ROAD LIGHTING

4.1 Importance of road lighting
4.2 Factors influencing night visibility
4.3 Requirement of level of illumination in roads
4.4 Design of the lighting system: selection of height of lamps, spacing between light
poles, height and overhang of light poles, lateral placement, etc.

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STREET LIGHTING

- **Lighting Basics**
  - Good visibility under day or night conditions is one of the fundamental requirements enabling motorists to move on roadways in a safe and coordinated manner.
  - Properly designed and maintained street lighting will produce comfortable and accurate visibility at night, which will facilitate and encourage both vehicular and pedestrian traffic.
  - The rate of highway crashes and fatalities that occur during night driving is several times higher in terms of vehicle kilometer than that during day driving.
  - One of the various causes of increased crash rate during night may be attributed to poor night visibility.
  - Road lighting is more important at intersections, bridge site, level crossings and in places where there is restriction of traffic movements.
  - Lighting on rural roads has not yet become common, evidently due to the cost consideration and less number of pedestrians and other slow traffic using the facility at night.
  - On urban roads where the density of population is also high, road lighting has other advantages like feeling of security and protection.

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STREET LIGHTING

- **Introduction**
  - A street light, light pole, lamppost, street lamp, light standard or lamp standard is a raised source of light on the edge of a road or path.
  - Modern lamps may also have light sensitive photocells that activate automatically when light is or is not needed: dusk, dawn, or the onset of dark weather.
  - This function in older lighting systems could have been performed with the aid of a solar dial.
  - Many street light systems are being connected underground instead of wiring from one utility post to another.

Street Lighting is intended to create an environment at night time in which people can comfortably see and identify the objects quickly and accurately on a roadways.

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STREET LIGHTING

- **Advantages of Street Lighting**
  - Prevention of crashes.
  - Increase in safety.
  - Lamp posts as a tool for fund raising via lamppost banner sponsorship programs.
  - Increase in aesthetic value of roads.

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STREET LIGHTING

- **Disadvantages of Street Lighting**
  - The loss of night vision because of the accommodation reflex of drivers eyes is the greatest danger.
  - Stray voltage is also a concern in many cities. Stray voltage can accidently electrify lampposts and has the potential to injure or kill anyone who comes into contact with the posts.
  - High winds or accumulated metal fatigue also occasionally topple street lights.
  - Street light lampposts pose a collision risk to motorists and pedestrians, particularly those affected by poor eyesight or under the influence of alcohol.

Stray voltage is the occurrence of electrical potential between two objects that ideally should not have any voltage difference between them.

Metal Fatigue: Metal fatigue is the common name used to describe the unexpected failure of metal parts by progressive fracturing while in service.

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STREET LIGHTING

- **Purpose of Street Lighting**
  - **Traffic Engineering Objectives**
    - Promotion of safety at night by providing quick, accurate, and comfortable seeing for drivers and pedestrians.
    - Improvement of traffic flow at night by providing light, beyond that provided by vehicle lights, which aids drivers in orienting themselves, delineating roadway geometries and obstructions, and judging opportunities for overtaking.
    - Illumination in long underpasses and tunnels during the day to permit drivers entering such structures from the open to have adequate visibility for safe vehicle operation.
  - **Other Objectives**
    - Reduction of street crimes after dark.
    - Enhancement of commercial (especially retail sales) properties by attracting evening shoppers, audiences, and other users.

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STREET LIGHTING

- **Visibility**
  - Visibility is the state of being perceived by the eye.
  - The purpose of roadway lighting is to attain a level of visibility which enables the motorist and pedestrian to see quickly, distinctly and with certainty all significant detail, notably the alignment of the road (its direction and its surrounding) and any obstacles on or about to enter the roadway.
  - Nearly all aspects of traffic safety involve visibility.

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STREET LIGHTING

- **Factors affecting Night Visibility**
  - Amount and distribution of light flux from the lamps.
  - Size of object.
  - Brightness of the object.
  - Brightness of the background.
  - Reflecting characteristics of the pavement surface.
  - Glare on the eyes of the driver.
  - Time available to see an object.
  - Viewer age
  - Viewer arousal level
  - Viewer expectation

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STREET LIGHTING

- **Light Distribution Requirement**
  - The general aim is to provide a sufficient contrast between the object and the carriageway so that the result in most situations are at least adequate safe driving without headlight.
  - On residential and other non-traffic routes, the motorist are expected to use headlight to help to achieve desirable level of visibility.
  - On these roads, lighting is intended to suit the needs of the pedestrians rather than the needs of motorist.

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STREET LIGHTING

- **Design Factors of Highway Lighting**

  Various factors to be considered in the design of road lighting are :

  1) Selection of types of Lamps
  2) Spacing of lighting units
  3) Height and overhang of mounting
  4) Lateral placement
  5) Luminaire distribution of light
  6) Lighting layouts.

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STREET LIGHTING

- Design factors of Highway Lighting
  - Selection of Types of Lamps
    - The most important element of the illumination system is the light source.
    - It is the principal determinant of the visual quality, economy, efficiency and energy conservation aspects of the illumination system.
    - An electric light source is a device, which transforms electrical energy, or power (in watts), into visible electromagnetic radiation, or light (lumens).
    - The rate of converting electrical energy into visible light is called luminous efficacy and is measure in lumens per watt.
    - The choice of lamp, its type, size and color depends on several considerations such as initial cost, life, rendering, wattage, brightness, efficiency in addition to distribution of light flux on the pavement surface.

STREET LIGHTING

- Design factors of Highway Lighting
  - Selection of Types of Lamps
    - Filament bulbs are used for minor street and pedestrian walkways.
    - Fluorescent light used for shopping street but they have short lamp life.
    - High-pressure sodium light produce excellent luminous efficiency, long life (4000 hours) and acceptable color.
    - Low pressure sodium light used in tunnels and on roads where high illumination levels and more uniform lights are required.

STREET LIGHTING

- Design factors of Highway Lighting
  - Selection of Types of Lamps
    - **Types of Lamp**
      - **Filament Lamp**
        - Most commonly used for many years.
        - Inexpensive, simple and easy to install.
        - Produced pleasing color rendition and its small size permitted good light control with a reasonably sized fixture.
        - However, its low efficiency and short rated life have made it undesirable for new installations.

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STREET LIGHTING

- Design factors of Highway Lighting
  - Selection of Types of Lamps
    - **Types of Lamp**
      - **Fluorescent Lamp**
        - No longer used for new roadway lighting installations, but still used for tunnel and sign lighting.
        - Its large size makes it difficult to obtain good light control in a reasonably sized luminaries.
        - The fluorescent lamp requires ballast and its light output is affected by low temperature more than other lamps.
        - Its one advantage is the broad light patterns that it provides on wet streets.

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STREET LIGHTING

- Design factors of Highway Lighting
  - Selection of Types of Lamps
    - **Types of Lamp**
      - **Mercury Lamp**
        - Initial cost is higher and it requires a ballast, but its high efficacy and long life make it considerably more attractive than the other lamp.
        - The blue-white color of the clear lamp is generally acceptable and the arc tube size provides a light source that is small enough to permit good light control.

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STREET LIGHTING

- Design factors of Highway Lighting
  - Selection of Types of Lamps
    - **Types of Lamp**
      - **High Pressure Sodium (HPS) Lamp**
        - It has replaced the mercury lamp.
        - It is characterized by a golden-white color light output.
        - Some of the newer HPS lamps include:
          - Improved color rendition
          - Internal starting devices
        - Dual arc tube or standby lamps that provide light as soon as power is restored after a momentary power interruption and that in addition, have a rated life of 40,000 hours.

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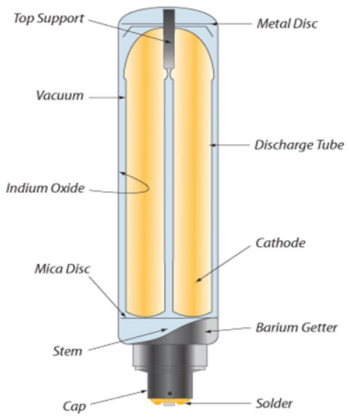
STREET LIGHTING

- Design factors of Highway Lighting
  - Selection of Types of Lamps
    - **Types of Lamp**
      - **Low Pressure Sodium (LPS) Lamp**
        - Characterized by a bright yellow color light output.
        - Requires special ballasts and increases materially in size as the wattage increases; the 185-W lamp is 3.5 feet long.
        - This large size makes it difficult to obtain good light control in a reasonably sized fixture.
        - The poor color rendition and large size of the LPS lamp have made it unpopular for use in other than industrial or security applications.

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STREET LIGHTING

- Design factors of Highway Lighting
  - **Spacing of Lamps**
    - Spacing of lamps is the distance measured parallel to the center line of the carriageway between successive lanterns in an installation.
    - The successive lantern may not be arranged on the same side of the carriageway.
    - The spacing of lighting units is often influenced by electrical distribution poles, property lines, road layout and types of side features and their illumination.
    - Large lamps with high mountings and wide spacing should be preferred from economy point of view.
      - In general, spacing should be 35-45m and should not exceed 55m.
      - Rough guide: Spacing should be 3-5 times of mounting height.
      - Spacing may be determined by the quality of illumination needed on different Street.

$$Spacing = \frac{Lamp\ Lumen * Coefficient\ of\ utilization * Maintenance\ Factor}{Average\ Lux * Width\ of\ road}$$


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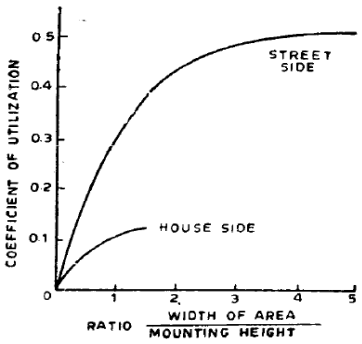
STREET LIGHTING

- Design factors of Highway Lighting
  - **Spacing of Lamps**
    - Maintenance factor (Light Loss Factor)
      - The efficiency of a luminaire is reduced over time. The designer must estimate this reduction to properly estimate the light available at the end of the lamp maintenance life. The maintenance factor may range from 0.50 to 0.90 with the optimum range from 0.65 to 0.75.
      - The maintenance factor is the product of the following:
        - Lamp Lumen Depreciation Factor (LLD)
        - Luminaire Dirt Depreciation Factor (LDD)



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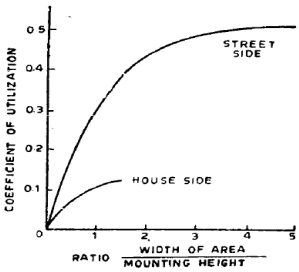
STREET LIGHTING



- Design factors of Highway Lighting
  - **Spacing of Lamps**
    - Maintenance factor (Light Loss Factor)
      - Lamp Lumen Depreciation Factor (LLD)
        - As the lamp progresses through its service life, the lumen output of the lamp decreases.
        - The initial lamp lumen value is adjusted by means of a lumen depreciation factor to compensate for the anticipated lumen reduction.
        - An LLD factor of 0.90 should be used.
      - Luminaire Dirt Depreciation Factor (LDD)
        - Dirt on the exterior and interior of the luminaire and to some extent on the lamp reduces the amount of light reaching the roadway. Take LDD = 0.87.

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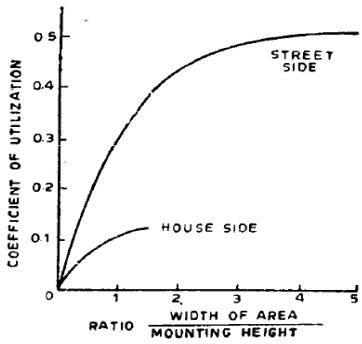
STREET LIGHTING

- Design factors of Highway Lighting
  - **Spacing of Lamps**
    - Coefficient of utilization: Coefficient of utilization is obtained from graph, corresponding to the pavement width & mounting height.
    - The maintenance factor takes into account the decrease in efficiency of lamp with age and an average value of about 80% may be assumed.



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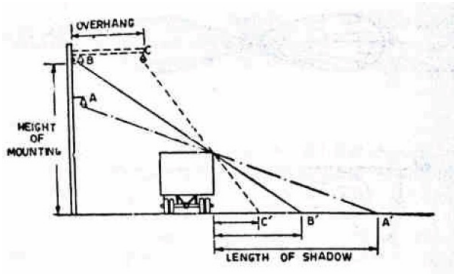
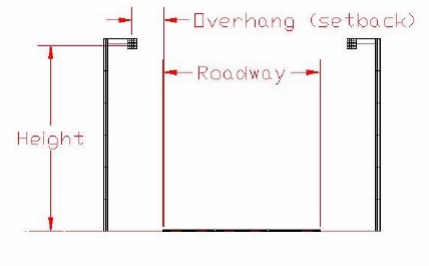
STREET LIGHTING

- Design Factors of Highway Lighting
  - **Height and overhang of mounting**
    - Height of mounting is the vertical distance between center of the lantern and carriageway.
    - The distribution of light, shadow and the glare effect from street lamps depends also on the mounting height.
    - Usually mounting height ranging from 6 to 10m higher value being preferred where possible at least for important urban road.
    - **Overhang:** the distance measured horizontally between the center of the lantern mounted on a bracket and the adjacent edge of carriageway.





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STREET LIGHTING

- Design Factors of Highway Lighting
  - **Lateral Placement**
    - Street lighting poles should not be installed close to the pavement edge.
    - If they are close to the carriageway, free movement of traffic is obstructed, decreasing the capacity of roadway.
    - **IRC recommended :**
      - For roads with raised kerb: min 0.3m (and desirable 0.6 m) from the edge of raised kerb.
      - For roads without raised kerb: - min.1.5m from the edge of the carriageway. (Subject to minimum of 5m from the center line of the carriage way)

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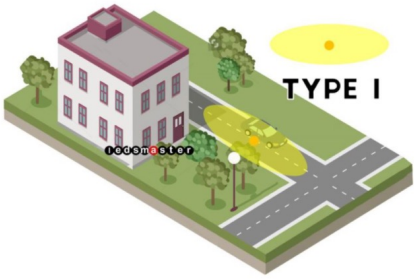
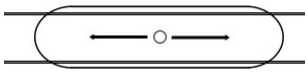
STREET LIGHTING

- Design Factors of Highway Lighting
  - **Luminaire Distribution of Light**
    - Followings are the major types of luminaire distribution of light :
    - **The type I** distribution is great for lighting walkways, paths and sidewalks.
    - This type of lighting is meant to be placed near the center of the pathway.
    - This provides adequate lighting for smaller pathways.
    - Type I is a two-way lateral distribution having a preferred lateral width of 15 degrees in the cone of maximum candlepower(is an obsolete unit expressing luminous intensity , equal to 0.981 candelas).





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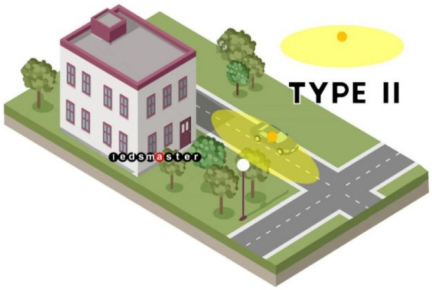
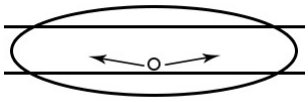
STREET LIGHTING

- Design Factors of Highway Lighting
  - **Luminaire Distribution of Light**
    - **The type II** distribution is used for wide walkways, on ramps and entrance roadways, as well as other long, narrow lighting.
    - This type is meant for lighting larger areas and usually is located near the roadside.
    - Type II light distributions have a preferred lateral width of 25 degrees.
    - Generally used on narrow roadways where the width of the roadway does not exceed 1.75 times the designed mounting height.





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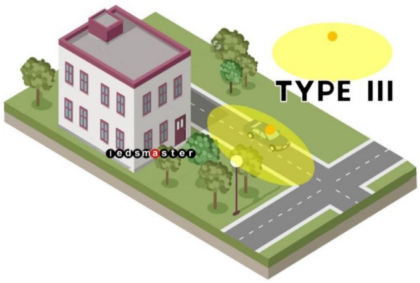
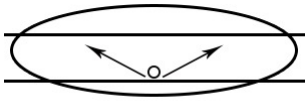
STREET LIGHTING

- Design Factors of Highway Lighting
  - **Luminaire Distribution of Light**
    - **The type III** distribution is meant for roadway lighting, general parking areas and other areas where a larger area of lighting is required.
    - Type III light distributions have a preferred lateral width of 40 degrees.
    - Generally used on medium width roadways where the width of the roadway or area does not exceed 2.75 times the mounting height.





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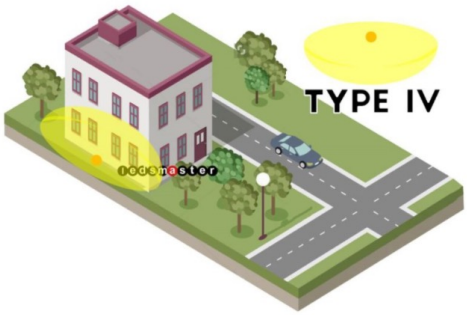
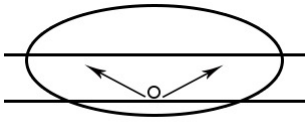
STREET LIGHTING

- Design Factors of Highway Lighting
  - **Luminaire Distribution of Light**
    - **The type IV** distribution produces a semicircular light meant for mounting on the sides of buildings and walls.
    - It's best for illuminating the perimeter of parking areas and businesses.
    - Type IV light distributions have a preferred lateral width of 60 degrees.
    - Generally used on wide roadways where the roadway width does not exceed 3.7 times the mounting height.





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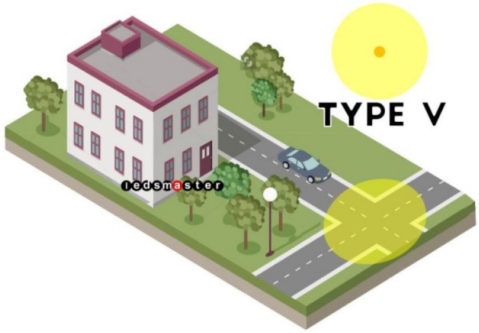
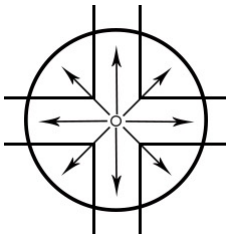
STREET LIGHTING

- Design Factors of Highway Lighting
  - **Luminaire Distribution of Light**
    - **Type V** produces a circular distribution that has the same intensity at all angles.
    - This distribution has a circular symmetry of candlepower that is essentially the same at all lateral angles.
    - It is intended for luminaire mounting at or near center of roadways, center islands of parkway, and intersections.
    - It is also meant for large, commercial parking.





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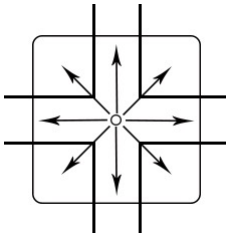
STREET LIGHTING

- Design Factors of Highway Lighting
  - **Luminaire Distribution of Light**
    - **Type VS** produces a square distribution that has the same intensity at all angles
    - This distribution has a square symmetry of candlepower that is essentially the same at all lateral angles.
    - It is intended for luminaire mounting at or near center of roadways, center islands of parkway, and intersections.
    - Type VS is used where the light pattern needs a more defined edge.



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STREET LIGHTING

- Design Factors of Highway Lighting
  - **Luminaire Distribution of Light**
    - **Requirements of level of illumination**
      - Distribution should be downward
      - It should produce maximum uniformity of pavement brightness
      - It should cover the adjacent area 3-5 m beyond the pavement edge.
      - For main highways 30 lux, for main roads 15 lux and for secondary roads 4-8 lux.
      - (Lux: SI derived unit of illuminance and luminous emittance)

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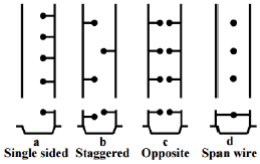
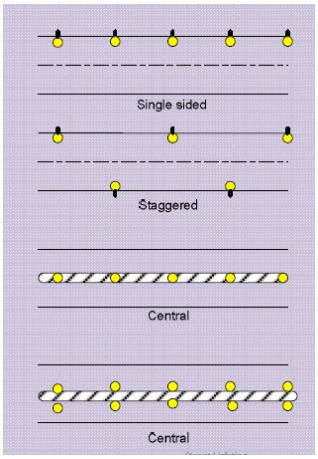
STREET LIGHTING



- Design Factors of Highway Lighting
  - **Layout of Lighting**
    - On straight roads the lighting layout may be of the following types.
      - Single side
      - Staggered (both side)
      - Central
    - Single side system is economical but suitable for only single lane roads.
    - For wider roads staggered system on both side or central system may be adopted.
    - Central mounting has the advantage that more light reaches the carriageway and footway than when the lanterns side mounted.

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STREET LIGHTING

- **Lighting Quality**
  - Quality of lighting refers to the relative ability of the light available to provide the contrast difference in the visual scene in such a manner that people may recognize the indications required for the seeing task.

Types of Lighting System Configurations

- Continuous freeway lighting
- Interchange lighting
- Underpass lighting
- Lighting for other streets and highways
- Lighting on bridges
- Lighting of roadways with median barriers
- Lighting at intersections


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NUMERICAL

Calculate the spacing between the lighting units to produce a lux equal to 7 from the following data:

Width of the road = 14m.

Mounting height = 8m

Lamp size = 7000 lumen

Luminaries type II

solution:

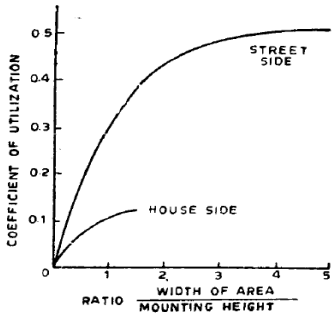
$$Spacing = \frac{Lamp\ Lumen * Coefficient\ of\ utilization * Maintenance\ Factor}{Average\ Lux * Width\ of\ road}$$

$$Spacing = \frac{7000 * Coefficient\ of\ utilization * 0.80}{7 * 14}$$

$$\frac{Pavement\ Width}{Mounting\ Height} = \frac{14}{8} = 1.75$$

From graph, Coefficient of Utilization = 0.38

$$Spacing = \frac{7000 * 0.38 * 0.80}{7 * 14} = 21.72\ m$$



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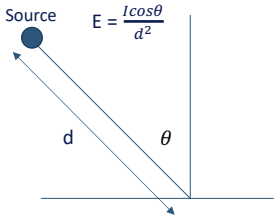
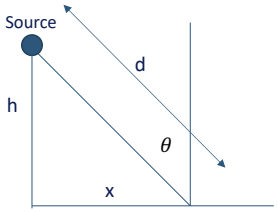
STREET LIGHTING

- **Definitions**
  - **Luminous flux:** This is the radiant power given by light source.
  - **Luminous Intensity (I):** Luminous flux emitted per unit solid angle.
  - **Illumination (E):** Luminous flux incident per unit area upon a point on a surface.

    E = dF / dA

    The unit of illumination in the metric system is lux or lumen per square meter.
  - **Luminosity:** Luminosity is the brightness sensation experienced by an observer when viewing a bright light or object. It is not a measurable quantity.
  - **Laws of Illumination:** The light from a square received on a plane normal to the incident light will be inversely proportional to the square of the distance (d) of the plane from the source. If the plane is inclined at an angle θ to the normal, the amount of light received is proportional to $\cos\theta$. These two laws can be combined together and expressed as below.





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NUMERICAL

Determine and explain in which case the distribution of light in street is better.

Case I: Height of Lamp = 4m

Spacing of Lamp = 40m

Case II: Height of Lamp = 8m

Spacing of Lamp = 40m

solution:

Case I

h = 4m

$x = \frac{Spacing}{2} = \frac{40}{2} = 20m$

$E_1 = \frac{I\cos\theta}{d^2}$

$E_1 = \frac{I*h}{d^3} = \frac{I*4}{(\sqrt{4^2+20^2})^3} = 4.7*10^{-4}\ I$

Case II

h = 8m

$x = \frac{Spacing}{2} = \frac{40}{2} = 20m$

$E_2 = \frac{I\cos\theta}{d^2}$

$E_2 = \frac{I*h}{d^3} = \frac{I*8}{(\sqrt{8^2+20^2})^3} = 8*10^{-4}\ I$

$E_2 > E_1$

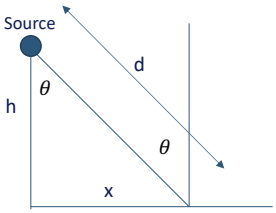
No glare if $\theta < 70^o$

$\theta_1 = \text{Tan}^{-1}(\frac{x}{h}) = \text{Tan}^{-1}(\frac{20}{4}) = 78.69^o$

$\theta_2 = \text{Tan}^{-1}(\frac{x}{h}) = \text{Tan}^{-1}(\frac{20}{8}) = 68.20^o$

No glare for Case II.

Therefore, Case II is adopted.



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