

ELECTRIC LIGHTING

7.1 INTRODUCTION

Light is a form of wave energy, with wavelengths to which the human eye is sensitive.

The radiant-energy spectrum is shown in Figure 7.1. Light travels through space at an approximate speed of 186,000 miles/sec (300,000 km/sec). There exist a wide wavelength range that the human eye cannot perceive. Among these are the wavelengths used in radio communications, the x-rays, etc.

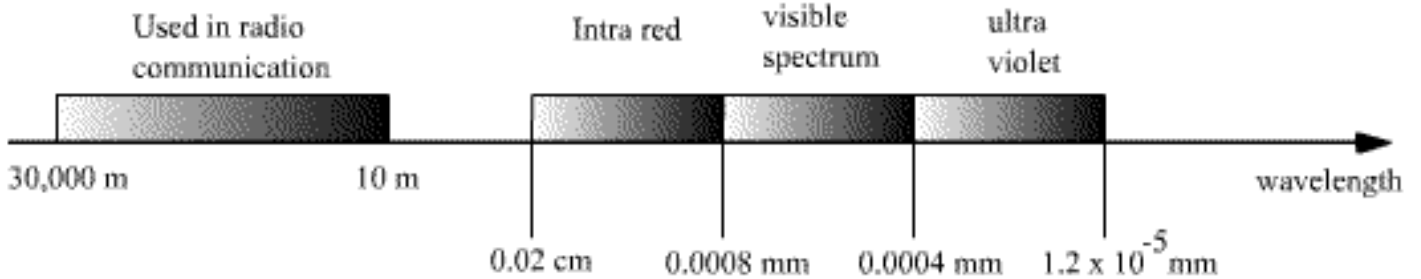


Figure 7.1. The radiant-energy spectrum

The impression of color depends on the wavelength of the light falling upon the eye. Violet light has the shortest wavelength and red, the longest to which the eye is sensitive.

Rays of light travel in straight lines. When a light wave passes from one medium to other, there occur three fundamental phenomena: absorption, reflection and refraction. The fraction of lighting energy absorbed by a body is dissipated in the form of heat. The rest is transmitted through the substance or reflected back.

7.2. ABSORPTION, REFLECTION, AND REFRACTION

Whenever a light ray impinges upon an object, the substance absorbs part of the energy. The

amount absorbed varies with the nature of the object, the wavelength of the incident light, and the angle at which the light strikes the surface. Table 7.1 shows the percentage of incident white light that is absorbed by various types of several materials used in electric lighting.

Table 7.1 Percent of a absorption of materials

Material	Absorption percent
Clear glass globes	5-12
Clear plastic globes	20-40
Amber Glass	40-60
White diffuse plastic	65-90

Besides the absorption, the light ray is also reflected by the surface. If the surface is smooth, the angle of reflection and incidence are equal with respect to a perpendicular line to the surface. This is shown in Figure 7.2.

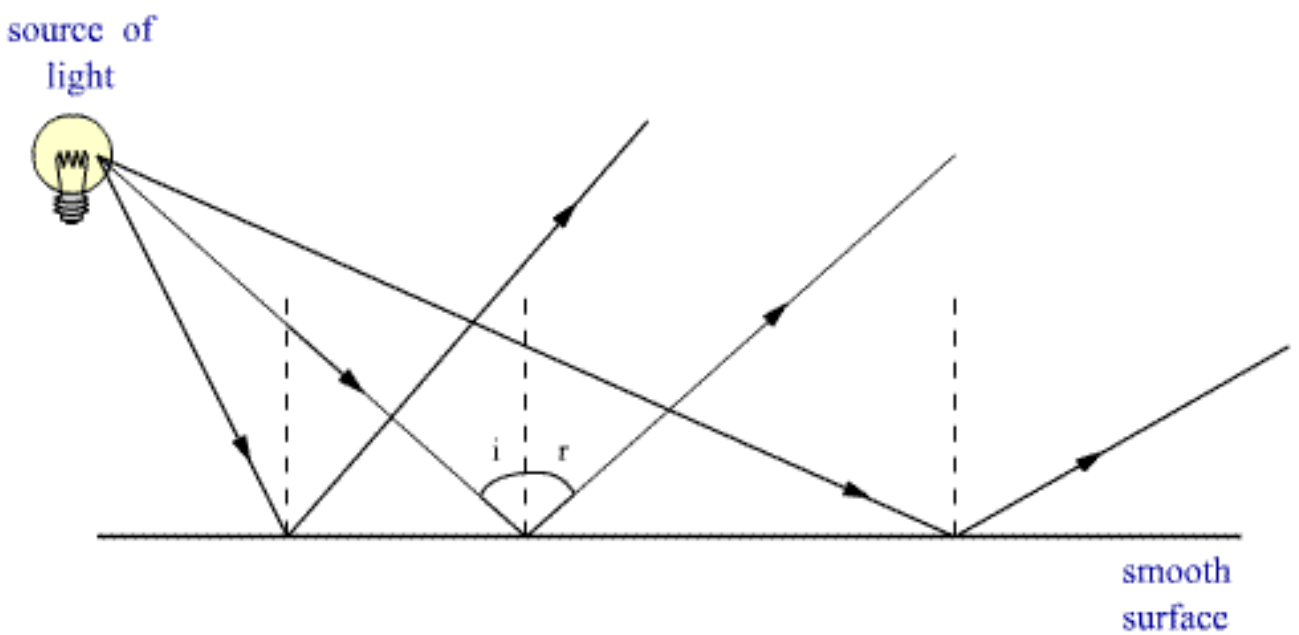


Figure 7.2. The Reflection of Light.

Any light ray that impinges on the surface of separation of two media with different density at an angle different of 90° with respect to the surface is refracted. This means that the direction of the ray is altered in the second substance. This is shown in Figure 7.3.

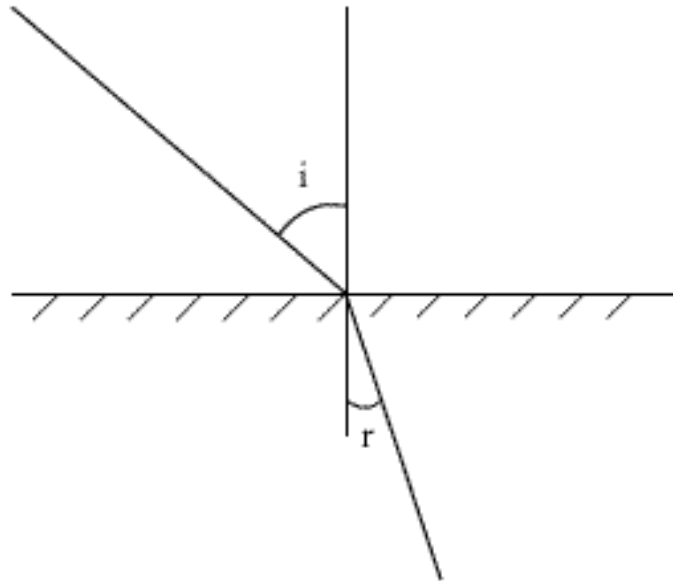


Figure 7.3. The Refraction of Light.

7.3. UNITS OF LIGHT

The standard candle was the historical starting point for the measurement of light. The candle with detailed specifications for wax, wick, and burning rate was assigned a luminous intensity of 1 candlepower (cd). Actually the cd is defined as the luminous intensity of light-producing power in the horizontal direction of a standard lamp which is made and used in accordance with U.S. Bureau of Standards specifications. From this starting point, three terms were defined:

The foot-candle (fc) – is the illumination, which is produced by a 1 cd point source (or its equivalent) on a surface that is exactly 1 ft distant from the point source.

The lumen (lm) – is the quantity of luminous flux which will, when uniformly distributed over a surface having an area of 1 ft^2 , produce an illumination of 1 fc on every point of surface.

The foot Lambert (fl) – is the density of illumination of 1 lumen per square foot.

There are several definitions that are useful when dealing with electric lighting.

Among them are:

Brightness: is the property of lighted objects, which enables them to be seen by virtue of the light issuing from them. The units of brightness are the Lambert, the foot Lambert and the cd/in^2 .

Glare: is defined as the brightness within the field of vision of such a character as to cause discomfort, annoyance, interference with vision, or eye fatigue. The two methods of causing glare are shown in Figure 7.4.

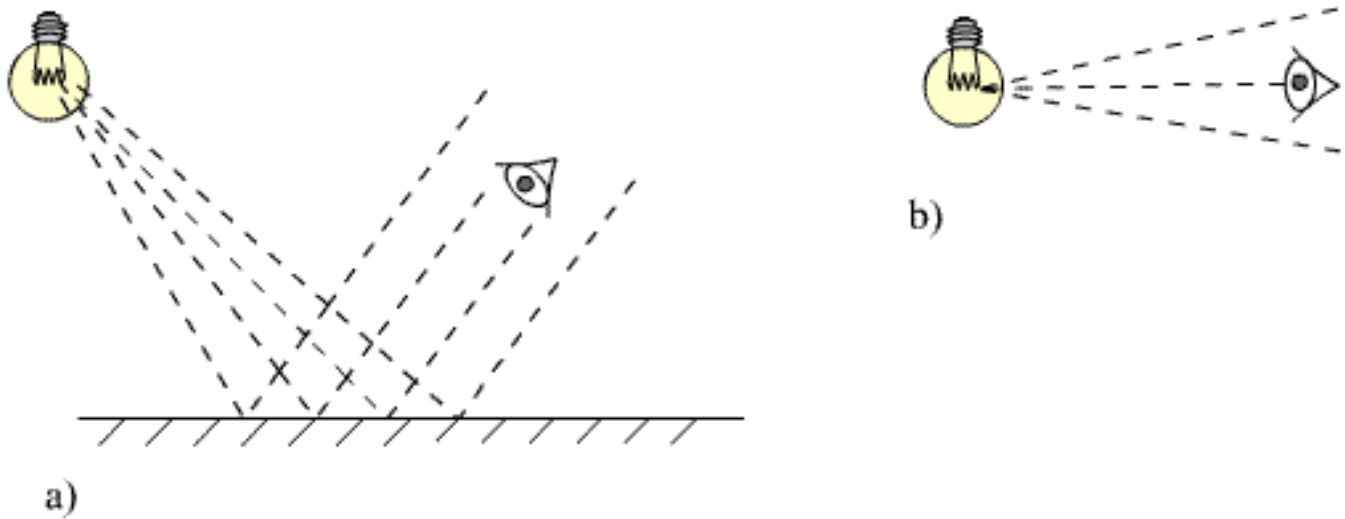


Figure 7.4. Methods of Causing Glare. a) Reflected Glare, b) Directed Glare.

The maximum brightness beyond which glare will result from a lighting source usually not exceed from 1 to 1.56 Lambert in the central portion of the visual field.

7.4. INCANDESCENT LAMPS

The incandescent lamp consists of a filament mounted in a glass bulb and provided with a suitable electrically connecting base. An incandescent lamp is shown on Figure 7.5

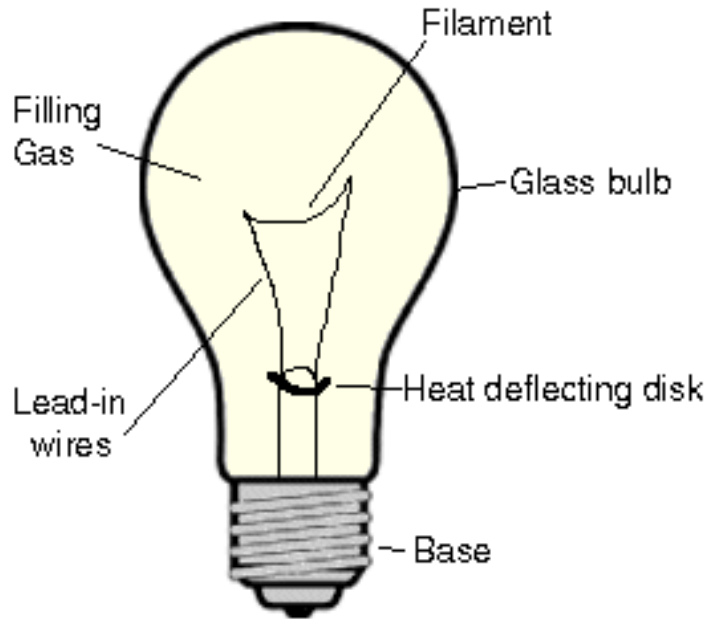


Figure 7.5. Incandescent Lamp Parts

The modern incandescent lamp is manufactured with a tungsten filament through which current passes. The lamp base is the portion of the lamp that matches the lamp holder. The wattage of incandescent lamps ranges from 2 W to 15000 W. The glass bulb part is available in different shapes, sizes, and colors.

Incandescent lamps may be classified according to:

1. The class of lamp:

- The filament operates in a vacuum
- The bulb is gas-filled

2. The shape of the bulb

- According to their shape, lamps are designated by a letter and a figure. The letter indicates the shape of the bulb and the figure the greatest diameter of the bulb in eighths of an inch.

3. The finish of the bulb

- Incandescent lamps can be obtained with the bulbs finished in several ways: clear inside-frosted,

white, daylight, colored glass, etc.

4. The type of the base

- There exist a wide range of different base shapes for incandescent lamps. The shape depends on the lamp wattage and application.

5. The type of filament

- The filament wire may be straight (s), coiled (c), or coiled coil (cc).

6. The type of service

Depending of the type of service provided the lamps may be classified as:

- General lighting service lamps are those of 120 V rating for ordinary uses in homes, offices, etc.

- Special lighting service lamps, which are used in similar locations, but they have special shape, color of bulb, or any other special feature.

- Miscellaneous lighting service, that include high-voltage lamps, projection lamps, sign and decorative lamps, traffic-signal lamps, low-voltage lamps. etc.

7.5 FLUORESCENT LAMPS

The fluorescent lamp functions through conduction in a gas. This gas can be mercury. The lamp consists of a tubular bulb with an electrode sealed in each end. When voltage is applied to electrodes an electron flow is created that disturbs the electrons in the mercury, causing them to shift and give off radiation. Figure 7.6 shows a fluorescent lamp.

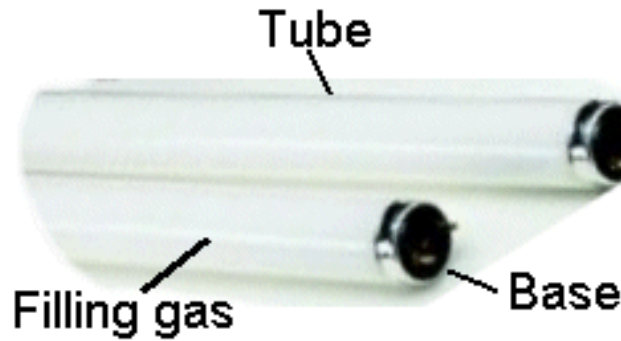


Figure 7.6. Fluorescent Lamp

The fluorescent lamp may be classified as:

- Preheat
- Instant start
- Rapid start

The preheat lamps are the older ones. They require separate starters and few seconds of heating time. The instant start lamps eliminated the need for starters. The lamp light as soon as the circuit is closed. The rapid start lamps have smaller and more efficient ballast.

For a fluorescent lamp to work, ballast are required. They serve several functions depending on the type of lamp used. their functions include:

1. To provide a controlled amount of electrical energy to heat the electrodes.
2. Supply higher voltage to start the arc.
3. To act as an impedance to limit current.

Figure 7.7. Shows a typical fluorescent ballast.

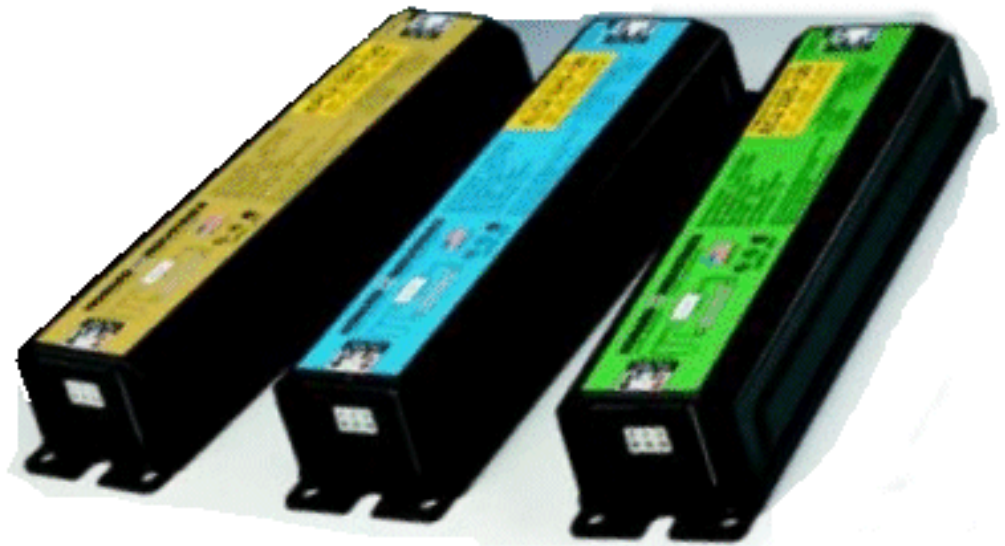


Figure 7.7. Ballast

The use of two lamps, connected in series with one ballast is a common practice, in order to save in the ballast cost and space.

As per *NEC*®, when used with indoor fluorescent fixtures, the ballast shall incorporate a thermal protection.

7.6 HIGH-INTENSITY DISCHARGE LAMPS (HID)

HID lamps are intense light sources that produce light by passing an electric arc through a conducting vapor. The arc radiates visible light, and its color is determined by the type of conducting vapor used.

The advantage of the HID lamps is the cost savings in achieving the highest lumen output per watt. Figure 7.8 shows the mean lumens per watt for different types of lamps on a wattage of 200 watts approximately.

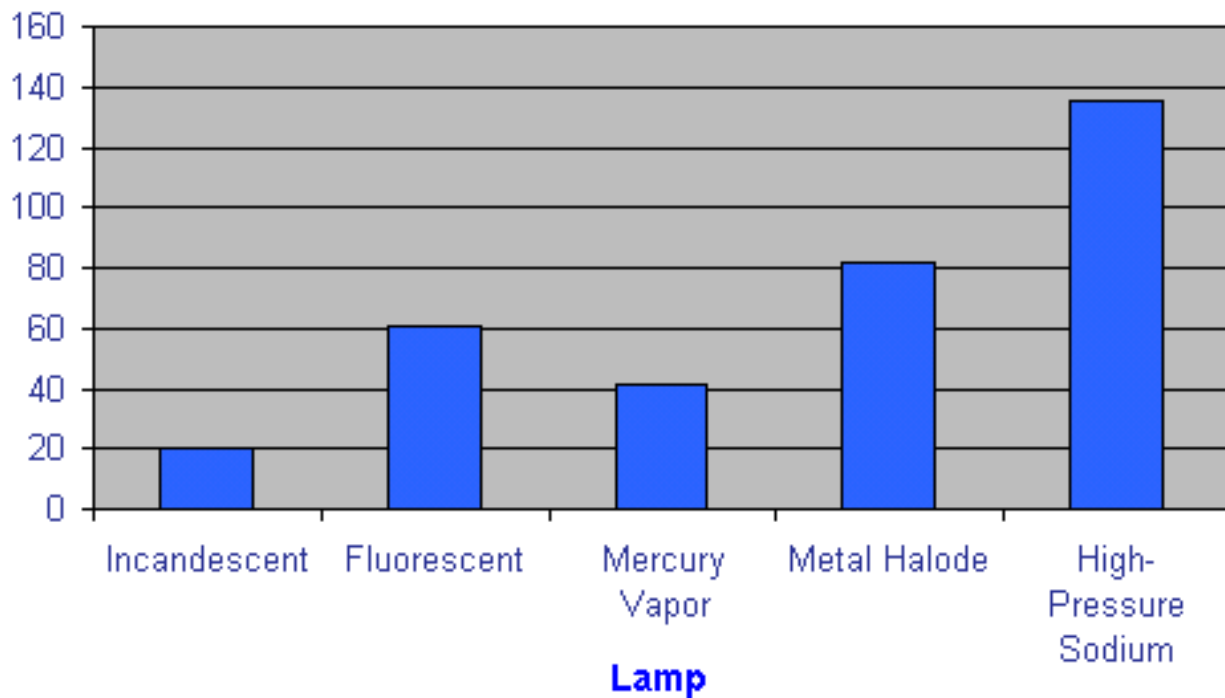


Figure 7.8. Mean lumens per watt for several types of lamp construction.

The phosphor-coated mercury lamps are the most widely used mercury lamps. The light is greenish-blue because of the lack of radiation in the red region of the spectrum.

Mercury vapor lamps are available in several wattage sizes and bulb shapes. Ballast are required for the operation of these lamps. The average life of mercury vapor lamps is 16,000 hr. Figure 7.9. Shows the mercury vapor lamp parts.

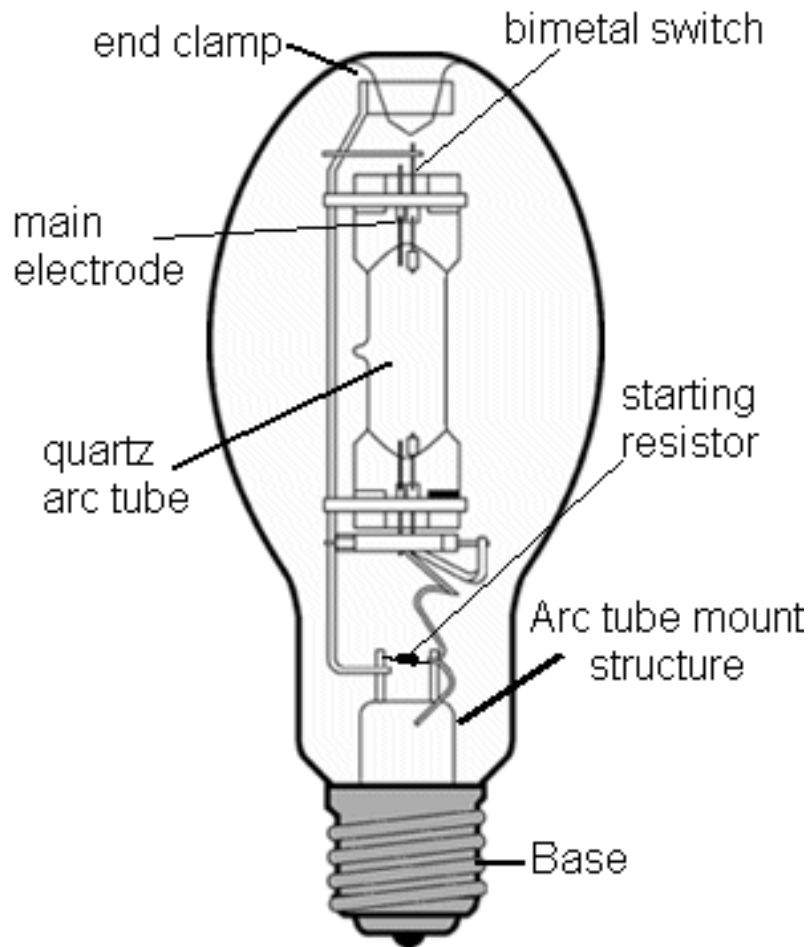


Figure 7.9. Mercury Vapor Lamp Parts

Metal halide lamps are similar to mercury vapor lamps. The major difference is that the arc tube contains halides of various metals in addition to the mercury. A characteristic for these lamps is that they must be burned in the position for which they are designed: base up, base down, or horizontal.

The high-pressure sodium (HPS) lamp has the highest light-producing efficacy of any commercial source of white light. The electric arc is sustained in a mercury and sodium vapor atmosphere. Major applications have been in roadways, parking lots, auditoriums, etc. Their major disadvantage is that not allow easy identification of colors.

Low-pressure sodium (LPS) lamps produce monochromatic light near the human eye peak sensitivity. They are one of the most efficient light sources available. The limitation to its applications is its yellow color. For applications where color discrimination is not an essential factor the LPS lamps may be very useful.

7.7 LUMINARIES

The luminaries are devices that direct, diffuses, or modify the light given out by the illuminating source, making its use more economical, effective, and safe to the eye. On Figure 7.10 may be appreciated a comparison between the distribution curve of a bare incandescent lamp and that of the same lamp equipped with a suitable reflector.

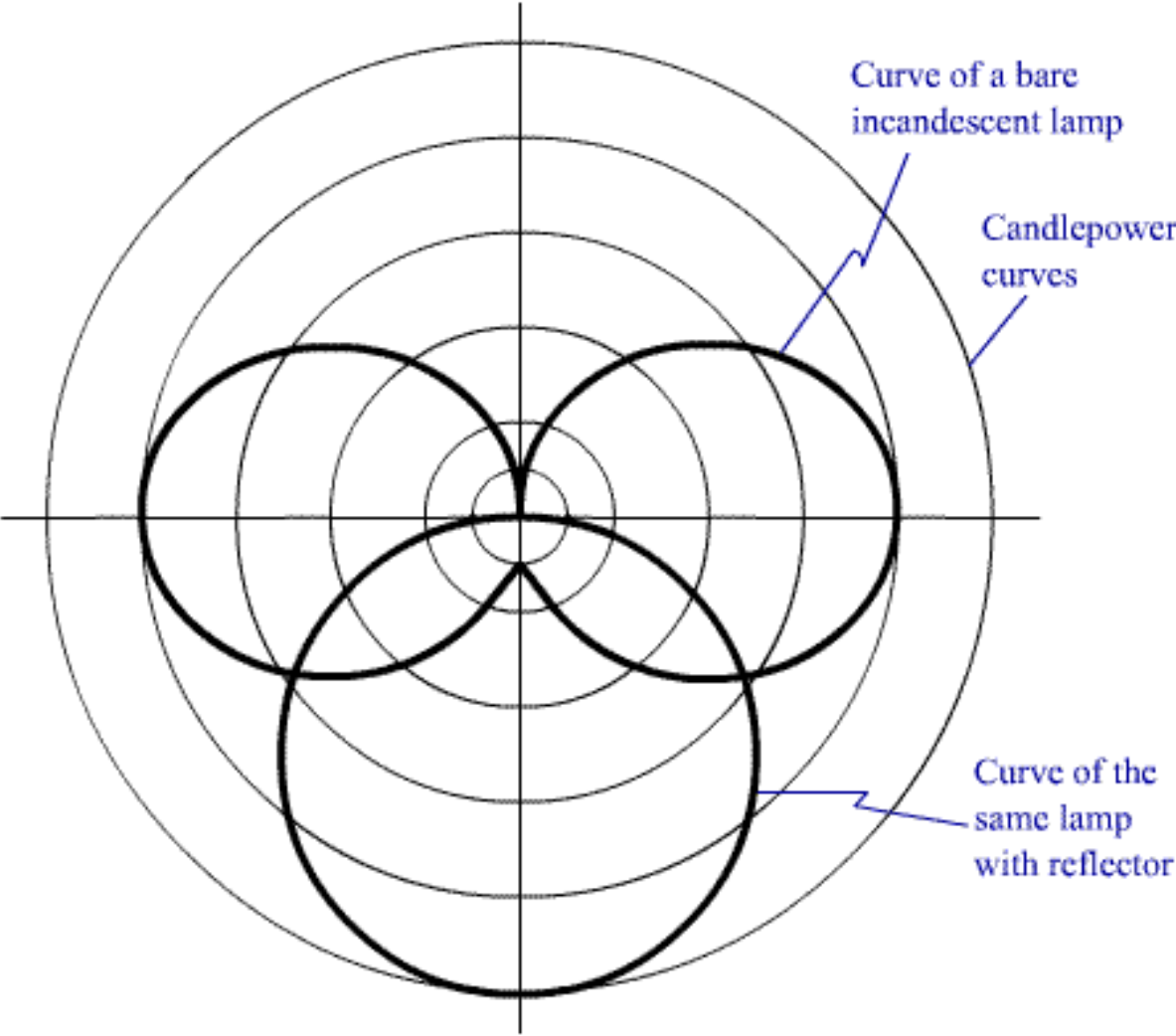


Figure 7.10. Distribution curves for a bare lamp and for the same lamp with reflector.

Figure 7.11 Shows several luminaries for different applications.

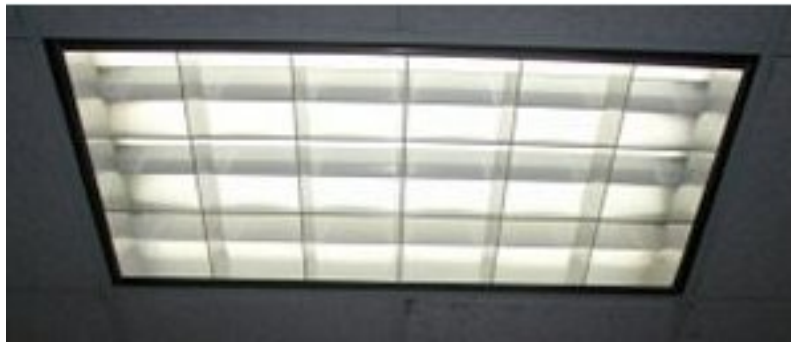


Figure 7.11. Luminaries

According to the way the light reaches the objects, the luminaries are classified as:

Direct Lighting: Practically all of the light of the luminaries is directed toward the working area, as shown in Figure 7.12.

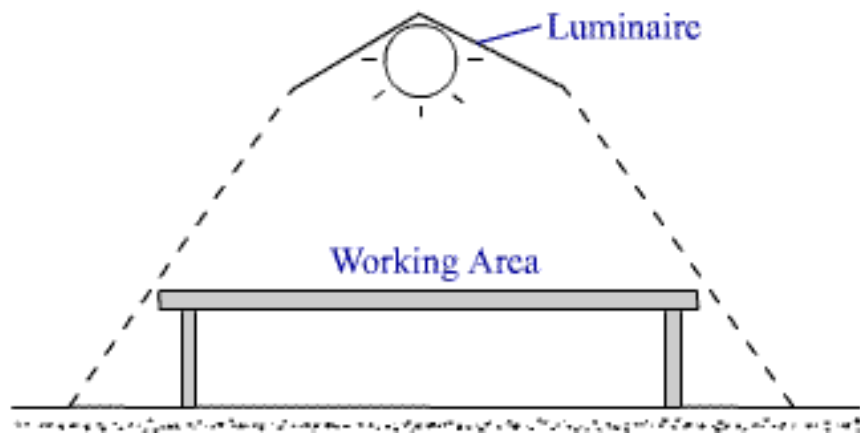


Figure 7.12. Direct Lighting

Indirect Lighting: Practically all of the light of luminaries is directed toward the ceiling in angles above the horizontal and reflected to the working surface.

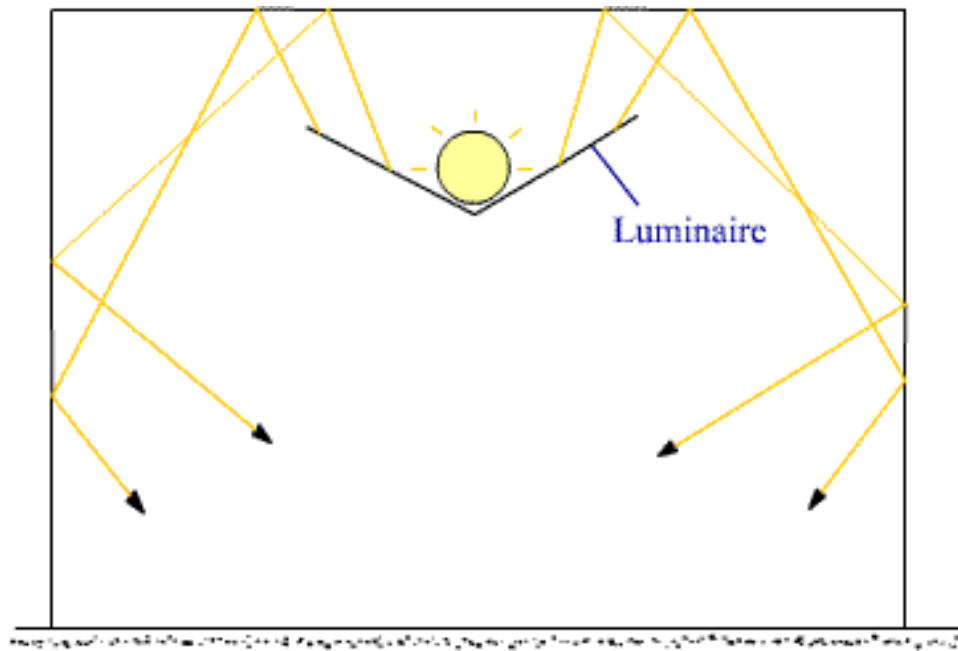


Figure 7.13. Indirect Lighting

Semi-direct and semi-indirect Lighting: Range between the direct and indirect lighting. In the semi-indirect the majority of the light is reflected on the ceiling and then directed toward the surface area. In the semi-direct lighting, the majority of the light impinges directly on the surface area.

Diffuse Lighting: Approximately half of light is directed downward, impinging on the working area, and the rest is reflected on the ceiling, as it can be seen in Figure 7.14.

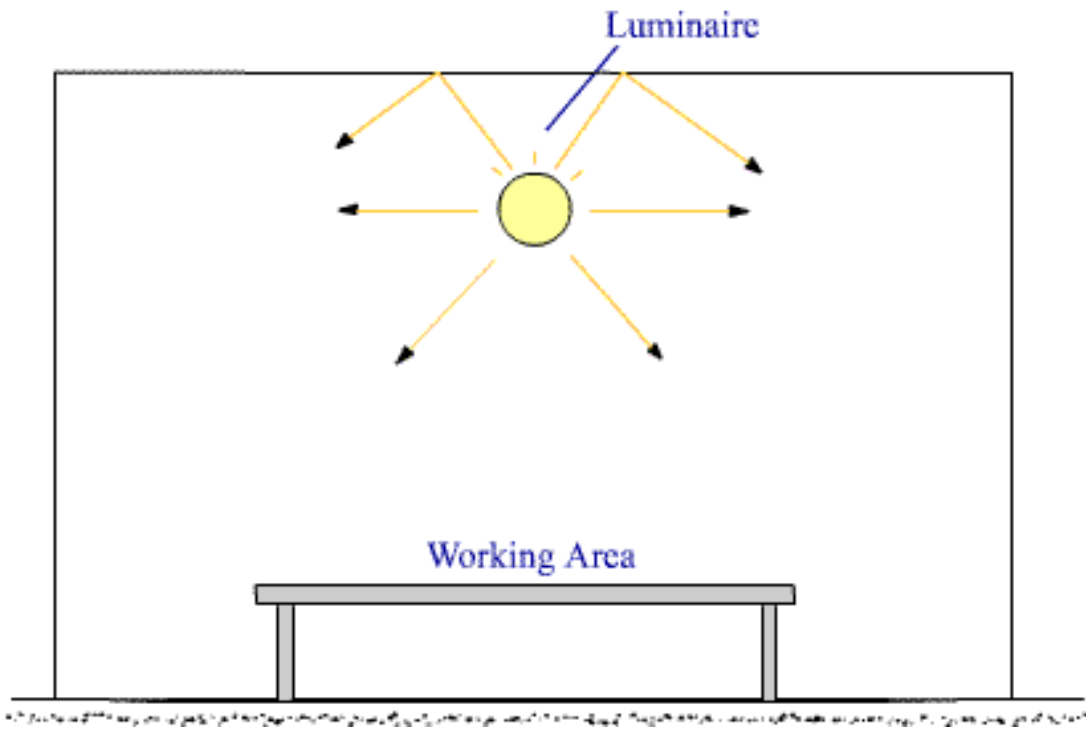


Figure 7.14. Diffuse lighting

According to the use they are intended for, the luminaries can be classified as:

- Commercial use
- Residential service
- Street lighting
- Flood lighting

The size of the incandescent lamp installed in a luminaire should be such that its wattage rating is not greater than the specified for the luminaire to be used with it.

7.8. LIGHTING INSTALLATION DESIGN

The objective of a lighting installation is to enable things to be seen through the light that is reflected from them. The basic requirements for an adequate lighting installation are:

- Sufficient light of unvarying intensity on all necessary surfaces.
- Light of a color and spectral character suited to the purpose for which it is employed.
- Comparable intensity of light on adjacent areas and on walls.
- Freedom from glare and from glaring reflections.
- Light so directed and diffused as to prevent objectionable shadows or contrasts of intensity.
- Lighting effect appropriate for the location and lighting units which are in harmony with their surroundings.
- A system which is simple, reliable, easy to maintain, and in initial and operating cost, not out of proportion to the results attained.

Several important rules are as follows:

- The lighting sources for general illumination should be located symmetrically throughout the area under illumination.
- For obtaining an uniform distribution of light on the working area, it is a good general rule to make the horizontal distance between luminaries equal to its mounting height. This may not be true for special reflectors that direct the light toward specific places.
- The light units shall be positioned symmetrically and not at the corners of the room.
- The light reflected from walls and ceiling of a room depends on the color and type of paint used. The lighter the color, greater the coefficient of reflection. It is important to have light walls and ceiling colors to obtain a good grade of reflecting. Also not to use too bright paint that may produce glare.

7.9. REVIEW QUESTIONS

7.1. What are the functions of the ballast?

7.2. When practically all of the light is directed in angles below the horizontal directly toward the usual working area, the system of illumination is called_____.