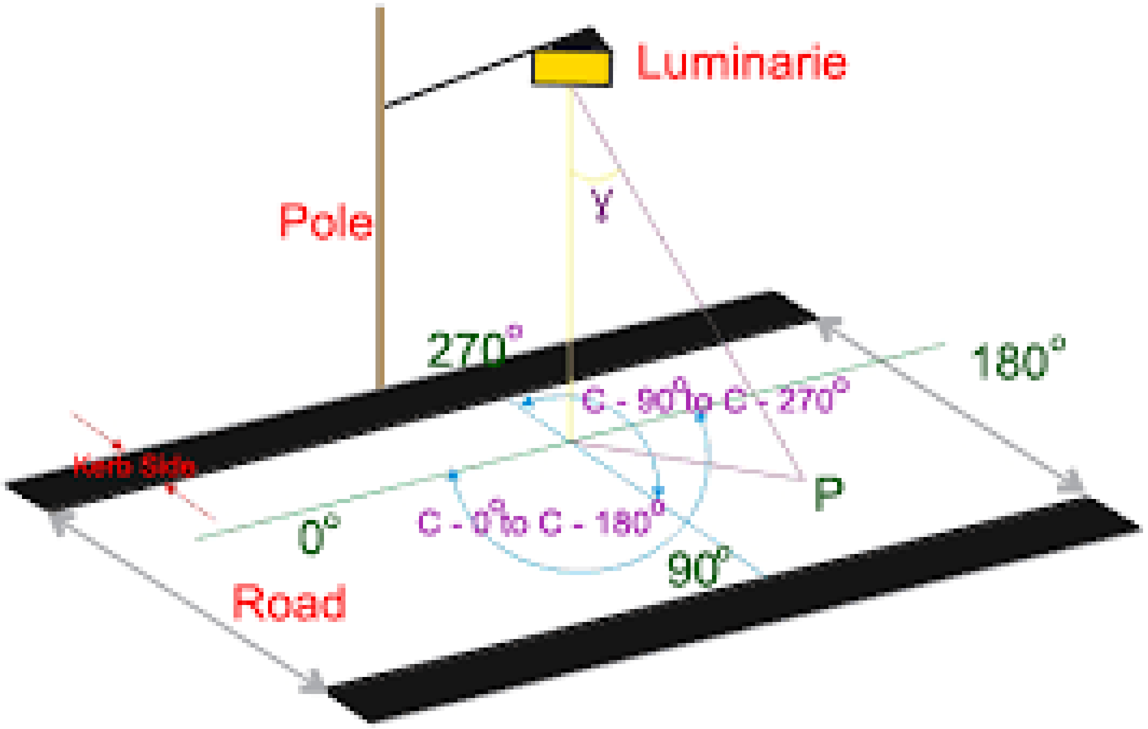
Street Light Luminaire

- Intensity distribution of the street light luminaire is measured with mirror Goniophotometer. And it is graphically represented by polar intensity diagram.

- But Intensity distribution of the road light is measured following C-ɣ photometric convention. In C-ɣ photometry, C is the angle on the road surface plane and ɣ is the angle created between vertical axis of the luminaire and lumen throwing direction, or in other word, ɣ is the angle of incidence.

- Initially on the surface of the road, point specific Illuminance values are collected.

- Then intensity I is calculated from the equation of the Illuminance,



MOD: 5

DESIGN OF OUTDOOR LIGHTING:

FLOOD LIGHTING

Outdoor Lighting

- ***Functional Lighting***
- ***Decorative lighting***

- Road, yard, flood lighting – *Functional lighting*

- Monumental lighting, facade lighting, special festival lighting – *Decorative lighting*

Primary Aim – ***Safety & Security,*** Amenity, Decoration & Commercial interior

- ***Pole height of more than 16 metre.***

Floodlighting

- Flooding of large surfaces with light from powerful projectors – *Flood Lighting*
- **Flood lights** are great **lighting** fixtures that emit a broad beam of **light**.
- F**lood lights** are used to **flood** an area with **light**. It is the best way to provide an enormous amount of non-natural **light** to an area.
- They are used for many purposes and also allow a range of **lighting** techniques.

Floodlighting

- To enhance the beauty of ancient monuments by night
- To illuminate advertisement boards and show cases
- To illuminate railway yards, sports stadium, car parks, construction sites etc.
- *Small buildings:*
- Uniform flood lighting used
- Flood lights are placed o nearby buildings or on suitable posts at distance of not more than 60 m.
- Light fall perpendicular to the building.

Flood Lighting- Features

- *Large or tall building:*
- Illuminated non-uniformly

- *According to beam spread, projector classification:*

1. ***Narrow beam projector*** – beam spread b/w 12-25 deg. Used for distance beyond 70 m.
2. ***Medium beam projector*** – beam b/w 25 -40 deg. Distance b/w 30 -70 m.
3. ***Wide Angle projector*** – beam b/w 40-90 deg. Used for distance below 30 m.

Projector classification according to beam spread.

Beam Type	Beam Spread	Use
Narrow Beam Projector	$12\text{-}25^0$	Distance beyond 70m
Medium Beam Projector	$25\text{-}40^0$	Distance between 30-70m
Wide angle Projector	$40\text{-}90^0$	Distance below 30m

Floodlighting

- LED floodlights are highly energy efficient and have a higher lumen per watt output than any other conventional lighting system. They are used for many purposes and also allow a range of lighting techniques.

- Why we consider Flood Lights with LEDs?
- Energy Efficient and Maintenance Free
- High Lumen Output
- Excellent Thermal Management
- Environment-Friendly

Luminaire Outdoor Display & Flood

- Flood type luminaires are common for outdoor applications. Major concern is luminaire grade for superb illumination quality, technical specifications and overall system maintenance due to high ground locations.
- Colored illumination might be a consideration as well.

Different types :

1. Aesthetic Floodlighting
2. Industrial and Commercial Floodlighting
3. Advertising

1. Aesthetic Floodlighting

- Enhance the beauty of building at night on festive occasion
  - Public places
  - Ancient buildings
  - Religious buildings

2. Industrial & Commercial Floodlighting

- Illuminating
  - Railway yards
  - Sports stadium
  - Car parks
  - Construction sites
  - Quarries

3. Advertising

- Illuminating advertising boards and sho

Floodlight Projector

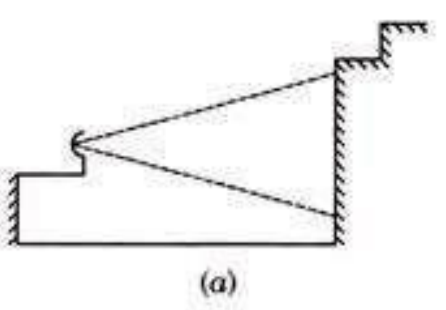
- Reflectors and its housing used for concentrating the light into a narrow beam.
- Installed in remote positions
  - Robust
  - Whether proof
- Reflecting surface
  - Made of silvered glass
  - Stainless steel
  - Chromium steel

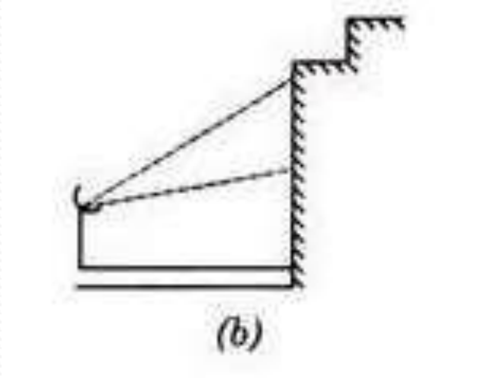
Efficiency
- Silvered Glass is 90%
- Polished Metal is 70%

Floodlight Projector contd…..

- Inclination of beam is varied in vertical and horizontal direction.
- 500W of 1000W lamps in projectors, ventilation is provided for adequate cooling.

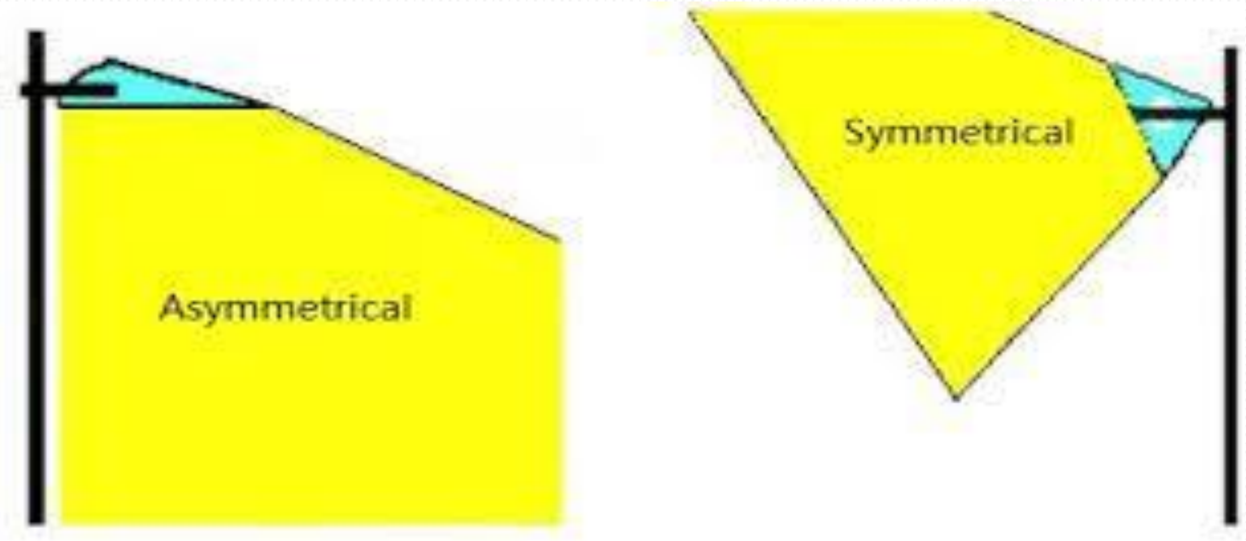
Location and Mounting of Projector:





- Symmetric projector kept 20 – 35m away from the surface to be floodlighted.
- Provide approximately parallel beam with beam spread of 35-30º

- Projector cannot be located away from the building.
- unsymmetrical reflector mounted in the basement area or on a bracket attached to the building
- Direct more intense light to wards the building.


Asymmetrical
Symmetrical

What is the main difference between Flood Light Luminaire and Road Light Luminaire?

The main difference between the flood light and the other luminaire used in road lighting is the former aiming direction with respect to the light intensity axis. That means, the **road light luminaire** is always aimed at a particular direction on the road surface spot wise. But **flood light covers the wide range surface of the aimed object like buildings, hording etc** and it is defined to a **proper mounting position**. Whereas road light luminaire cannot cover wide range of road surface area.

Floodlighting Calculations

- 1st Step : Illumination level required
  - depends on
    - Type of building
    - Purpose of flood lighting
    - Amount of conflicting light in the vicinity.

Floodlighting Calculations, Illumination level required

Building Surfaces	Reflection Factor	Lux Recommended For Brightness of Locality		
		Low	Medium	High
White terra cotta	60—80	50	100	150
Cream terra cotta				
Light marble				
Light gray lime stone	40—60	70	120	200
Bed Ford lime stone				
Buff lime stone				
Smooth buff face brick				
Briar hill sand stone	20—40	100	150	250
Smooth gray brick				
Medium gray lime stone				
Common tan brick				
Dark field gray brick	10—20	120	180	300
Common red brick				
Brown stone				

Floodlighting Calculations

- 2nd Step : Type of projector
  - Depends on
    - Beam size – determines the area covered by the beam
    - Light output – determine the illumination provided.
- Beam angle is decided keeping in view the distance of projector from the surface.

Floodlighting Calculations

- 3rd Step : No. of projector

$$N = \frac{A \times E \times depreciation\,factor \times waste\ light\ factor}{utilizatin\,factor \times wattage\ of\ lamp \times luminous\ efficiency\ of\ lamp}$$

N – no. of projectors

A – Area of surface to be illuminated

E- Illumination level required in lumens/m^2

Waste Light Factor

- When illuminated by multiple sources, the amount of light wasted on account of overlapping and falling of light beyond the edges of the area to be illuminated.
- Multiply theoretical value of lumen with
  - 1.2 for rectangular areas
  - 1.5 for irregular areas, statues, monuments.

Depreciation Factor

- Ratio of illumination under ideal condition to the illumination under normal conditions.
- Due to the accumulation of dirt and dust on the reflectors and in the source of the projector, reduce the light effectiveness.
- 50 – 100% more light must be provided so that illumination is adequate at the interval between the cleaning periods.

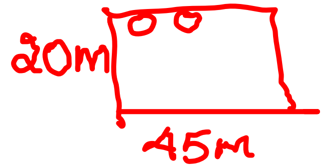
Coefficient of Utilization

- beam factor.
- Ratio of beam lumens to lamp lumens.
- Range between 0.3 to 0.5.
- As Light emitted by the projector is not along the direction of beam but some of it is absorbed by the reflector and by the front glass.

Q. The front of a building 45 m x 20 m is illuminated by twenty 1000-W lamps arranged so that uniform illumination on the surface is obtained. Assuming a luminous efficiency of 18 lumens/watt and a coefficient of utilization of 0.4, determine the illumination on the surface, waste light factor1.2 and depreciation factor 1.3.

$$N = \frac{A \times E \times \text{Waste light factor} \times \text{Depreciation factor}}{U.f \times \text{Wattage of Lamp} \times \text{luminous efficien}}$$

Projector



$A = 45 \times 20$

$N = 20$

$E = ?$

$W.L.L = 1.2$

$Df = 1.3$

$Uf = 0.4$

$\eta = 18$

$W = 1000W$

2) The front of the building measuring 50 m * 15 m is to be floodlighted by means of projectors placed at a distance of 25 metres away. The average illumination required is 100 lux. Determine the number and size of projectors required. Assume waste light factor of 1.2, depreciation factor 1.5 and coefficient of utilization 0.5.

$$N = \frac{A \times E \times \text{Waste light factor} \times \text{Depreciation factor}}{U.f \times \text{Wattage of Lamp} \times \text{luminous efficiency}}$$

1). • Assuming 1000 W lamps having a efficiency of 18 L/W are used.

$$N = \frac{50 \times 15 \times 1.2 \times 1.5 \times 100}{0.5 \times 1000 \times 18} = 16 \text{ projectors}$$

≈15

Conclusion: Hence 16 projectors of 1000W each with Beam Angle of 20° will be required.

Beam Angle $= 2\tan^{-1}\left(\frac{W}{2\times 8}\right)$

θ Angle of Spread $= 2\tan^{-1}\left(\frac{W}{L}\right) \sim 20^\circ$, $L = 50$

$W = \sqrt{x^2 + y^2} = \sqrt{6^2 + 7.5^2} = 9$

$X = \frac{50}{8} = 6$ $\quad Y = \frac{15}{2} = 7.5$

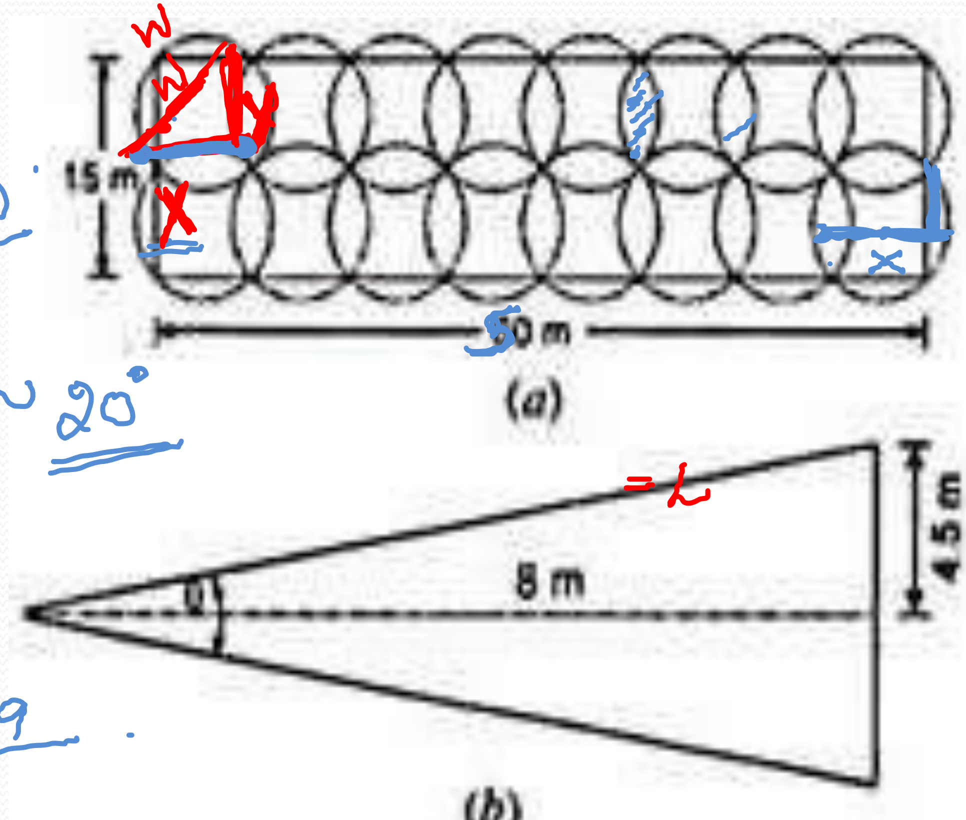
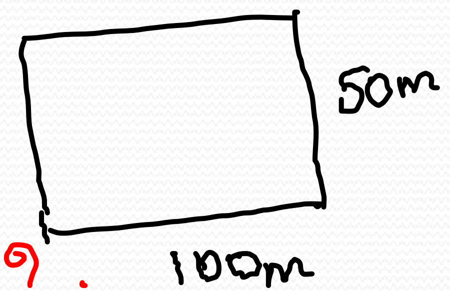


Fig. 7.53

39. The boundary of football Stadium is 100×50 m. The recommended illumination level is 500 lux. Luminaires of 1000 W. with light o/p of 92000 lumens are used for installation. Calculate no. of luminaires required. Sketch the configuration of light fittings. u.f = 0.8, M.f = 0.8, L.L.f = 1.2.

$E = 500$ lux.

$W = 1000W$, $O/p = 92000$ lumens.



$$\text{Efficacy} = \frac{O/p}{W} = \frac{92000}{1000} = 92 \text{ lms/W}$$

$N = ?$

Steps

1) E level req'd, $E = 500$ lux.
2) Selection of Projector & θ = ✓
3) $$N = \frac{A \times E \times Df \times LLf}{u.f \times \text{Wattage} \times \text{Efficacy}} = \frac{100 \times 50 \times 500 \times 1.2 \times 0.8}{0.8 \times 1000 \times 92}$$

$\simeq 32.6 \simeq 3$