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Lighting for Beginners

A BASIC GUIDE
Find out where to begin and how to manage your knowledge well.

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eISBN No: 978-629-7667-33-1

First published in 2024

Published by:

UNIT PENERBITAN
Politeknik Sultan Salahuddin Abdul Aziz Shah,
Persiaran Usahawan, Seksyen U1,
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Telephone no.: +603 5163 4000
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e ISBN 978-629-7667-33-1

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PREFACE

This eBook was written primarily for students on Building Services Engineering undergraduates to assist them to understand the principles of lighting and daylighting; and design for lighting. This eBook set out lighting theory and design theory and illustrates the applications by the inclusion as many useful graphics and examples as possible.

The content of this eBook conforms to the latest SLL Code of Lighting and CIBSE. It has five chapters, which cover the fundamental topics in lighting, daylight and lighting design, generally taught in the lighting curriculum in Malaysian Polytechnics. Although it does contain necessary information required to face examination, the emphasis here is on conceptual clarity and strength in fundamental. The students are encouraged to consult all other possible sources of reference to obtain a full and thorough understanding of the subjects.

We express our gratitude to all, including colleagues, students, friends and family members, who contributed in making this module possible. We welcome suggestions from readers for improving this module in any manner. May Allah forgive us for any error in this humble work and may He bless our effort with mercy and acceptance.

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CHAPTER N.1

Introduction to lighting

Introduction to lighting

1.1 EARLY LIGHTING

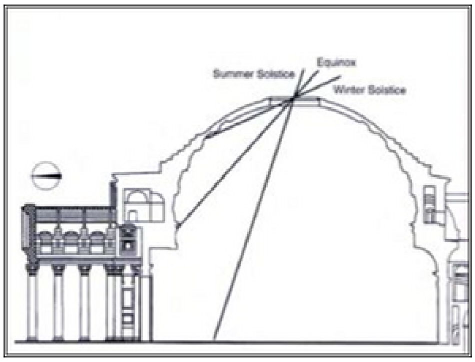
The first man-made lighting attempted about 70 millennia ago. It is ignited in a shell or rock filled with combustible materials like dried vegetation or wood and is sprinkled with fat.

The sun which is million years away from earth has always been the primary source of light. As time goes by, human used materials such as pottery to form a basic lamp. The word lamp is derived from the Greek word lampas which means torch. The lamp used wicks which are dipped into the fat in order to control the burning rate.

The Greeks started the terra cotta lamps. In 900 BC, Muhammad ibn Zakariya Razi, a Persian scholar invented the kerosene lamp. But lamp developments continued with the introductions of lamp tubes, chimneys, vents and other devices with practical housing.

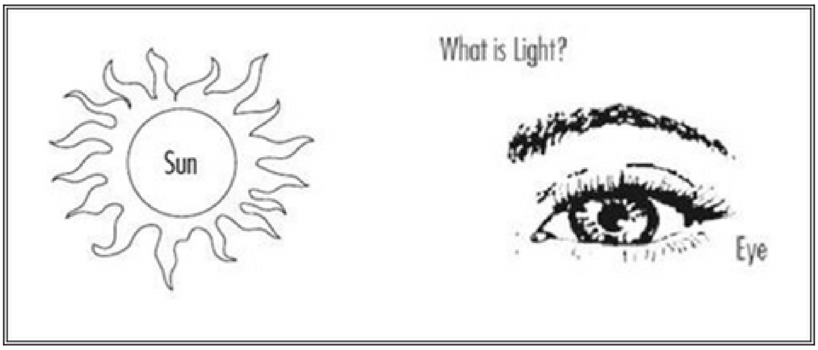
Day lighting is first incorporated with architecture by the Romans. The Pantheon and Greek palace at Knossos incorporated light wells in order to bring daylight into the building interior.

Carbon-arc lamp was the first electric lamp invented in the year of 1801 by an English chemist, Sir Humphrey Davy. The first electric light bulb was created by Sir Joseph Wilson, an English inventor. But it flaws as the filament used burnt up too quickly. In 1879, Thomas Edison in the United States made the first practical electric light bulb which is brighter and last longer.



1.2 BASIC ENERGY AND LIGHT

Light is a kind of energy in the form of electromagnetic radiation which can be detected by the human senses of sight. Light is a visually evaluated radiant energy which is visible by the human eye.



It can be transmitted through space without the need of any material or substance to help propagate it.

Definitions of light

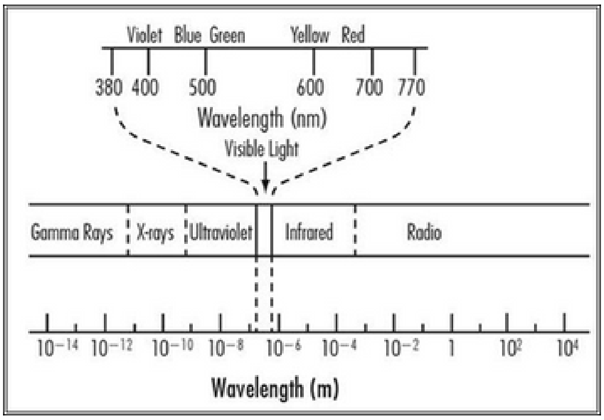
Definition 1 - Light is a form of electromagnetic radiation.

Definition 2 - Light is type of energy of particular wavelengths of electromagnetic radiation which can be detected by the human sense of sight.

Definition 3 - Light is a combination of radiation and our response to it.

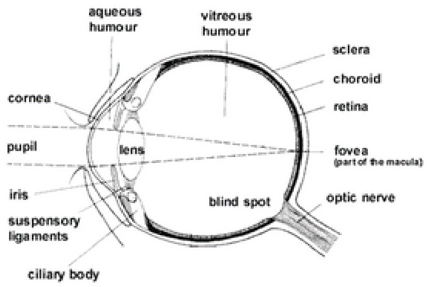
Definition 4 - Light is a flow of particles or a form of wave motion

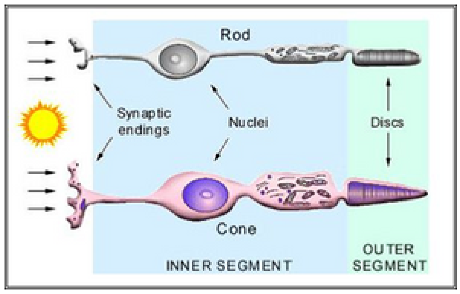
Light occupies a very narrow band of the electromagnetic spectrum that is between 380 nm and 780 nm. The spectrum of wavelengths is shown below.



1.3 VISUAL EFFECT OF LIGHT

The visible portion of the radiant energy that reaches the eye is absorbed by special receptors (rods and cones) in the retina, which covers the inner wall of the eye. In the retina, the rods and cones convert the radiant energy into electrical signals. The nerves transmit the electrical impulses to the brain where the light sensation is created.



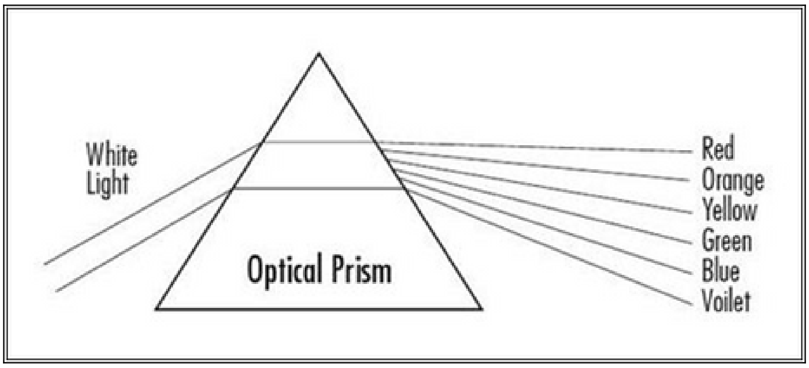


The eye is a sensory organ with extraordinary capabilities; just a few highly sensitive “components” complement each other to form a remarkable visual instrument.
The cones nerves play the important role in the human vision. It operates during day time and bright surroundings. It can detect colours. While the rod nerves help our vision during night time with dark surroundings. It helps human to see even with existence of very small amount of light. It does not translate colours into the vision.
Our ability to perform a visual task depends on how well our eyes perceive the details of the task. Factors determining the visibility of task details include size, luminance, contrast and glare. These factors are interrelated.

Size
Making the objects larger such as moving them closer to the eye, makes them easier to see. Human eye need less light to perform a task when detail size is increased.
Luminance
Visual performance requires sufficient light. The optimum level of luminance needed to perform a task depends on the nature of the activity.
Contrast
Luminance variation or contrast allows us to distinguish a visual task from its surroundings.
Glare
Bright light which interferes with visual perception is called glare. An overly bright area in our field of vision reduces our ability to perceive visual information needed for task performance.

1.4 LIGHTING AND COLOUR

Each wavelength of light gives rise to a certain sensation of colour. A light source emitting radiant energy, relatively balanced in all visible wavelengths, such as sunlight, will appear white to the eye. Any colour can be imitated by a combination of no less than three suitable primary colours. A suitable set of primary colours usually chosen is red, green and blue. A beam of white light passing through a prism is dispersed into a colour spectrum.



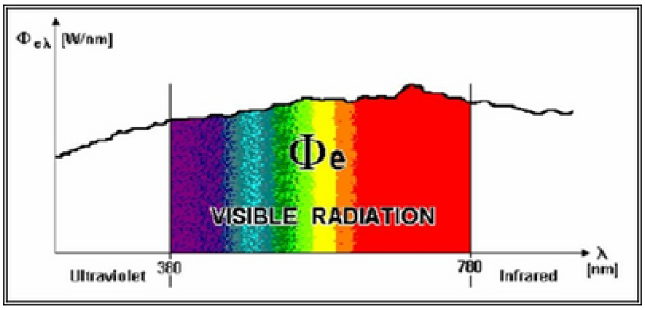
Surface colours

The perceived colour, or colour appearance, of a surface is the colour of the light reflected from the surface. Certain wavelengths are more strongly reflected from a coloured surface than others, which are more strongly absorbed, giving the surface its colour appearance.

The colour depends on both the spectral reflectance of the surface and the spectral power distribution of the light source. In order to see the colour of the object, that colour must be presented in the spectrum of used light source.

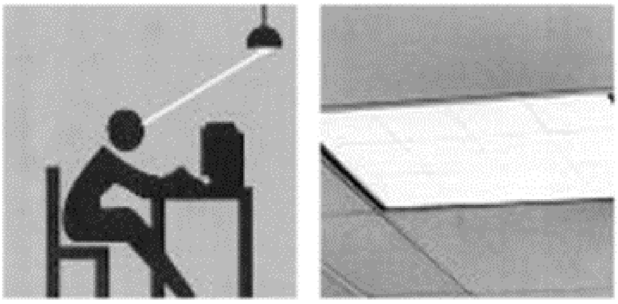
Colour rendering

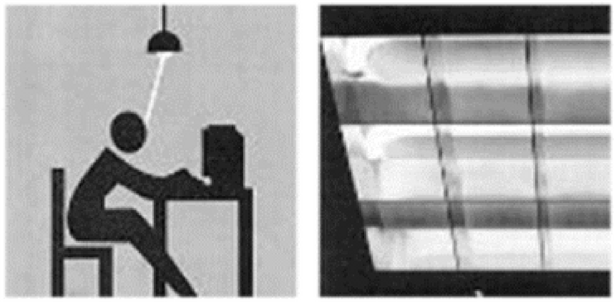
Colour rendering is a general expression for the effect of a light source on the colour appearance of objects, compared with the effect produced by a reference or standard light source of the same correlated colour temperature.



1.5 GLARE

Glare is experienced when there is difference in the luminance's of adjacent surfaces. This refers to impairment of the visual efficiency of the eye by excessive relative and absolute luminance. In addition to direct glare from the sun, glare may also arise in interior rooms through excessive contrast between the high luminance of the patch of sky visible through the windows and the substantially lower luminance of the adjacent surfaces enclosing the room.





The degree of glare thus depends on:
(a) The luminance and the size of the light-emitting surface seen by the eye,
(b) The ratio of this luminance to the luminance of this environment or background,
(c) The distance of the glare-producing surface from the eye and its position in the field of vision.

Glare caused by a bright object directly in our field of vision is called direct glare. Glossy or polished surfaces, which reflect the image of a bright object, produce reflected glare. A bright light source within our field of view produces high angle direct glare.

A bright light source visible almost directly overhead produces low angle direct glare in or peripheral vision. Our eyebrows help shield our eyes from this type of glare.
A glossy surface can reflect a mirror-like image of overhead lighting directly into one's eyes. This distracting reflected glare reduces contrast between a task and it surroundings.
Bright light sources or images of distant objects reflected in VDT screens create glare, a major cause of both reduced VDT task visibility and VDT operator visual discomfort.

1.6 CONTRAST AND BRIGHTNESS

Contrast

Contrast is the difference in luminance or colour that makes an object (or its representation in an image or display) distinguishable. In visual perception of the real world, contrast is determined by the difference in the color and brightness of the object and other objects within the same field of view. Because the human visual system is more sensitive to contrast than absolute luminance, we can perceive the world similarly regardless of the huge changes in illumination over the day or from place to place. The maximum contrast of an image is the contrast ratio or dynamic range

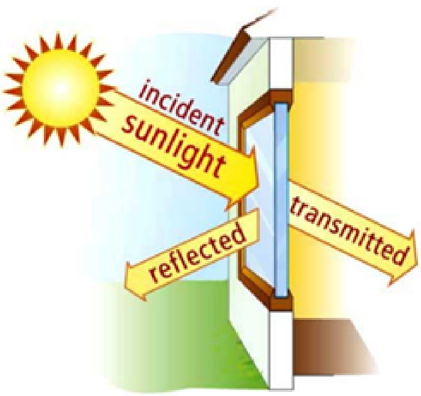
Brightness

Brightness is an attribute of visual perception in which a source appears to be radiating or reflecting light. In other words, brightness is the perception elicited by the luminance of a visual target. This is a subjective attribute/property of an object being observed and one of the color appearance parameters of color appearance models. Brightness refers to an absolute term and should not be confused with Lightness

1.7 OPTICAL BASIC CONCEPTS

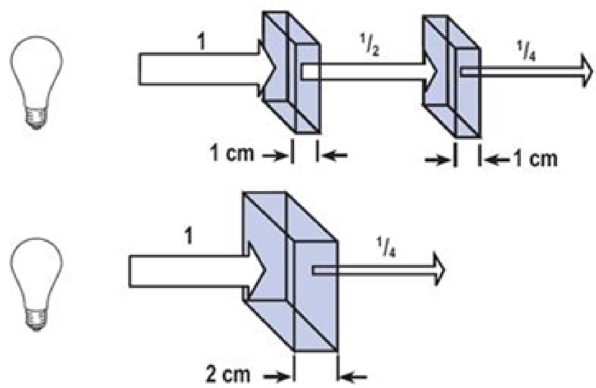
Transmission

When light passes through an object, it is called transmission. Absorption, reflection, refraction, and diffusion (explained in the following sections) all affect light transmission.



Absorption

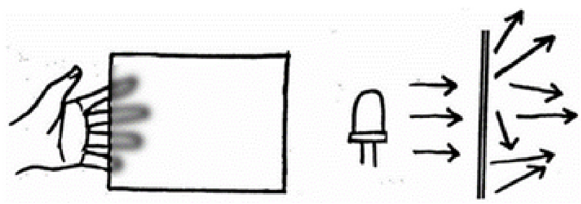
An object can absorb part or the entire incident light, usually by converting it into heat. Many materials absorb some wavelengths while transmitting others, which is called selective absorption.

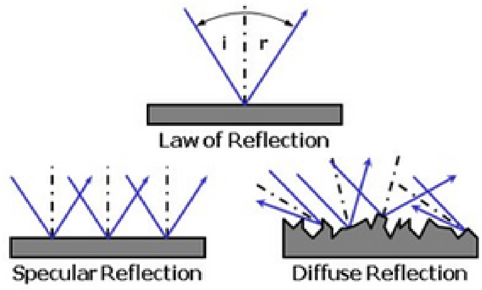


Diffusion

When light strikes a perfectly smooth surface, the reflection is specular. But, when it strikes a rough surface, the light is reflected or transmitted in many different directions at once, which is called diffusion or scattering.

The amount of diffuse transmission or reflection that occurs when light moves through one material to strike another material depends on two factors: the difference in refractive index between the two materials and; the size and shape of the particles in the diffusing material compared to the wavelength of the light. For example, the molecules in air happen to be the right size to scatter light with shorter wavelengths, giving us blue sky.





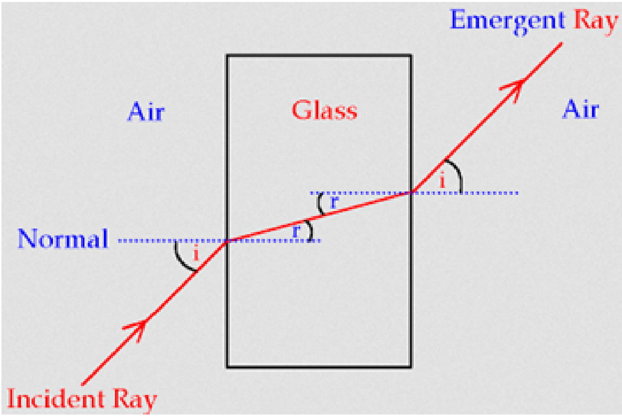
Reflection

There are three general types of reflection: specular, spread, and diffuse. A transparent substance transmits almost all light, but it reflects a little bit of light from each of its two surfaces. This reflection occurs whenever light travels through a change in the refractive index. For example, when light strikes a material such as glass at a normal incident angle, each of the two boundaries with air reflects approximately 4% of the light. As the angle of incidence increases, so does the amount of reflected light.

A specular reflection, such as what you see in a mirror or a polished surface, occurs when light is reflected away from the surface at the same angle as the incoming light's angle. A spread reflection occurs when an uneven surface reflects light at more than one angle, but the reflected angles are all more or less the same as the incident angle. A diffuse reflection, sometimes called Lambertian scattering or diffusion, occurs when a rough or matte surface reflects the light at many different angles.

Refraction

When light travels from one material to another (such as from air to glass), it refracts — bends and changes velocity. Refraction depends on two factors: the incident angle (θ) and the refractive index of the material, denoted by the letter n.



1.8 BASIC PHOTOMETRICS PRINCIPLES

Photometry is concerned with humans' visual response to light. Photometry examines only the radiation that humans can see.

Luminous Flux
Definition 1 - Luminous flux is a measuring of the visible light energy emitted.
Definition 2 - Luminous flux is the rate of flow of light energy.
Definition 3 - Luminous flux is the quantity of light emitted by a light source.

Luminous Flux is measured in lumens and denoted as F.

Luminous Intensity
Definition 1 - Luminous intensity is the power of a light source or illuminated surface, to emit light in a particular direction.
Definition 2 - Luminous intensity is the quantity which describes the power of a source or illuminated surface or illuminated surface to emit light in a given direction.
Definition 3 - Luminous intensity is the property of a source to emit light in a given direction

Luminous intensity is measured in candela and denoted as I.

Illuminance
Definition 1 - Illuminance as a measurement of the light falling on a surface.
Definition 2 - Illuminance is the density of luminous flux reaching a surface.
Definition 3 - Illuminance is a measure of photometric flux per unit area, or visible flux density.

Illuminance is measured in lux (lumen per square meter) or footcandles (lm/ft2) and denoted as E.

Luminance
Definition 1 - Luminance is the intensity or density of visible radiation per unit area of a surface seen from a particular direction.
Definition 2 - Luminance is the illuminance per unit solid angle.
Definition 3 - Luminance is the intensity of the light emitted in a given direction per projected area of a luminous or reflecting surface.

Luminance (L) is measured in candela/m2 and denoted as L.

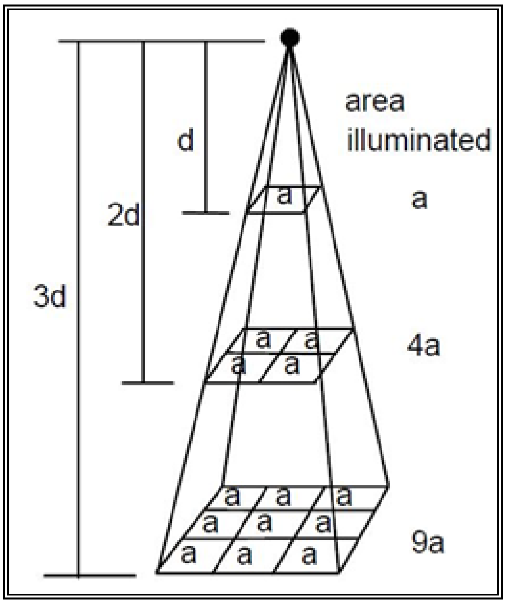
1.9 LAWS OF ILLUMINATION

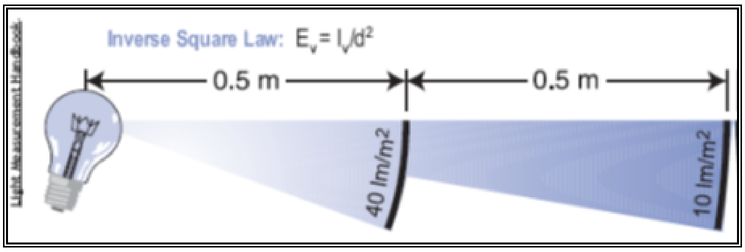
Inverse Square Law

The area illuminated by the point light source increases in proportion to the square of the distance. It follows that the average illuminance would decrease by the same ratio. The inverse square law, which quantifies this effect, relates illuminance (E) and intensity (I)

$$E = \frac{I}{d2}$$

Where d = the distance between the source and the object. In other words, as a surface that is illuminated by a light source moves away from the light source, the surface appears dimmer. In fact, it becomes dimmer much faster than it moves away from the source.



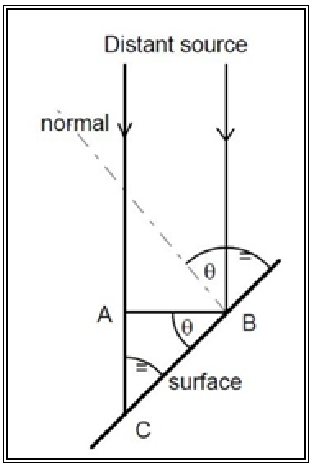


The inverse square law can only be used in cases where the light source approximates a point source.

1.9 LAWS OF ILLUMINATION

Lambert's Cosine Law

When light does not fall normally on a surface, the area illuminated increases reducing the average illuminance by the same ratio. In other words, Lambert's cosine law states that the illuminance falling on any surface depends on the cosine of the light's angle of incidence, θ.



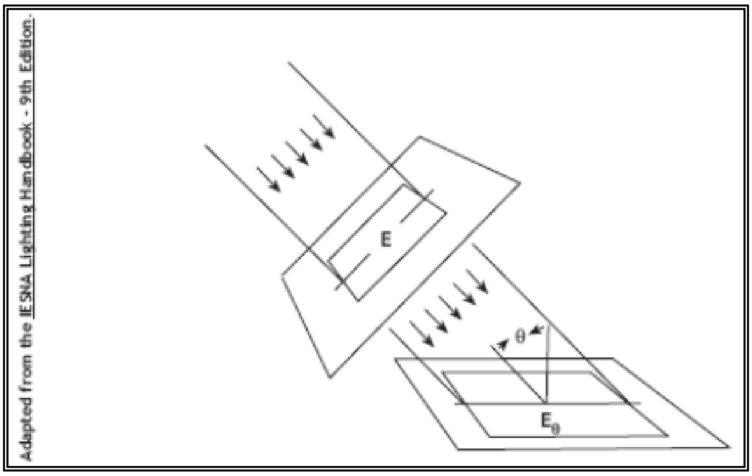


Fig. shows light from a distant source striking surfaces AB and BC. The rays of incident light may be taken as parallel.

$$\frac{AB}{BC} = \cos\theta$$

where θ = The angle between the incident light and the normal to the surface BC. Therefore the average illuminance on a surface is given by the general formula:

$$E = \frac{I \cos^3\theta}{d^2}$$

1.10 SAMPLES OF CALCULATIONS

1. A 250-Watts Sodium-Vapour lamp emits a light of 22,500 candelas and is situated 5 meters above the road. Calculate the illuminance for:

a. A point situated directly beneath the lamp
Tepat dibawah lampu

(5 marks)

b. At a horizontal distance along the road of 6 meters
Pada jarak mendatar disepanjang jalan berukuran 6 meters

(7 marks)

For answer please

SCAN ME

SAMPLES OF CALCULATIONS

2. A point source of light emits a total flux of 2550 lumen. It is suspended 3500 mm above the centre of a square table with side's length of 600 mm. Caculate illuminance level based on the following:

a. Centre of surface table
Ditengah permukaan meja

(4 marks)

b. Centre side of the table
Ditengah tepi meja

(8 marks)

For answer please

SCAN ME

SAMPLES OF CALCULATIONS

3. A meeting table measuring 3 m x 4 m is illuminated by a point's source of light. The light source is suspended 2 m above the centre of the table. Given the distribution of luminous intensity is $I\theta = 1000\,(1+2\cos\theta)$ cd. Calculate:

   a. The illuminance at the centre of the table
   b. The illuminance at the centre of the shorter side of the table

(12 marks)

For answer please

SCAN ME

1.11 EXERCISE QUESTIONS

1) A 36W T12 Cool-White fluorescent lamp emits a luminous intensity of 1850 candela. It is located 2m on top of the center of a round table. The radius of the table is 1.2m. Calculate the maximum and minimum illuminance on the table. Determine the points for the maximum and minimum illuminance produced on that table.

2) A T8 fluorescent lamp produces a luminous intensity of 1900cd. Calculate the illuminance produced at the work surface which is located at:

   a) 3m from the light source
   b) 10m from the light source

3) A 40W T8 Fluorescent lamp emits a total flux of 2400 lumen. It is located 3.1m on top of the center of a square table. The dimension of the table is 3m x 3m. Calculate the maximum and minimum illuminance on the table. Determine the points for the maximum and minimum illuminance produced on that table.

4) A metal Halide lamp produces a luminous flux of 4000lm. The lamp is located 6m above the center point of a round table with a diameter of 2.4m. Calculate the maximum and the most minimum illuminance on that table.

5) A 63W LED lamp emits a total flux of 2380 lumen. It is located 2.5m on top the centre of a rectangular table. The dimension of the table is 4m x 2m. Calculate the most minimum illuminance produced on that table.

6) A lamp has a luminous intensity of 2500 cd and act as a point source. Calculate the illuminance produced on the work surface when:

   a) It is located directly below the lamp with a distance of 2.5m
   b) It is moved about 1.5m to the left side of the lamp.

CHAPTER N.2

Daylight Lighting

Daylight lighting

2.1 INTRODUCTION

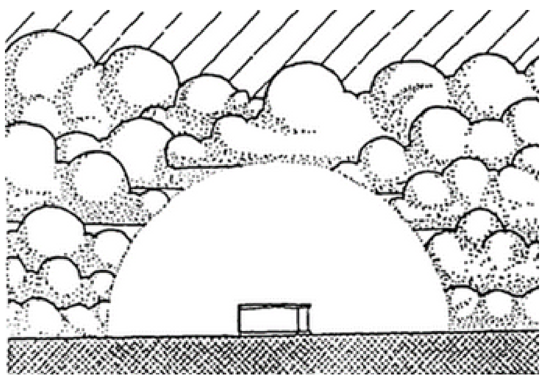
The sun releases a power flux of 63 MW. This power is equivalent to six thousand million lumens, for every square meter of its surface area. Of this around 134 kilolux reaches the earth's outer atmosphere. The atmosphere absorbs about 20% of this light and reflects another 25% back into outer space. A fraction of the remaining 55% reaches the ground directly, as sunlight, the rest is first diffused by the atmosphere (skylight) - these two together make up daylight

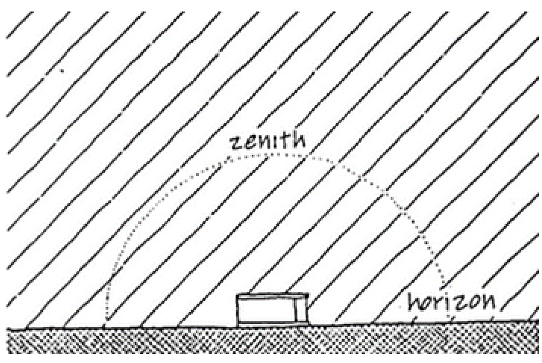
2.2 SOURCES OF DAYLIGHT

Daylight is the combination of sunlight and skylight. Sunlight comes or originated from the sun. Sunlight is also known as the visible direct beam solar radiation. Skylight emerged from a clear sky. This is kind of light which has been scattered by molecules of air, aerosols and particles such as water droplets in clouds in the atmosphere.

In any part of the world, daylight has played a crucial factor in the design of buildings. Even there are some regulations has been made in certain countries to prohibit people sit farther than 6 meters from a window as good daylight contributes to better health which in turn has implication for absenteeism and productivity.

Sky Conditions for Daylighting purposes, sky conditions are classified as either overcast, clear or partly cloudy. Each classification has characteristics that influence daylighting design.





2.3 CIE STANDARD SKY

The CIE standard sky is a model of an overcast sky in which the illuminance steadily rises above the horizon. This sky was defined by the Commission Internationale d’ Eclairage (CIE). The luminance at any altitude angle θ above the horizon is given by:

The CIE Standard General Sky defines a set of 15 general sky types that represent various sky conditions, ranging from overcast to cloudless, with varying levels of direct sunlight. Additionally, there’s a 16th type based on a simpler mathematical model for overcast skies, which was used by CIE prior to this standard. These sky types serve as a universal basis for classifying measured sky luminance distributions and provide a method for calculating sky luminance in daylighting design procedures. The luminance distribution of the sky depends on weather, climate, and the sun’s position throughout the day. The CIE Standard General Sky is described in ISO 15469:2004/CIE S 011:2003

2.4 DAYLIGHT FACTORS

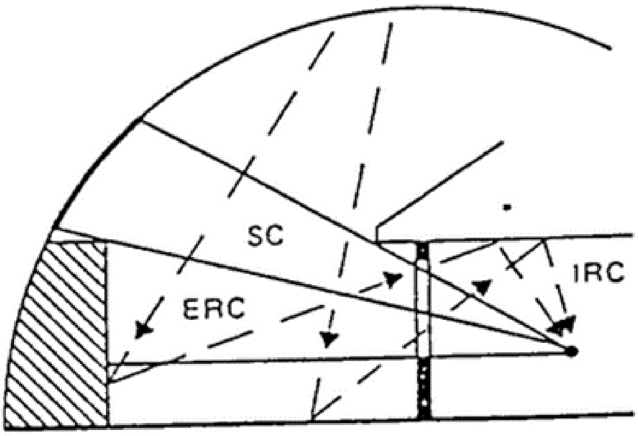
Daylight factor is the illuminance received at a point indoors from a sky of known or assumed luminance distribution, expressed as a percentage of the horizontal illuminance outdoors from an unobstructed hemisphere of the same sky. Direct sunlight is excluded from both values of illuminance.

Daylight factor components
There are three possible paths along which light can reach a point inside a room through glazed windows. They are:

(a) Light from the patch of sky visible at the point considered, expressed as the sky component (SC),

(b) Light reflected from opposing exterior surfaces and then reached the point, expressed as the externally reflected component (ERC),

(c) Light entering through the window but reaching the point only after reflection from internal surfaces, expressed as the internally reflected component (IRC).



Daylight factor is the summation of the three components:

$$DF = SC + ERC + IRC$$

sky component (SC)

The sky component is usually the greatest in magnitude among the three. Its magnitude depends on the area of sky visible from the point considered, and in the case of CIE sky, also on the position of this area at the sky dome.

The procedure for a measurement position on the line of window and at sill level is as follows:

(a) Establish H, the window head height above the work plane level

(b) Establish D, the distance from the window to the point considered,

(c) Express D as a multiple of H (i.e., the H/D ratio) and locate this at the head of the table for Sky Components

(d) Establish W1 and W2, i.e., the width of window to either side of the perpendicular (W1 + W2 = total width)

(e) Express both widths as a multiple of D (i.e., ratios W1/D and W2/D) and locate these in the first column of the table

(f) Read the two values in the table. The sky component for the point considered is the sum of the two values.

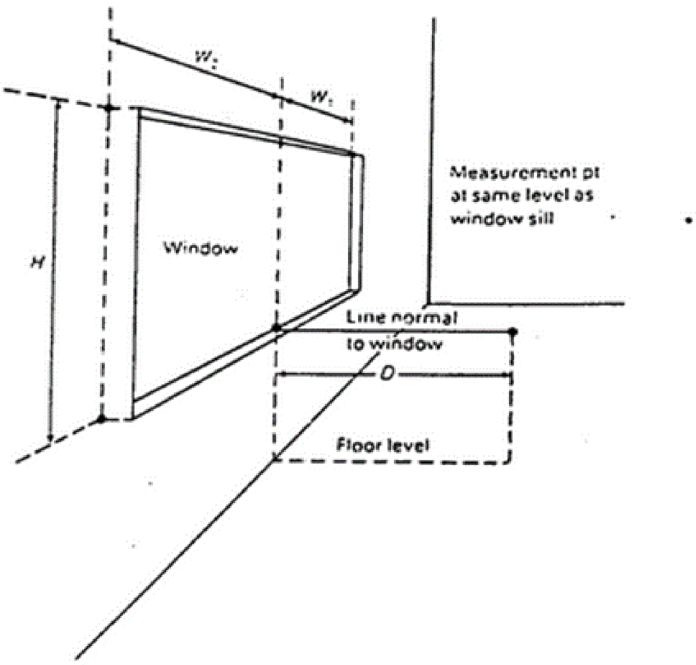
Daylight Factor Estimation

Sky components (CIE Standard overcast sky) for vertical rectangular windows with clean clear glass

Ratio W/D = Width of Window to One Side of Normal : Distance from Window

Ratio H/D = Height of Window Above Working Plane : Distance from Window

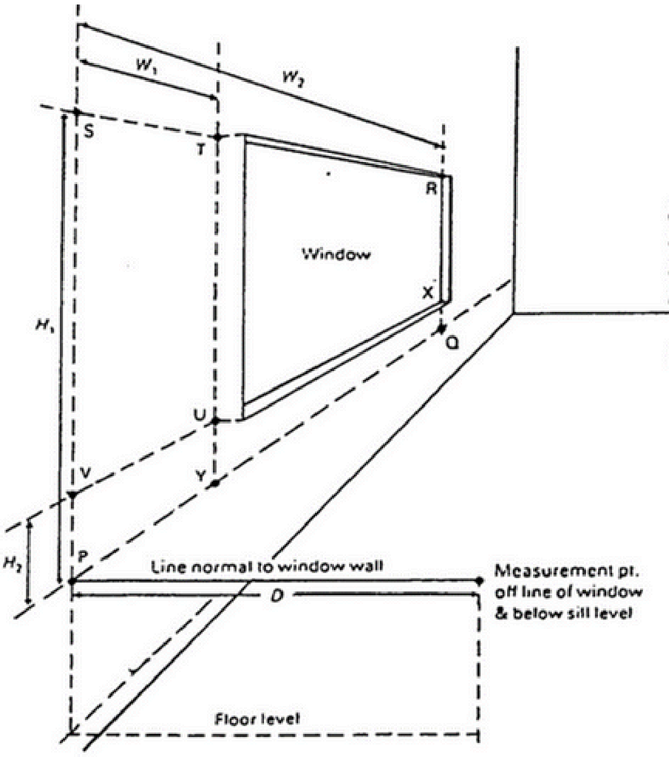
H/D \ W/D	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	4.0	6.0	∞
∞	0	1.3	2.5	3.7	4.9	5.9	6.9	7.7	8.4	9.0	9.6	10.7	11.6	12.2	12.6	13.0	13.7	14.2	14.6	14.9	15.0
5.0	0	1.2	2.4	3.7	4.8	5.9	6.8	7.6	8.3	8.8	9.4	10.5	11.1	11.7	12.3	12.7	13.3	13.7	14.0	14.1	14.2
4.0	0	1.2	2.4	3.6	4.7	5.8	6.7	7.4	8.2	8.7	9.2	10.3	10.9	11.4	12.0	12.4	12.9	13.3	13.5	13.6	13.7
3.5	0	1.2	2.4	3.6	4.6	5.7	6.6	7.3	8.0	8.5	9.0	10.1	10.6	11.1	11.8	12.2	12.6	12.9	13.2	13.2	13.3
3.0	0	1.2	2.3	3.5	4.5	5.5	6.4	7.1	7.8	8.2	8.7	9.8	10.2	10.7	11.3	11.7	12.0	12.4	12.5	12.6	12.7
2.8	0	1.1	2.3	3.4	4.5	5.4	6.3	7.0	7.6	8.1	8.6	9.6	10.0	10.5	11.1	11.4	11.7	12.0	12.2	12.3	12.3
2.6	0	1.1	2.2	3.4	4.4	5.3	6.2	6.8	7.5	7.9	8.4	9.3	9.8	10.2	10.8	11.1	11.4	11.7	11.8	11.9	11.9
2.4	0	1.1	2.2	3.3	4.3	5.2	6.0	6.6	7.3	7.7	8.1	9.1	9.5	10.0	10.4	10.7	11.0	11.2	11.3	11.4	11.5
2.2	0	1.1	2.1	3.2	4.1	5.0	5.8	6.4	7.0	7.4	7.9	8.7	9.1	9.6	10.0	10.2	10.5	10.7	10.8	10.9	10.9
2.0	0	1.0	2.0	3.1	4.0	4.8	5.6	6.2	6.7	7.1	7.5	8.3	8.7	9.1	9.5	9.7	9.9	10.0	10.1	10.2	10.3
1.9	0	1.0	2.0	3.0	3.9	4.7	5.4	6.0	6.5	6.9	7.3	8.1	8.5	8.8	9.2	9.4	9.6	9.7	9.8	9.9	9.9
1.8	0	0.97	1.9	2.9	3.8	4.6	5.3	5.8	6.3	6.7	7.1	7.8	8.2	8.5	8.8	9.0	9.2	9.3	9.4	9.5	9.5
1.7	0	0.94	1.9	2.8	3.6	4.4	5.1	5.6	6.1	6.5	6.8	7.5	7.8	8.2	8.5	8.6	8.8	8.9	9.0	9.1	9.1
1.6	0	0.90	1.8	2.7	3.5	4.2	4.9	5.4	5.8	6.2	6.5	7.2	7.5	7.8	8.1	8.2	8.4	8.5	8.6	8.6	8.6
1.5	0	0.86	1.7	2.6	3.3	4.0	4.6	5.1	5.6	5.9	6.2	6.8	7.1	7.4	7.6	7.8	7.9	8.0	8.0	8.1	8.1
1.4	0	0.82	1.6	2.4	3.2	3.8	4.4	4.8	5.2	5.6	5.9	6.4	6.7	7.0	7.2	7.3	7.4	7.5	7.5	7.6	7.6
1.3	0	0.77	1.5	2.3	2.9	3.6	4.1	4.5	4.9	5.2	5.5	5.9	6.2	6.4	6.6	6.7	6.8	6.9	6.9	6.9	7.0
1.2	0	0.71	1.4	2.1	2.7	3.3	3.8	4.2	4.5	4.8	5.0	5.4	5.7	5.9	6.0	6.1	6.2	6.2	6.3	6.3	6.3
1.1	0	0.65	1.3	1.9	2.5	3.0	3.4	3.8	4.1	4.3	4.6	4.9	5.1	5.3	5.4	5.4	5.5	5.6	5.6	5.7	5.7
1.0	0	0.57	1.1	1.7	2.2	2.6	3.0	3.3	3.6	3.8	4.0	4.3	4.5	4.6	4.7	4.7	4.8	4.8	4.9	5.0	5.0
0.9	0	0.50	0.99	1.5	1.9	2.2	2.6	2.8	3.1	3.3	3.4	3.7	3.8	3.9	4.0	4.0	4.0	4.1	4.1	4.2	4.2
0.8	0	0.42	0.83	1.2	1.6	1.9	2.2	2.4	2.6	2.7	2.9	3.1	3.2	3.3	3.3	3.3	3.3	3.4	3.4	3.4	3.5
0.7	0	0.33	0.68	0.97	1.3	1.5	1.7	1.9	2.1	2.2	2.3	2.5	2.5	2.6	2.6	2.6	2.6	2.7	2.7	2.8	2.8
0.6	0	0.24	0.53	0.74	0.98	1.2	1.3	1.5	1.6	1.7	1.8	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1
0.5	0	0.16	0.39	0.52	0.70	0.82	0.97	1.0	1.1	1.2	1.3	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5
0.4	0	0.10	0.25	0.34	0.45	0.54	0.62	0.70	0.75	0.82	0.89	0.92	0.95	0.95	0.96	0.96	0.96	0.97	0.97	0.98	0.98
0.3	0	0.06	0.14	0.18	0.26	0.30	0.34	0.38	0.42	0.44	0.47	0.49	0.50	0.50	0.51	0.51	0.52	0.52	0.52	0.53	0.53
0.2	0	0.03	0.06	0.09	0.11	0.12	0.14	0.16	0.20	0.21	0.21	0.22	0.22	0.22	0.22	0.23	0.23	0.23	0.23	0.24	0.24
0.1	0	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



SC1 : H/D & W1/D

SC2 : H/D & W2/D

SC = SC1 + SC2



WINDOW

SC1 -SRQP : H1/D, W2/D
SC2 -STYP : H1/D, W1/D
SC3 -VXQP : H2/D, W2/D
SC4 -VUYP : H2/D, W1/D

SC = SC1 - SC2 - SC3 + SC4

Ratio of window area to floor area	*Window area as percentage of floor area*	*Floor reflection factor*											
		10%				*20%*				*40%*			
		Wall reflection factor											
		20%	*40%*	*60%*	*80%*	*20%*	*40%*	*60%*	*80%*	*20%*	*40%*	*60%*	*80%*
1 : 50	2	—	—	0.1	0.2	—	0.1	0.1	0.2	—	0.1	0;2	0.2
1 : 20	5	0.1	0.1	0.2	0.4	0.1	0.2	0.3	0.5	0.1	0.2	0.4	0.6
1 : 14	7	0.1	0.2	0.3	0.5	0.1	0.2	0.4	0.6	0.2	0.3	0.6	0.8
1 : 10	10	0.1	0.2	0.4	0.7	0.2	0.3	0.6	0.9	0.3	0.5	0.8	1.2
1 : 6.7	15	0.2	0.4	0.6	1.0	0.2	0.5	0.8	1.3	0.4	0.7	1.1	1.7
1 : 5	20	0.2	0.5	0.8	1.4	0.3	0.6	1.1	1.7	0.5	0.9	1.5	2.3
1 : 4	25	0.3	0.6	1.0	1.7	0.4	0.8	1.3	2.0	0.6	1.1	1.8	2.8
1 : 3.3	30	0.3	0.7	1.2	2.0	0.5	0.9	1.5	2.4	0.8	1.3	2.1	3.3
1 : 2.9	35	0.4	0.8	1.4	2.3	0.5	1.0	1.8	2.8	0.9	1.5	2.4	3.8
1 : 2.5	40	0.5	0.9	1.6	2.6	0.6	1.2	2.0	3.1	1.0	1.7	2.7	4.2
1 : 2.2	45	0.5	1.0	1.8	2.9	0.7	1.3	2.2	3.4	1.2	1.9	3.0	4.6
1 : 2	50	0.6	1.1	1.9	3.1	0.8	1.4	2.3	3.7	1.3	2.1	3.2	4.9

**Assuming ceiling reflection factor = 70 per cent; angle of external obstruction = 20 degrees.*

Externally reflected component (ERC)

ERC can be obtained using a specific table. The procedure is to treat the external obstruction visible from the reference point as a patch of sky whose luminance is some fraction of the unobstructed sky luminance. In other words, the SC for the obstructed area is first calculated as described above and is then converted to the ERC by multiplying the ratio of the luminance of the obstructed area to the sky luminance.

Additional correction factors

The SC, ERC and IRC will be reduced by the following factors:

Maintenance factor, M, allowing for dirt and other causes of deterioration of glazing;

Location of Building	Inclination of Glazing	Maintenance Factor	
		Non-industrial or clean industrial work	Dirty industrial work
Non-industrial or Clean Industrial Area	Vertical	0.9	0.8
	Sloping	0.8	0.7
	Horizontal	0.7	0.6
Dirty industrial Area	Vertical	0.8	0.7
	Sloping	0.7	0.6
	Horizontal	0.6	0.5

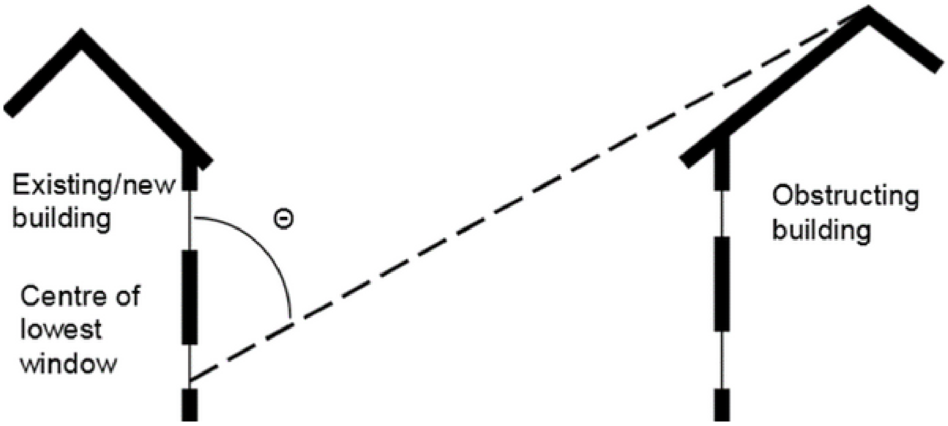
2.5 AVERAGE DAYLIGHT FACTOR

The average indoor illuminance on a reference plane or working planes as a percentage of the simultaneous outdoor illuminance from the unobstructed sky.

$$\overline{DF} = \frac{M\,W\,\theta\,T}{A\left(1-R^2\right)}\%$$

Where:
W = total glazed area of windows or rooflights
A = total area of all the room surfaces (ceiling, floor, walls and windows)
R = area-weighted average reflectance of the room surfaces
M = a correction factor for dirt
T = glass transmission factor
Θ = angle of visible sky

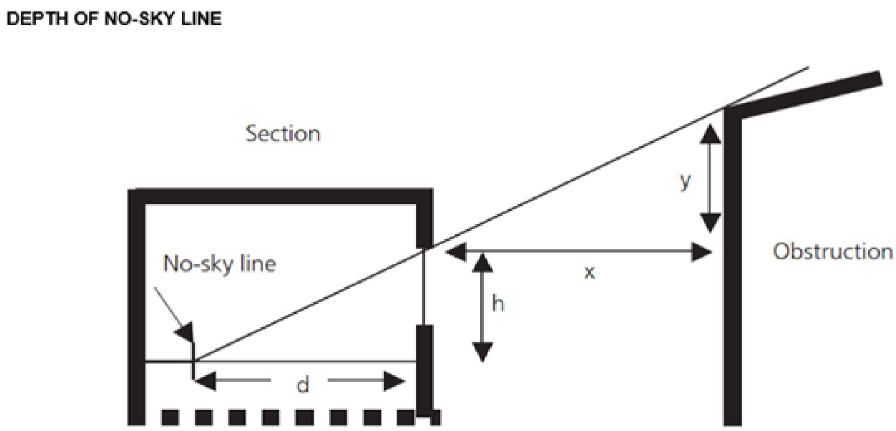
Location	Average Daylight Factor (%)	Minimum Daylight Factor (%)	Working Plane
General Office	5	2	desks
Classroom	5	2	desks
Entrance Hall	2	0.6	working plane
Library	5	1.5	tables
Drawing Office	5	2.5	boards
Sport Halls	5	3.5	floor



Guide values for a typical dwelling with light-coloured walls are as follows:
R = 0.5
M = 1.0 (vertical glazing that can be cleaned easily)
0.8 (sloping glazing)
T = 0.7 (double glazing)
0.6 (double glazing with low-emissivity coating
Θ = 65" (vertical glazing)
The glazed area of the windows can be obtained from either measuring off scaled drawings or measuring the window opening and multiply with below correction factors (from BS 8206 Part 2)

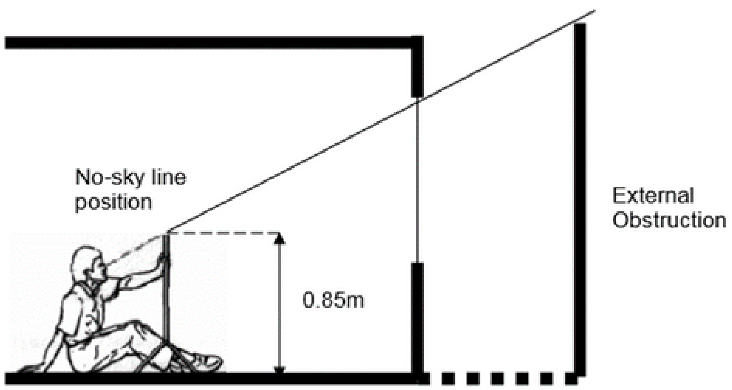
Type of frame	Correction factor
Metal patent glazing	0.9
Metal frame large pane	0.8
Wood frame large pane	0.7
Wood frame "Georgian" pane	0.6

no-sky line
The no-sky line divides those areas of the working plane, which can receive direct skylight, from those which cannot. It is important as it indicates how good the distribution of daylight is in a room. Areas beyond the no-sky line will generally look gloomy. At the no-sky line, that last visible patch of sky above the obstructions will just disappear when the window head is slighted through a point at working plane height.



$$d = \frac{xh}{y}$$

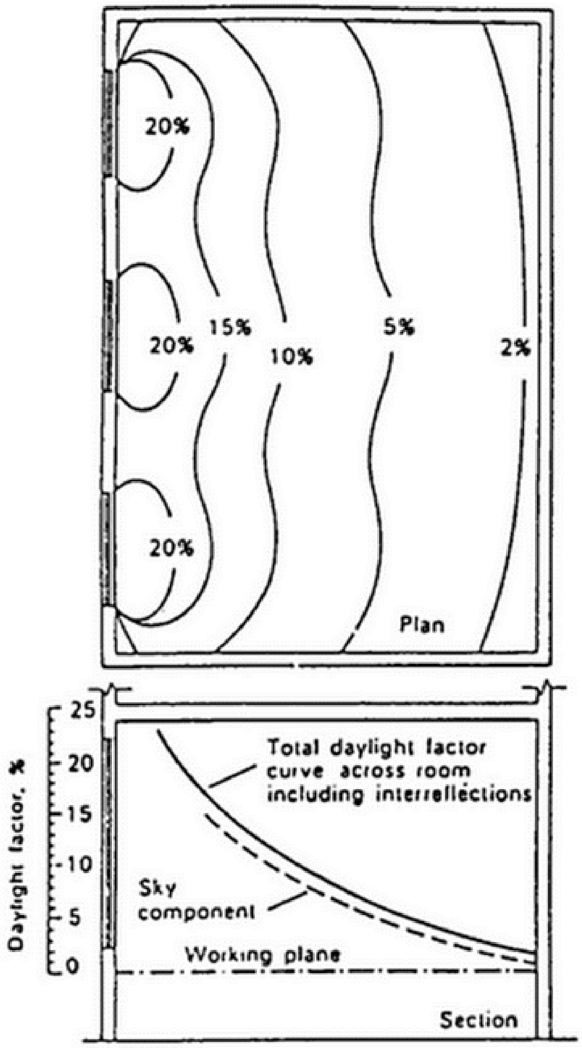
Where:
h = height of the window head above the working plane
y = height of the obstruction above the window head
x = its distance from the outside wall
If d is greater than the room depth, then no part of the room lies beyond this no-sky line.



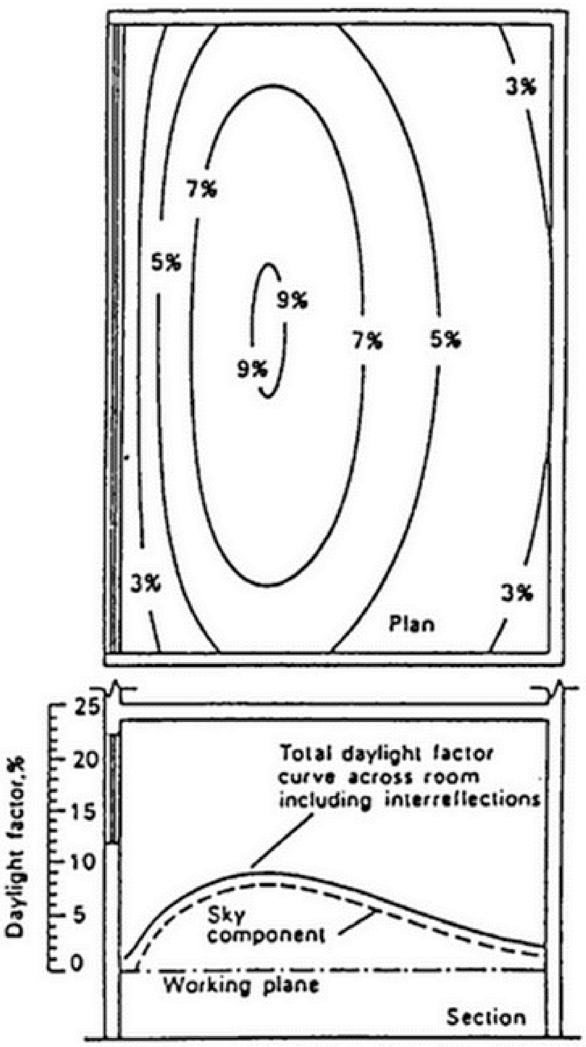
2.6 DAYLIGHT FACTOR CONTOURS

If the overall distribution of daylight in a room is to be predicted, the best method is to set out a grid and calculate the SC and ERC for each of the grid-points. The daylight factor inside a room will vary according to position. Daylight factors are often given as working plane contours. Tall windows provide deeper daylight penetration, while multiple windows provide more even daylight distribution.

The average IRC can then be found, corrected by factor D, and added to each value, after which the factors M, G and B can be applied. By interpolating between grid-point values, a set of daylight factor contours can be drawn, indicating the distribution of daylight.



Window design for tall, narrow windows



Window design for long, high window

Figure shows how the DF varies across a room were using two types of windows, both having the same total area:

(a) is for three tall windows, and
(b) is for one long, high-level window.

Window (a) will give a good open view, but (b) will provide more even daylight illumination.

The following points should be considered in the design of fenestration:

(a) The window head should be as high as possible, say at least 2 m above floor level, to enable one can see out when standing.

(b) The window sill should not be higher than 1 m from floor level to enable one can see out when sitting.

(c) The window surface area should be evenly distributed over the outside wall and the window heights and widths should not be too small in relating to the window wall because this reduces the uniformity of lighting and produces undesirable shadows.

2.7 COMBINED LIGHTING

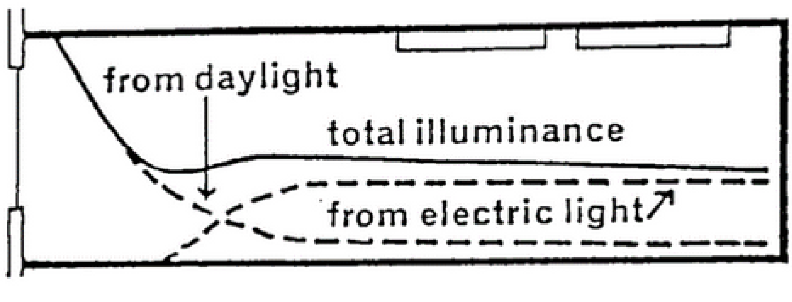
Although natural light is more pleasant to work in than artificial light, the levels of available daylight vary throughout the day and also throughout the year. Also the illumination levels provided by daylight are uneven – high illumination near windows, poor illumination towards the rear of the room. A compromise is to combine artificial lighting with daylight. This system is known as PSALI.

PSALI

PSALI – Permanent Supplementary Artificial Lighting of Interiors. PSALI is a system of combined artificial lighting and daylighting, where the two are blended together to provide an even illumination. Parts of the room are permanently lit by artificial light. PSALI retains most of the psychological advantages of artificial lighting, but can illuminate deeper plan rooms than could be lit with daylight alone.

The principle of PSALI is to provide illumination that appears to be of good daylight character even though most of the working illumination may be from artificial light. The distribution of light provided by PSALI means that illumination increases gradually towards the windows. The supplementary illumination provided by PSALI can be found by choosing a design lighting level and subtracting the contribution of daylight. The lamps used for PSALI should match natural light in colour appearance (Colour Corrected Temperature, CCT). Fluorescent tubes with a CCT of 4000-6500K are often used for PSALI, often with recessed fitting. PSALI is also used to control the switching of lights on and off as daylight levels go up and down. In bright light all illumination may be provided by daylight. At night all lighting is artificial. Light-level switching of luminaires is known as photo-electric switching

The required quantity of artificial light input is to achieve an illumance at the rear of the room comparable to, but slightly less than, the daylight illuminance nears the window. For example:



2.8 EXERCISE QUESTIONS

1. An office space of 10m long by 5m wide, have a ceiling height of 3m. It has a window of 2m wide by 1m high located at the center of the 10m by 3m wall. The window sill is 1m from the floor level. The glass transmission value is 0.8. The reflection factors for room surface are as showed in table 1. By using all data that were provided, determine:

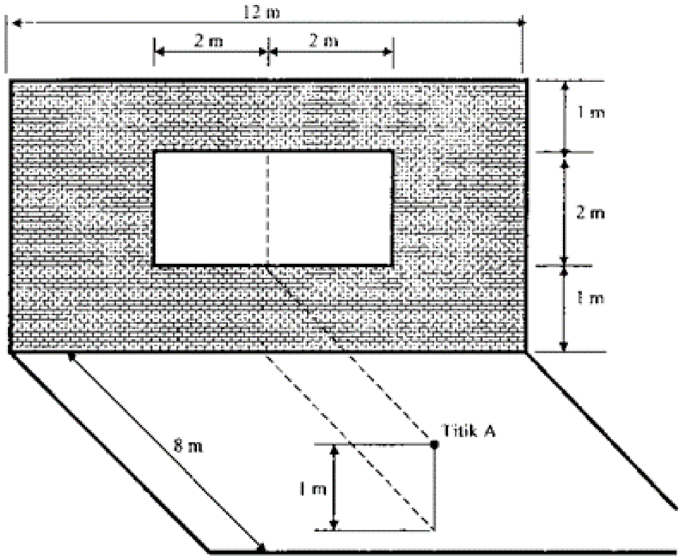
a)The Average daylight factor for the office

b)The No Skyline area if the office is blocked by a 10m high building located about 8m away.

Surface	Reflection Factor
Ceiling	0.7
Floor	0.2
Wall	0.5
Glass	0.15

2.A room measuring of 15m x 8m x 5m (height) has a window with dimension of 10m x 2m (height). The window is located at 15 m wall. Reflection factor for the surface of ceiling, walls, floors and glass are 70%, 60%, 30% and 20% respectively. The glass transmission value is 85%. Calculate the average daylight factor.

3.The chart below is the view of a lecture room. Room size is 12 m long, 8 m wide and 4 m high. The lecture room is located in the residential areas. The window size is 4 m wide and 2 m height. It is a vertical window. Wall reflection factor is 60%. Floor reflection factor is 20%.' A' reference point is 2 m from the wall. It is up to 1 m from the floor. Calculate the percentage of the daylight factor for the room.



4.Define what is the CIE standard sky?

5.Daylight to arrive at a point in the room is made up of three basic components. State and show all three of these components in the diagram.

6.A 14m x 8m steel work workshop has a floor height of 3m. It is located in the heavy industrial area. It is equipped with a window size of 5 m wide and a height of 1.5m. The value of wall reflection factor is 60%. The value of the floor reflection factor is 40%. Assuming that there is no external structure will block the view from the window. Calculate Daylight Factor of point A which is 3m from the window. Point A is located 90o towards the window.

CHAPTER N.3

Artificial Lighting

Artificial Lighting

3.1 INTRODUCTION

The main functions of artificial lighting:
Task - Artificial light may provide sufficient light level for people to carry out any particular activity or job.
Movement - Artificial light may provide sufficient light level for people to move about with ease and safety.
Display - Artificial light may provide sufficient light level to feature the character of the building in a manner suitable for its character and purpose.

3.2 TYPES OF ARTIFICIAL LIGHT

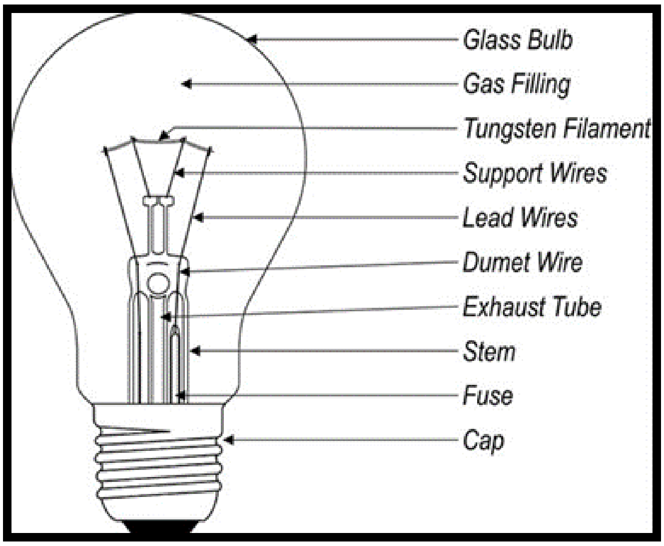
Electric Lamps
Electric lamp is a device that converts electrical energy into light. It has many types of lamps depends on its light generation method.

Incandescence
Incandescence or temperature radiation occurs when solids or liquids emit visible radiation when they are heated to temperatures above 1,000 K. As the temperature increased, the intensity increases and the appearance become whiter and clearer.

Electroluminescence
Electroluminescence is the emission of light when low voltage direct current is applied to a semi-conductor device containing a crystal and a pn junction. The most common electroluminescent device is the LED.

Electric or gas discharge
When an electric current passes through a gas, the atoms and molecule emit radiation, whose spectrum is characteristic of the elements present.

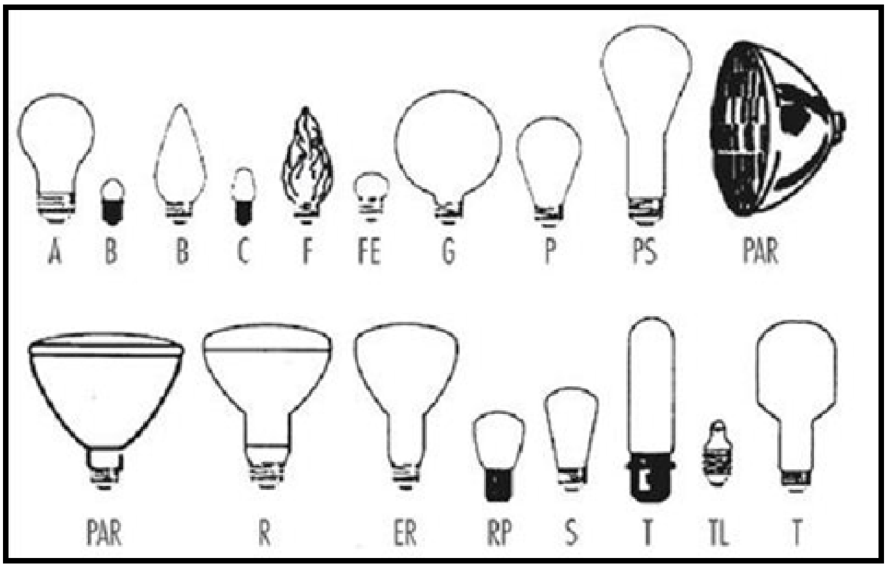
3.3 TUNGSTEN FILAMENT LAMP (GLS)



Tungsten Filament Lamp is a lamp in which light is produced by a tungsten filament heated to incandescence by an electric current. The inert gas permits operation at higher temperatures, compared to vacuum, resulting in a smaller evaporation rate of the filament. The electric current is passed through a coiled tungsten filament, contained in a glass envelope that is filled with an inert gas. When heated by an electrical current, the filament emits electromagnetic radiation.

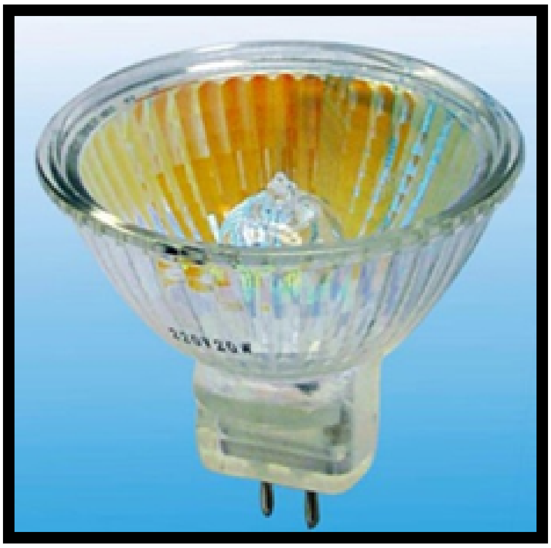
The wattage ranges of the lamp are between 40 to 200 Watts. The typical luminous efficacy of the lamp is 12 lumens per watt. The operational lifespan of the lamp is 1000 hours. The filament temperatures are limited to about 2700 Kelvin. The color rendering index is 97 CRI. It has an instant warm up and restrike time. The Tungsten Filament lamps are widely used in homes, offices, display lighting and public buildings.

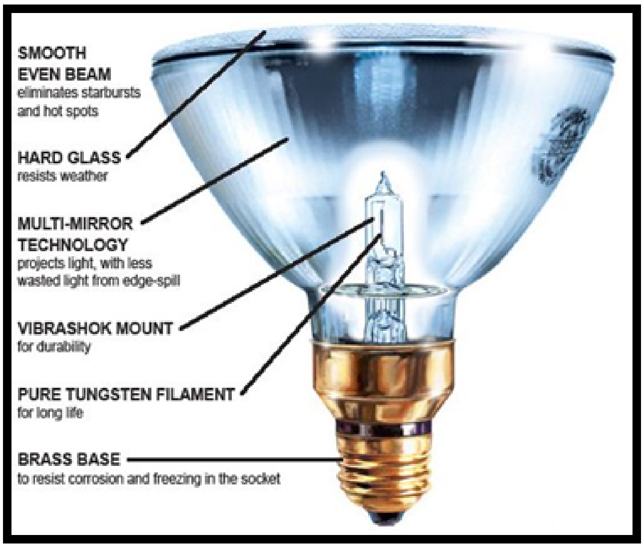
TUNGSTEN FILAMENT LAMP (GLS)



Shape Type	Shape Name	Applications
A	Arbitrary (standard)	universal use for home lighting
B	Bullet	decorative
BR	Bulging reflector	for substitution of incandescent R lamps
C	Cone shape	used mostly for small appliances/indicator lamp
ER	Elliptical reflector	for substitution of incandescent R lamps
F	Flame	decorative interior lighting
G	Globe	ornamental lighting and some floodlights
P	Pear	standard for car and locomotive headlights

3.4 TUNGSTEN HALOGEN LAMP (T-H)

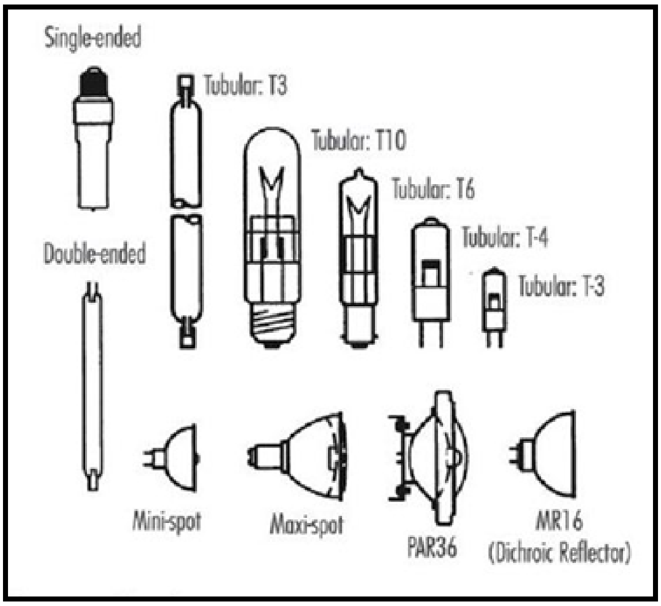




Tungsten halogen lamp has a tungsten filament similar to the standard incandescent lamp. This lamp is in the category of incandescent lamp. It contains a halogen gas in the bulb, which reduces the filament evaporation rate and thus increases the lamp life. It is a type of incandescent lighting. The lamp has an inner coating that can reflect heat. When a halogen element is added to the filling gas under certain design conditions, a chemical reaction occurs, as a result of which evaporated tungsten is re-deposited on the filament, preventing any deposits on the bulb wall. The halogen is important in order to stop the blackening and slows the thinning of the tungsten filament.

The tungsten has the capability to withstand high temperature operating conditions because its bulb was made of quartz glass. The wattage ranges of the lamp are between 300 to 2000 Watts. The typical luminous efficacy of the lamp is between 10 to 35 lumens per watt. The operational lifespan of the lamp is between 1700 to 2500 hours. The filament temperatures are from 2800 to 3400 Kelvin. The warm up time for this lamp is instant.

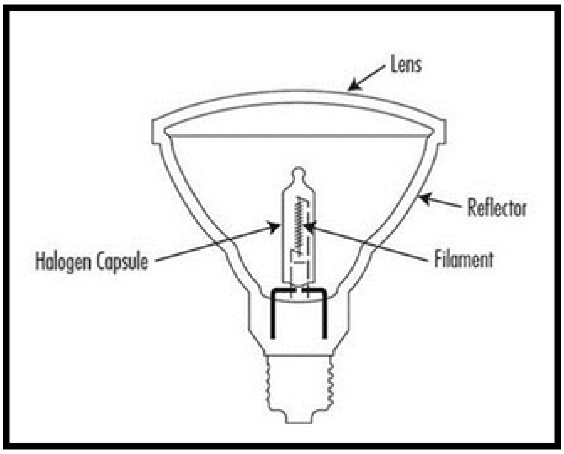
TUNGSTEN HALOGEN LAMP (T-H)



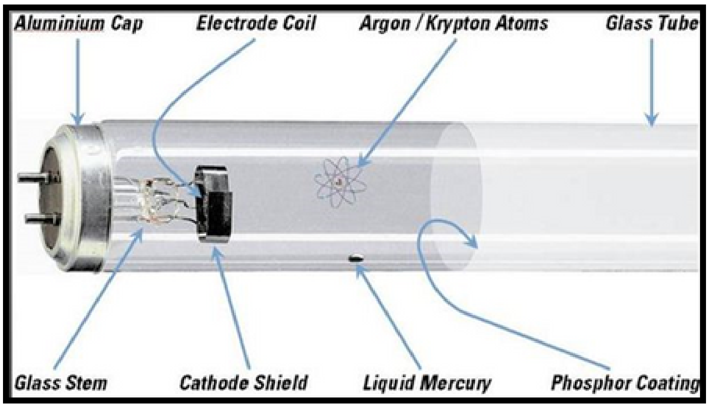
The halogen bulb comes in two basic configurations which are single and double ended. Halogen lamps are used for television and film production. Another use of this lamp has been home and commercial lighting.

Halogen PAR lamps

Halogen PAR lamps are lamps with a Parabolic aluminium reflector (PAR) which use a halogen capsule instead of a simple filament. The halogen capsule includes a tungsten filament and halogen gas.



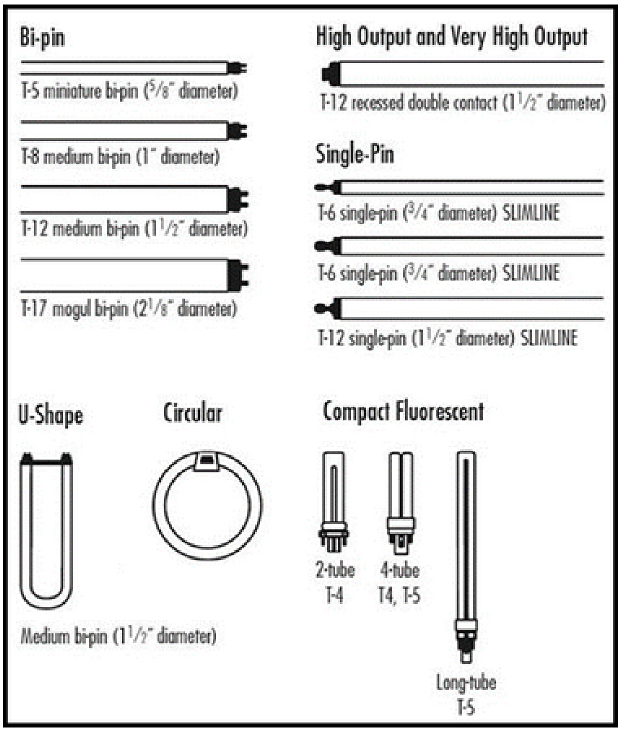
3.5 TUBULAR FLUORESCENT LAMPS (MCF)



A Tubular fluorescent lamp consists of a cylindrical glass tube, coated on the inside with fluorescent phosphors. Each fluorescent tube contains a minute dose of either mercury or amalgam and a mixture of inert gases such as argon and krypton. At either end of the tube are electrodes (cathodes) which pass an electrical charge from one end to the other, exciting ions in the process.

The wattage ranges of the lamp are between 20 to 125 Watts. The typical luminous efficacy of the lamp is between 80 lumens per watt. The operational lifespan of the lamp is more than 8000 hours. The filament temperature is in between 3000 to 6500Kelvin. This Lamps is used both for outdoor and indoor. It is also used for the backlight of the LCD displays, decorative lighting and signs, and small area general lighting.

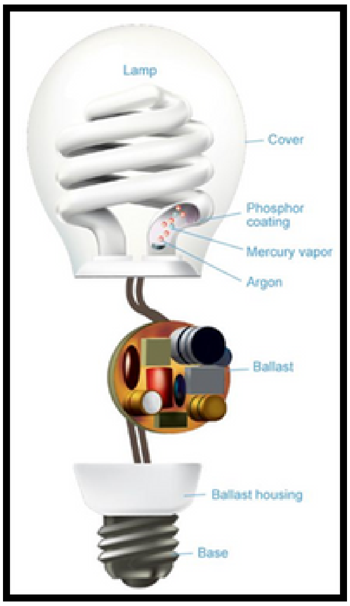
TUBULAR FLUORESCENT LAMP (MCF)



A fluorescent lamp is a low-pressure mercury electric discharge lamp. It consists of a glass tube filled with a mixture of argon gas and mercury vapour at low pressure. When current flows through the ionized gas between the electrodes, it emits ultraviolet (UV) radiation from the mercury arc.

The UV radiation is converted to visible light by a fluorescent coating on the inside of the tube. The lamp is connected to the power source through ballast, which provides the necessary starting voltage and operating current.

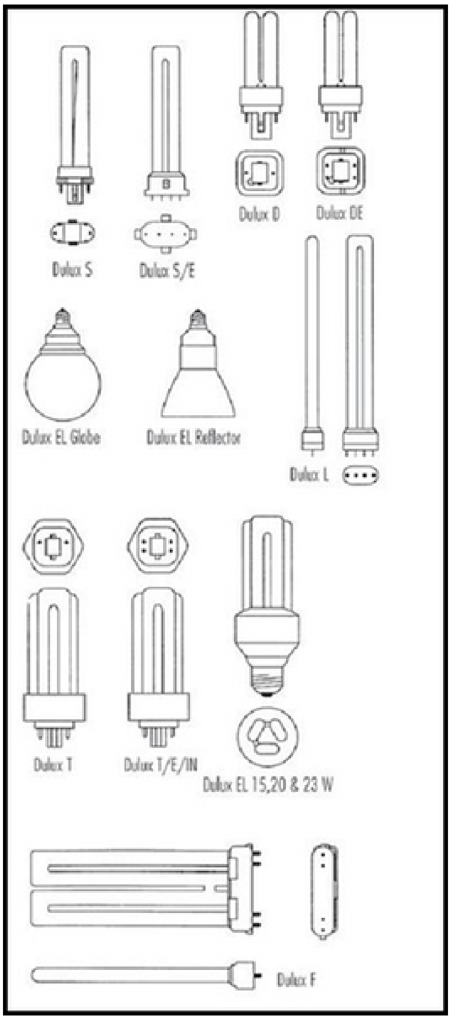
3.6 COMPACT FLUORESCENT LAMPS (CFL)



In a CFL, an electric current is driven through a tube containing argon and a small amount of mercury vapor. This generates invisible ultraviolet light that excited a phosphor fluorescent coating on the inside of the tube, which then emits visible light. There are two general types of lamps. Self-ballasted or screw based lamps, for direct replacement of incandescent lamps and pin-based lamps for compact fluorescent light fixtures. They are also available in a large variety of sizes and wattages, and in twin-tube, quad-tube, long tube, twisted, reflectorized and fully enclosed versions.

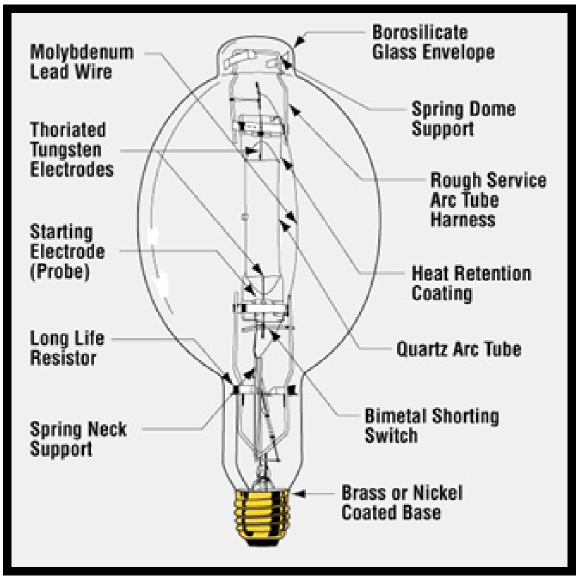
CFLs need a little more energy when they are first turned on, but once the electricity starts moving, it use about 75 percent less energy than incandescent bulbs. The wattage ranges of the lamp are between 9 to 20 Watts. The typical luminous efficacy of the lamp is between 60 lumens per watt. The operational lifespan of the lamp is more than 8000 hours. The filament temperature is 3000 Kelvin.

COMPACT FLUORESCENT LAMP (CFL)



The CFLs are widely used in homes, offices and public buildings.

3.7 METAL HALIDE LAMP (MBI)



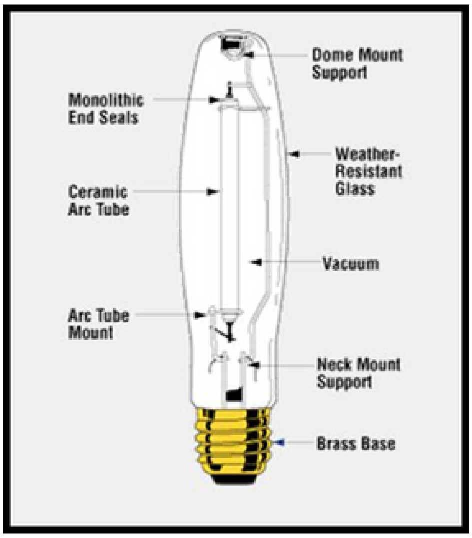
Metal halide lamps consist of an arc tube or burner within an outer envelope or bulb. The tube may be made of either quartz or ceramic and contains a starting argon gas, mercury and metal halide salts. This arc tube can operate at higher temperatures and pressures.

The Metal Halide lamps start when their ballast supplies a high starting voltage higher than those normally supplied to the lamp electrodes through a gas mixture in the arc tube. The gas in the Metal halide arc tube must be ionized before current can flow and start the lamp. The ballast used regulates the lamp starting and lamp operating current.

As temperature and pressure increase, the materials within the arc tube vaporize and emit light and ultraviolet radiation.

The wattage ranges of the lamp are between 20 to 125 Watts. The typical luminous efficacy of the lamp is between 65 up to 115 lumens per watt. The operational lifespan of the lamp is 20,000 hours. The filament temperature is in between 3000 to 20,000 Kelvin. The warm up time is between 1 to 15 minutes. The most prominent use of the Metal Halide lamp is in stadiums, sports fields, parking lots and street lighting. Smaller wattages are used in merchandising areas, assembly spaces, schools and public buildings.

3.8 HIGH PRESSURE SODIUM LAMP (SON)



In a high pressure sodium lamp, a compact arc tube contains a mixture of xenon, sodium and mercury. The xenon gas which is easily ionized facilitates striking the arc when voltage is applied across the electrodes. The heat generated by the arc then vaporizes the mercury and sodium. The mercury vapor raises the gas pressure and operating voltage and the sodium produces light when the pressure within the arc tube is sufficient. High pressure sodium lamps are the most efficient artificial white light source which saves a lot of energy compared to other lamps.

The wattage ranges of the lamp are between 70 to 1000 Watts. The typical luminous efficacy of the lamp is 125 lumens per watt. The operational lifespan of the lamp is 8000 hours. The filament temperature is 2100 Kelvin. The most prominent use of the High Pressure Sodium lamp is for outdoor lighting, municipal lighting, home yard lighting and high bay lighting.

3.9 LED LAMP

As lamps, LEDs are superior to incandescent bulbs in many ways. First and foremost is efficiency: LEDs output far more light power per watt of electrical input than an incandescent lamp. This is significant advantage if the circuit is battery-powered, efficiency translating to longer battery life. Second is the fact that LEDs are far more reliable, having a much greater service life than incandescent lamps. This is because LEDs are cold devices which operate at much cooled temperatures than an incandescent lamp with a white-hot metal filament, susceptible to breakage from mechanical and thermal shock. Third is the high speed at which LEDs may be turned on and off. LEDs are used to transmit digital (on/off) information as pulses of light, conducted in empty space or through fiber-optic cable, at very high rates of speed.

LEDs excel in monochromatic lighting applications like traffic signals and automotive tail lights. A white LED is a blue LED exciting a phosphor which emits yellow light. The blue plus yellow approximates white light.

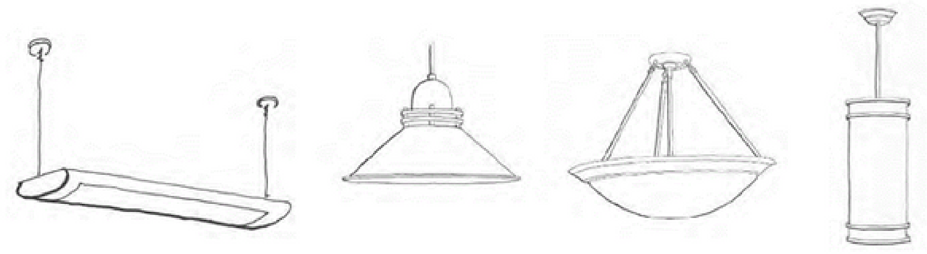
3.10 LUMINAIRE

A luminaire is the light fitting that holds or contains a lamp. Usually it absorbs and redirects some of the luminous flux emitted by the lamp. Luminaires are comprised of a light source (or lamp), reflector, shade, lens, refractor, mounting hardware and an electrical connection. LED luminaires include a power control unit to power the light source. Fluorescent and high intensity discharge luminaires include a ballast to operate the lamp. Induction luminaires utilize a generator and low voltage luminaires require a transformer.

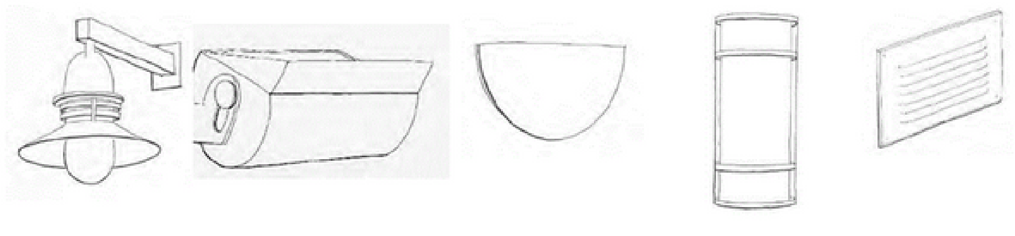
In the design of lighting installations, the choice of lamp must be combined with the choice of luminaire. Luminaires also serve a number of mechanical and electrical purposes such as positioning the lamp in space, protecting the lamp and contains the electrical control gear.

3.11 TYPE OF LUMINAIRE

Pendant mounted luminaires
Pendant mounted luminaires are suspended from the ceiling and may light down onto a table, up light the ceiling, or provide a glow in all directions.



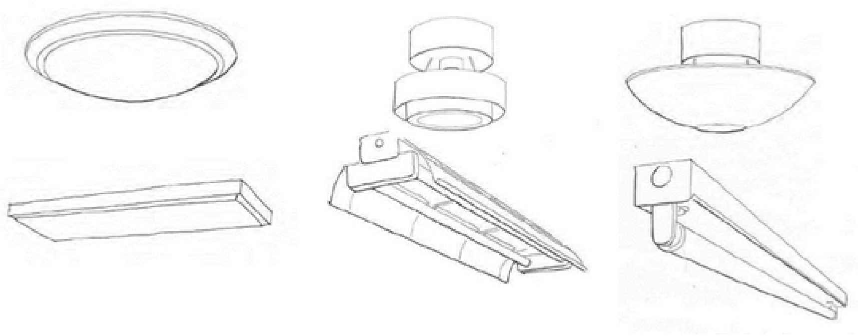
Wall mounted luminaires
Sconces or up lights may light the wall, ceiling, or provide a decorative glow.



TYPE OF LUMINAIRE

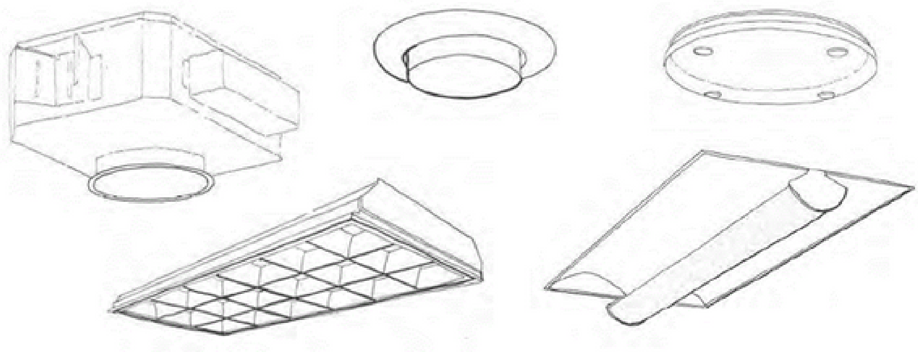
Ceiling or surface mounted luminaires

Ceiling or surface mounted luminaires provide a downlight and may also glow, depending on the type of housing and lens. Fluorescent luminaires are available in linear or compact versions. This type of luminaire is mounted directly to the ceiling.



Recessed luminaires

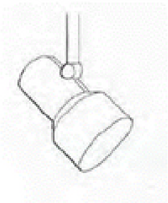
Luminaires that are recessed into the ceiling typically light the horizontal surface below, or possibly an adjacent wall. These types of luminaires are often used for general ambient lighting.

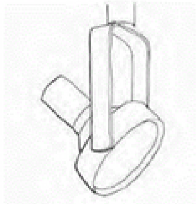


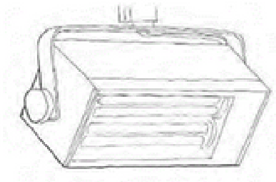
TYPE OF LUMINAIRE

Track lighting luminaires

Track mounted luminaires are adjustable and can also be relocated along the length of track. These typically use tungsten halogen or low wattage metal halide directional sources especially appropriate for accent lighting.

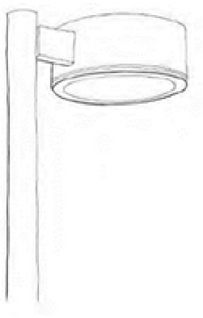


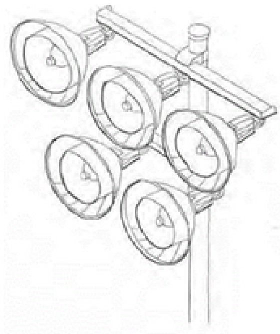




Pole mounted luminaires

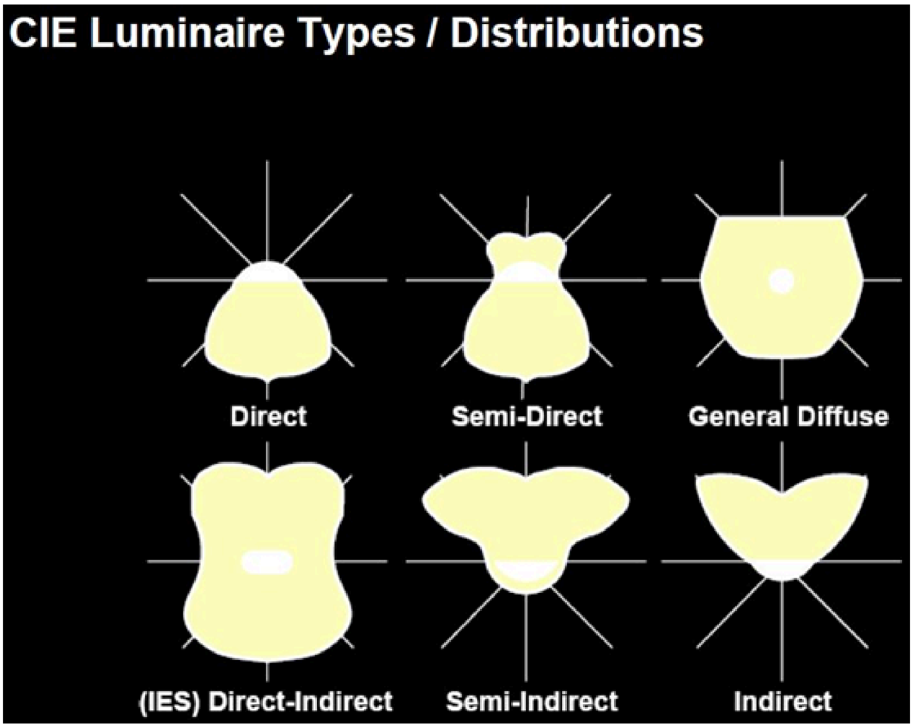
Pole mounted luminaires for exterior lighting come in a wide range of heights, but can generally be grouped in one of three categories: high mast luminaires, area luminaires and pedestrian scale luminaires on shorter poles.





3.12 LIGHT OUTPUT RATIO

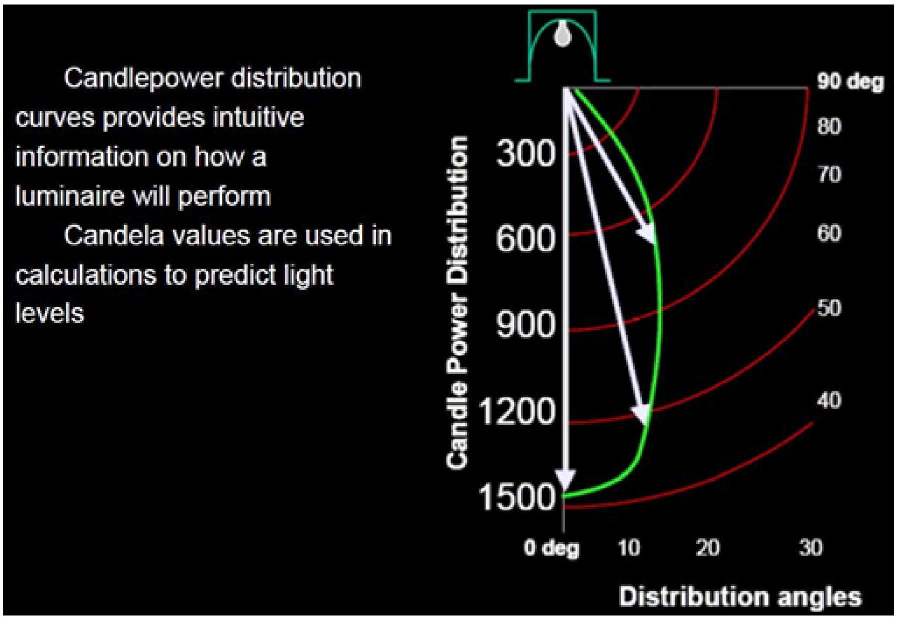
Light output ration is the proportion of the total light from the luminaire emitted into the upper and lower hemisphere formed by a plane through the middle of the lamp filament. These are the downward light output ratio (DLOR) for the luminaires.

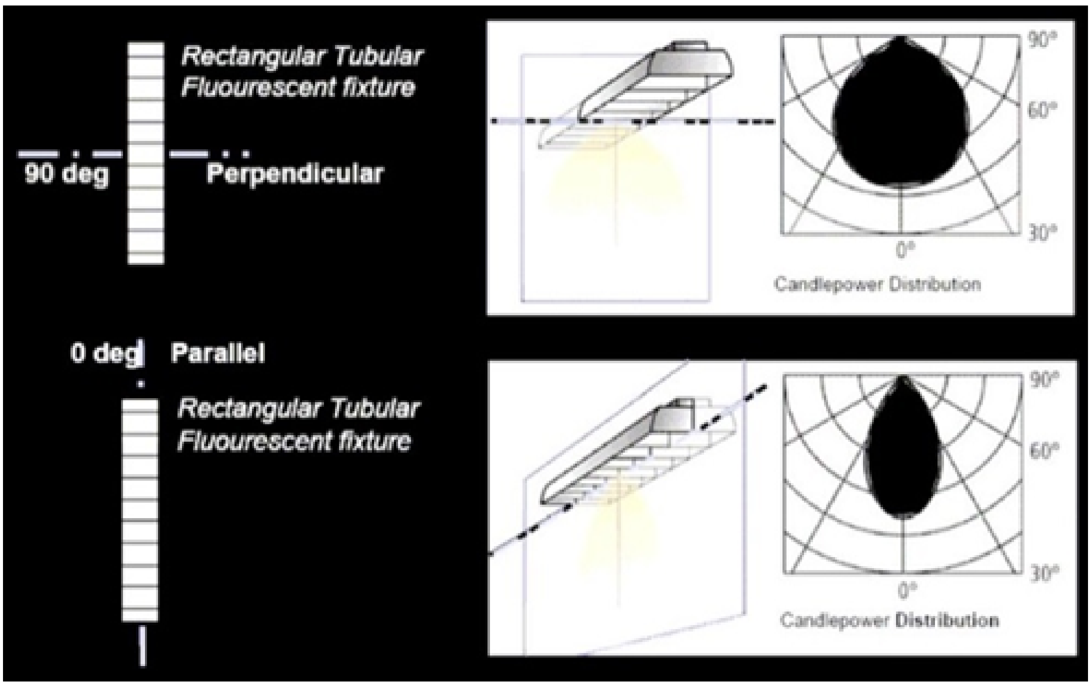


Type of Luminaire (CIE Classifications)	Downward Light Output Ratio (DLOR)
Direct	90 – 100%
Semi-Direct	60 – 90%
General Diffusing	40 – 60%
Semi-Indirect	10 – 40%
Indirect	0 – 10%

3.13 POLAR CURVE

Polar curve shows the directional qualities of light from a lamp or luminaire by a graphical plot on to polar coordinate paper. The luminous intensity of a lamp in any direction can be measured by means of a photometer, the results plotted and joined by a curve. This is then represents the distribution of light output from the fitting.





3.14 LIGHTING CONTROL

Lighting controls are devices that turn off or dim lights when they're not needed. They include simple switches and dimmers; more sophisticated occupancy sensors, time clocks, and photo sensors; and complex, computer-controlled building automation systems.

There are four primary reasons for using lighting controls:

- ·Saving energy
- ·Saving money
- ·Providing convenience and flexibility
- ·Meeting building energy codes

Strategies for saving lighting energy include:

a)Occupancy responsive: Switching lights on when needed and off when not needed in response to unscheduled comings and goings of occupants.

b)Timing: Switching lights on prearranged schedules.

c)Manual Dimming: Adjusting lights by hand (user controlled).

d)Daylighting: Dimming or turning out lights automatically when daylight from a window or skylight provides sufficient light.

e)Tuning: Adjusting light levels to match occupants' needs or desires (either by initial calibration or by user)

f)Adaptation Compensation: Reducing interior light levels when it's dark outside, and increasing them when it's bright outside, to reduce the range of light to which the human eye must adapt. Lower light levels at night are not only more comfortable but usually safer because people's eyes need not adapt as much (especially when moving from a lighter to a darker area)

Lighting Control Devices

Devices are particular products such as occupancy sensors and dimmers that are used to accomplish the strategies discussed above.

Manual Switches

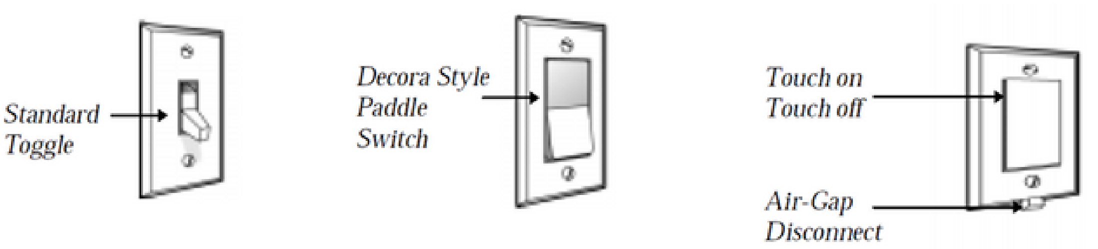
Manual switches are the simplest control devices; they rely totally on people to manage the use of lighting energy.

Standard Wall Switches

Most switches are standard toggle or the large paddle style, and most are rated 15 or 20 amps (A) at 120 or 120/277 volts (V) AC> Because they are air-gap devices(have an opening between contacts), these switches can also serve as safety-disconnect devices for services and maintenance.

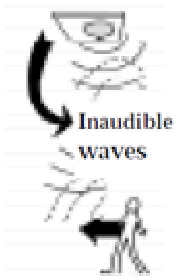
Electronic or "Touch" Switches

The standard rating for touch switches is 1000 volt-amperes (VA) at 120 V. "Touch-on touch-off" switches are electronic and the circuit is broken by an air gap.



Occupancy Sensors

Devices which switch lights on or off based on detection of motion within a specific room or area called "occupancy sensors". There are three basic technologies used for detecting motion which are Passive Infrared (PIR), Ultrasonic (ULT) and Audible.

Sensor type	How it works	Advantages	Disadvantages
Passive Infrared (PIR)  	Detects body heat crossing a detection zone. Lens design determines area of detection.	• Fairly immune to "false-ons" from motion in adjacent spaces. • Good in spaces where a cut-off (non-sensed) area is required. • Effective even at higher mounting heights	• "Line-of-sight" required to detect motion (more so than for ultrasonic). • Thus, beware of odd-shaped rooms, vestibules, columns and partitions.
Ultrasonic  	Emits ultrasound frequency shift in reflected signal signifies motion.	• Better than PIR at detecting motion when line-of-sight is interrupted; good in odd-shaped rooms and rooms with obstructions (vestibules, columns, etc.). • Can be more sensitive to small motions than PIR	• May be more sensitive to "false-ons" from adjacent spaces, air turbulence, or objects hanging in space than PIR. • Has less sensitivity in high spaces (when mounted over 12-14').
Audible	Detects leading-edge noise only, ignoring constant noise.	Simple and inexpensive (old Technology)	Very sensitive to "false-ons". Could be kept on by noise from adjacent space.

Personal Occupancy Sensors

This type of motion sensor is used for office workstations and similar applications. The sensor is connected to a single outlet or plug strip to control plug-in electric loads such as task lights, computer peripherals, and space heaters. The sensor can be mounted under a shelf facing the occupant, or be freestanding and moved around by the occupant. The sensor connects to the outlet or power strip with a telephone-type connector cable.

Timers

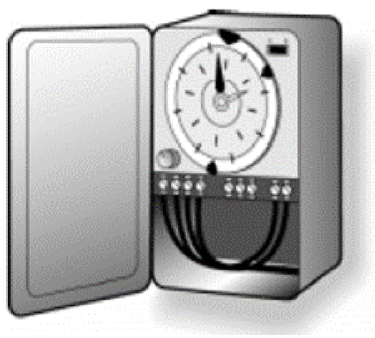
Timers are simple devices that turn on lights for a predictable period of time. Although insensitive to occupancy, timers serve a valuable function by ensuring that lights will always be turned off after a specified time. Timers are good for short-occupancy spaces like library stacks. Timers and time clocks are less costly and easier to install than other control devices.

Mechanical Timers

Mechanical timers use a twist dial that winds a spring to measure time. After the set period, the circuit is opened which turns off the lights. The range of the device is fixed by the mechanics of the switch. Most mechanical timers are rated 15 A at 120 V. They are air-gap devices.

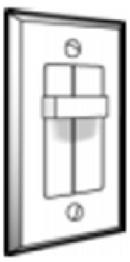
Electronic Timers

Electronic timers generally have a touch control to set the time lights should go off and an optional “time-out” warning. Some electronic timers are not air-gap devices.



Manual Dimmers
Dimming reduces light levels by reducing the power input to a light fixture, which saves energy.

Incandescent Dimmers
Most incandescent dimmers now use a solid-state device called a “triac” to control the flow of power to the lights. Triacs turn lights on and off 120 times per second. Decreasing the proportion of on-time lowers the power draw and apparent brightness. Dimmer types include standard, inductive-load, and solid-state-load dimmers.
When incandescent lights are dimmed there is a slight “red shift,” making the light appear warmer (redder) when dimmed. Dimming devices can have special features such as touch control (“touch” dimmers) and dimming-level memory (“presets”). They can also be configured for multi-location dimming of the same lights or for interconnection to “master” dimmers. Standard dimmer rating is 600 watts (W) – 600 VA for inductive loads. Typical higher ratings include 1000 W, 1500 W, and 2000 W.



Classic Slide Dimmer

Two Gang Rotary Dimmer

Fluorescent Dimmers
Most fluorescent dimming devices function much like incandescent dimmers and offer many of the same options and features. Dimming fluorescent lights generally requires a dimming ballast in addition to the dimming device. Besides the common wall dimmer, a wireless-remote dimmer control is available. This hand-held device transmits an infrared signal to a receiver mounted in or near a lighting fixture to dim the fixture(s) continuously or to pre-set levels.

Photo switches and Photo sensors
There are two principal types of photoelectric controls:

a)Photo switches are devices that turn lights on or off according to the amount of light striking the sensor (photocell) surface. Most photo switches are designed for switching outdoor lighting at dawn and dusk. Exterior photo switches are not adjustable.

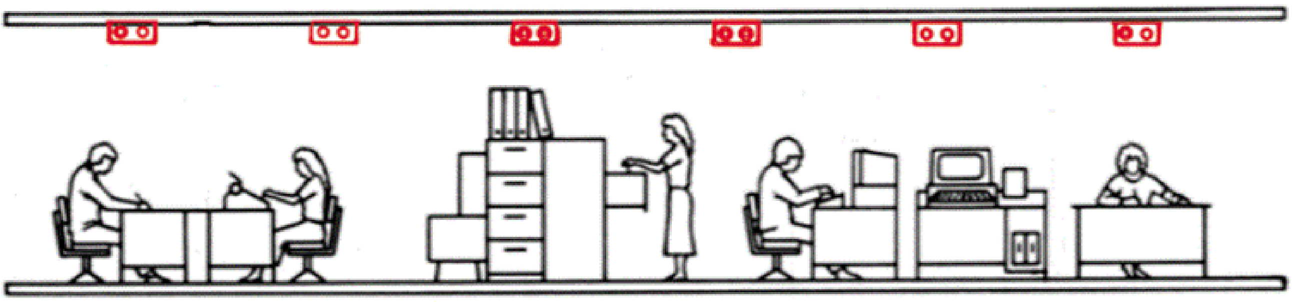
b)Photo sensors can continuously vary light output, usually by controlling fluorescent dimming electronic ballasts. They dim lights for daylighting. Most photo sensors have adjustments similar to occupancy sensors, including time delay, response speed and sensitivity.

CHAPTER N.4

Lighting Design

4.1 Design Method

General Lighting
A lighting design method that provides illumination on the whole area of the room. This is probably the most commonly used artificial lighting system. A regular array of luminaires provide
An average maintained illuminance on the working plane. This type of system will normally provide a rather bland “shadow free” lighting installation but great flexibility of work stations is possible as tasks can be moved around. Some of the bland effect can be reduced by introducing some sparkle and contrast into the design. Point sources provide sparkle whilst directional or indirect lighting provides contrast. The main disadvantage of general lighting schemes is their high energy costs because the whole area is illuminated to the highest level of illumination required for the single most difficult task.



4.1 Design Method

Localized Lighting

A lighting design method that provide a higher illuminance over a particular area of an interior. If the location of a particular work area is known then localized lighting can be used to raise the illuminance on this area whilst maintaining general illuminance at a lower level. The average general illuminance should be at least one third of the task illuminance where localized lighting is provided. Localized lighting tends to provide a more interesting design with emphasis placed on the work station. Localized lighting is more efficient with regard to energy costs because of the more efficient use of light, however, good maintenance of these schemes is essential.

4.1 Design Method

Local Lighting

Lighting design that provide illumination in a small area. This is the term used for lighting which illuminates a specific individual workstation. General illuminance should be at least one third of the local illuminance. The light should be positioned to minimize shadows, veiling reflections and glare. A desk would typically be illuminated from the left hand side (for a right handed person) so that there are no distracting shadows or veiling reflections. The eye should be protected from the lamp itself by the use of a “shade”. Local lighting ensures efficient use of light energy. Local individual control should be provided. Disadvantages are that low wattage lamps are normally less efficient and maintenance costs are generally higher with local lighting.

4.2
DESIGN PLANNING

1 OBJECTIVE

Set the goals
Determine the objectives of the design in terms of safety, task and appeatance requirement. Priorities should be allocated and constraints identified

2 SPECIFICATION

Specify criteria
Express the design objectives as a set of compatible design criteria and acknowledge those objectives which cannot be quantified

3 GENERAL PLANNING

System type
Consider the relationship between natural and electric lighting. Resolve the type of lighting system which will achieve he desired objectives

4 DETAIL PLANNING

Calculations/details
Plan the final scheme using accurate data to ensure the most economical and effective final design

5 VERIFICATION

After completion, examine the installation in order to assess its terms of the design objectives and its acceptability to the client/users

CHAPTER N.5

Emergency Lighting

INTRODUCTION TO EMERGENCY LIGHTING

Emergency lighting is lighting for an emergency situation when the main power supply fails. The loss of mains electricity could be the result of a fire, power cut or local circuit failure and the normal lighting supplies fail. This may lead to sudden darkness and a possible danger to the occupants, either through physical danger or panic.

Emergency lighting is normally required to operate fully automatically and give illumination of a sufficiently high level to enable persons of all ages to evacuate the premises safely. Emergency lighting is an essential part of the building services installation. To ensure the system is well designed and as reliable as possible, planning is important through all phases of the project, from considering legal requirements to final commissioning and maintenance.Consultation between all interested parties at an early stage of the design cannot be over emphasised to avoid expensive modifications to the completed system. Considerable legislation and associated standards exist covering the various types of premises that involve the need to incorporate emergency lighting.

The first stage of system design is to gather the information needed on the project, normally by consultation with the Regulatory Authority and the user. This should cover legislative and likely operational requirements, and customer preferences.

THE OBJECTIVES AND THE PURPOSES OF THE EMERGENCY LIGHTING

Emergency Lighting is needed:

a)To illuminate the escape routes.
b)To provide illumination along such routes to allow safe movements towards and through the exits provided.
c)To ensure that fire alarm call points and firefighting equipment provided along escape routes can be readily located and used.
d)To permit operations concerned with safety measures

The main purpose of the installation is to ensure that lighting is provided promptly, automatically and for a suitable time in a specific area when normal power supply to the lighting fails. Other purposes of the installation are to ensure that:-

a)The means of escape can be safely and effectively used.
b)Activities in particularly hazardous workplaces can be safely terminated.
c)Emergency actions can be effectively carried out at appropriate locations in the workplace.
d)Specific emergency routes and exits must be indicated by signs in accordance with the national regulations.
e)Emergency routes and exits requiring illumination must be provided with emergency lighting of adequate intensity in case the lighting fails.

LAWS AND REGULATIONS OF THE EMERGENCY LIGHTING

It is necessary to ensure that design of the emergency lighting shall satisfy all of the conditions determined in the following documents:

a)The Uniform Building By-laws Regulations
b)BS 5266-1: 2005 Emergency Lighting – Code of Practice for emergency lighting premises
c)BS 5266-2:1998 Emergency lighting. Code of practice for electrical low mounted way guidance systems for emergency use
d)BS 5266-4:1999 Emergency lighting. Code of practice for design, installation, maintenance and use of optical fibre systems

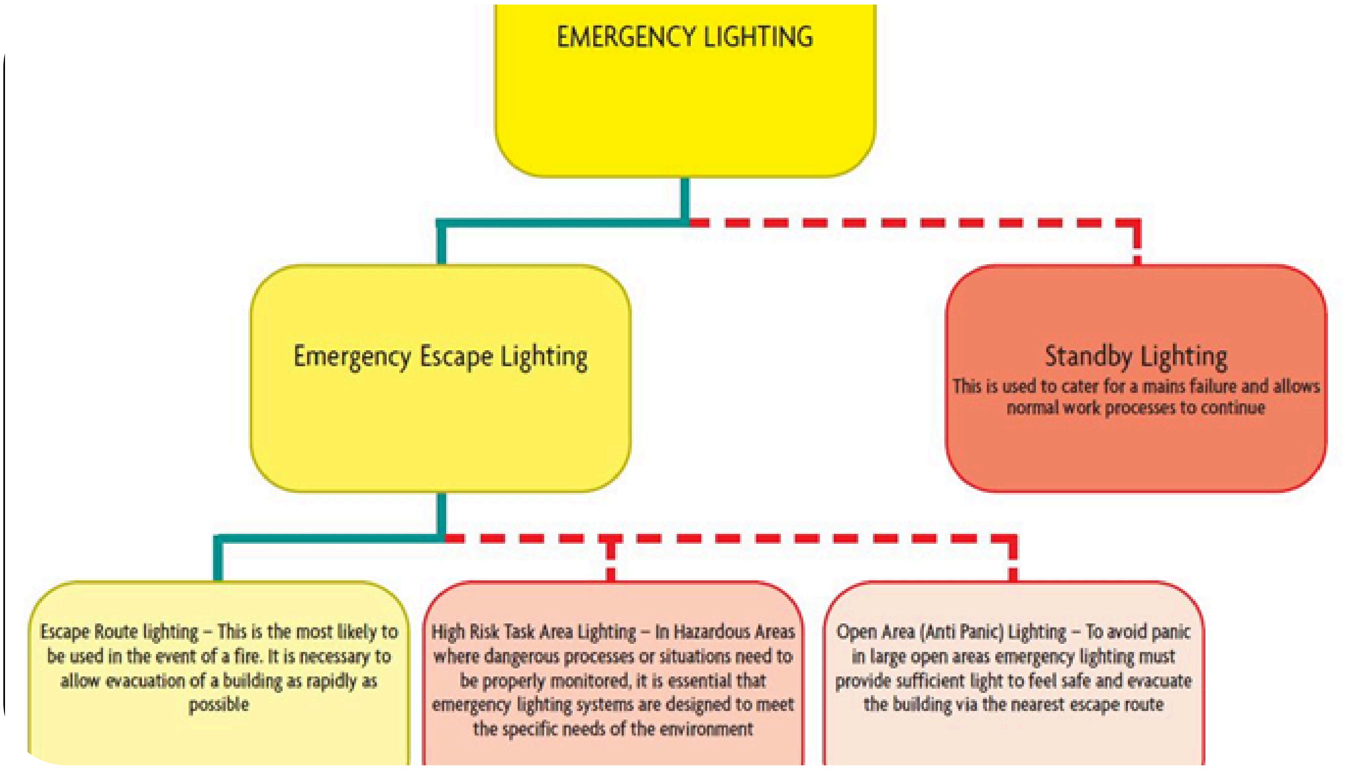
FORMS OF EMERGENCY LIGHTING BASED ON BS 5266-1: 2005

Under this standard, the emergency lighting is formed into five main specific forms.

First and foremost is the emergency escape lighting. This is the emergency lighting system provided to enable safe exit in the event of failure of the normal supply.

Secondly is the standby lighting. This is the emergency lighting system provided to enable normal activities to continue in the event of a failure of the normal mains supply.

The third is the escape route lighting. This is the emergency lighting system provided to ensure that the means of escape is effectively identified and be safely used at all times whilst the premises are occupied.



The fourth is the high risk task area lighting. The objective of high-risk task area lighting is to ensure the safety of people involved in a potentially dangerous process or situation and to enable proper shut down procedures for the safety of other occupants of the premises i.e. laboratories, plant or switchgear rooms etc.

Finally is the open area (anti-panic) lighting. This emergency lighting is provided at areas of undefined escape routes such as in halls or premises larger than 60 m2 floor area or smaller area. So that there is adequate lighting to allow persons to orientate themselves and find the appropriate escape route, without causing panic in the process.

CATEGORIES OF OPERATION

Non-maintained

The emergency light units only illuminate in the event of a mains failure. In this mode of operation the emergency lighting lamps are not normally energized. An automatic monitoring and switching system is provided to switch on the emergency lighting if the normal supply is interrupted. Under this category, the system is able to handle emergency duration up to 2 hours.

If separate lamps are required to provide normal lighting and emergency lighting in the same place, these lamps may either be housed in separate luminaires or may be combined in single sustained luminaires. Such sustained luminaires may also contain a separate charger, battery and control circuit for use with non-centralized battery systems.

Maintained Operation

The emergency light units are illuminated at all times using the same lamps for both normal and emergency operation. A maintained mode of operation may be achieved using a prime mover driven generator as the emergency lighting power source, provided that it can be run up and put on load in the required time. In such circumstances, failure of the normal supply would automatically start up the generator and switch the input to the lighting circuits from the normal supply to the generator output. Under this category, the system is able to handle emergency duration up to 3 hours.

Where batteries are used, either as the sole source of emergency lighting supplies or as back up to a generator, there are two methods of achieving maintained operation:

Maintained floating systems.

In this mode of operation the battery charger is fed from the normal supply and connected in parallel with the battery and the emergency lighting loads. If the normal supply fails the battery will continue to supply the emergency lighting and no changeover switch or similar device is required.

Maintained changeover systems.

In this mode of operation the emergency lighting system and the battery charger are separately connected to the normal supply and no load is connected to the battery. If the normal supply is interrupted, an automatic changeover device is actuated to connect the emergency lighting system to the battery. Automatic changeover contactors complying with BS 764 or an equivalent standard of electrical performance are recommended for this application.

Sustained

The emergency light units are fitted with two lamps or two sets of lamps. One of which operates on mains 240V AC supply, the other which operates from the battery supply in the event of mains failure. It is basically a non-maintained system with the addition of mains lamps which should be illuminated whenever the premises are occupied. Under this category, the system is able to handle emergency duration up to 1 hour.

TYPES OF EMERGENCY LIGHTING LUMINAIRE

a) Single Point Luminaire

An emergency lighting luminaire containing a lamp, a secondary cell battery and a charging circuit to charge the battery from the mains. During failure of the main supply, the emergency lamp will get the supply power from the integral battery installed.

b) Slave Luminaire

An emergency lighting luminaire containing a lamp but with no batteries. During failure of the main supply, the emergency lamp will get the supply power from a remote sources.

c) Combined Luminaire

A single point or slave emergency lighting luminaire which also functions as a normal luminaire.

ESSENTIAL PRE-DESIGN INFORMATION

Before designing an emergency lighting scheme the following information needs to be determined from the site drawings or from the specifications provider:

a) The duration of the emergency lighting:

I. Three hour duration is required in places of entertainment and for sleeping risk.
II. Three hour duration is required if evacuation is not immediate, or early re-occupation is may occur.
III. One hour duration may be acceptable, in some premises, if evacuation is immediate and re-occupation is delayed until the system has recharged.

a) Emergency lighting of the maintained type should be used in areas in which the normal lighting can be dimmed and in common areas within where a build-up of smoke could reduce the effectiveness of normal lighting. Maintained lighting which combines both emergency and normal lighting functions may also be desirable for aesthetic or economic reasons.

b) The exit signs always need to be illuminated to be visible at all times when the premises are occupied. Because of the difficulties of ensuring that the normal lighting will adequately do this maintained signs are required in licensed and entertainment venues and they should be used in any premises which are used by people who are unfamiliar with its layout.

DESIGN PROCEDURE

Locate luminaires at points of emphasis.These are mandatory locations to cover specific hazards and to highlight safety equipment and signs. The luminaires act as beacons over parts of the escape route that may be dangerous at low levels of illumination and also highlight other safety equipment that may need to be operated.

This procedure should be performed regardless of what part of the building is considered and whether the area is an emergency escape route or defined as an open area.

MANDATORY LOCATIONS

An emergency lighting luminaire shall generally be sited to provide appropriate illuminance at positions where it is necessary to emphasize potential danger or safety equipment. The positions to be emphasized shall include the following:

- At each exit door intended to be used in an emergency,

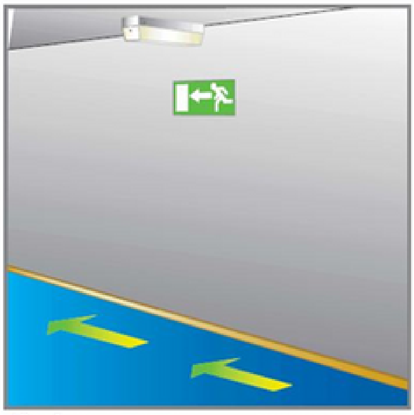
- Mandatory emergency exits and safety signs,

- Near to each final exit and outside the building to a place of safety

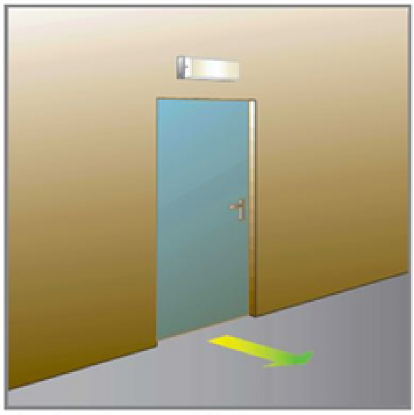
The safety of occupants must be protected until they are away from the influence of the building. If the area outside the building has hazards in darkness such as a river bank the risk assessment should determine if further emergency luminaires are needed till a place of safety can be reached.

If street lighting is available and adequate it may be used with the agreement of the fire authority.

At each exit door

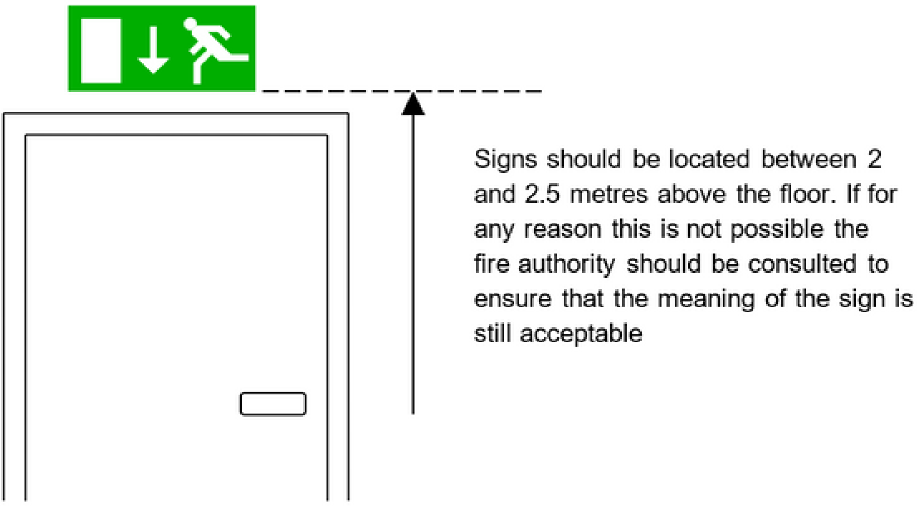


All safety exit signs



Outside and near each final exit

While this normally relates to exit direction and first aid signs the risk assessment may indicate that other safety signs such as a radioactive warning also need emergency illumination. Exit signs should not be used in the photometric calculations unless their characteristic has been tested and authenticated data is available.

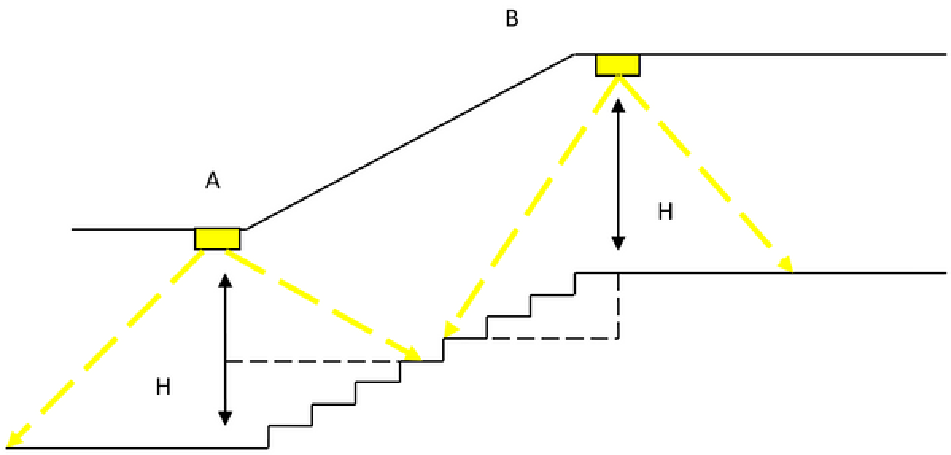


While this normally relates to exit direction and first aid signs the risk assessment may indicate that other safety signs such as a radioactive warning also need emergency illumination. Exit signs should not be used in the photometric calculations unless their characteristic has been tested and authenticated data is available.

• Near to stairs, so that each flight of stairs receives direct light

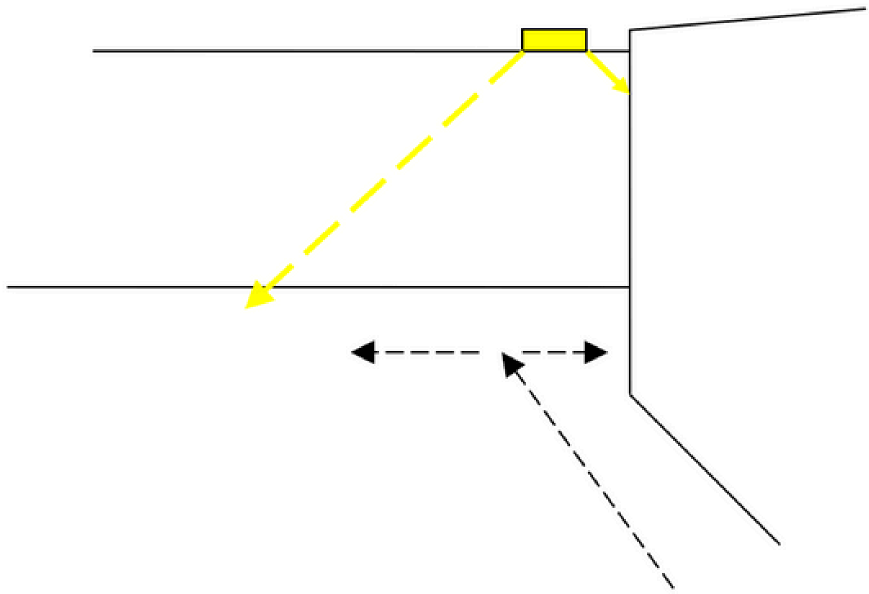
The luminaires must be located so each tread receives direct light. Generally at least two luminaires will be needed to provide the 1 lux minimum level on the centre of each tread

The spacing from luminaire A is reduced as the height being reduced as the point's illuminated rise up the stairs so the cosine correction factor reduces the light. The spacing from fitting B may be reduced as although the cosine correction improves in comparison with the floor level as the treads descend at some point the effect of increased distance from the luminaire will outweigh this.

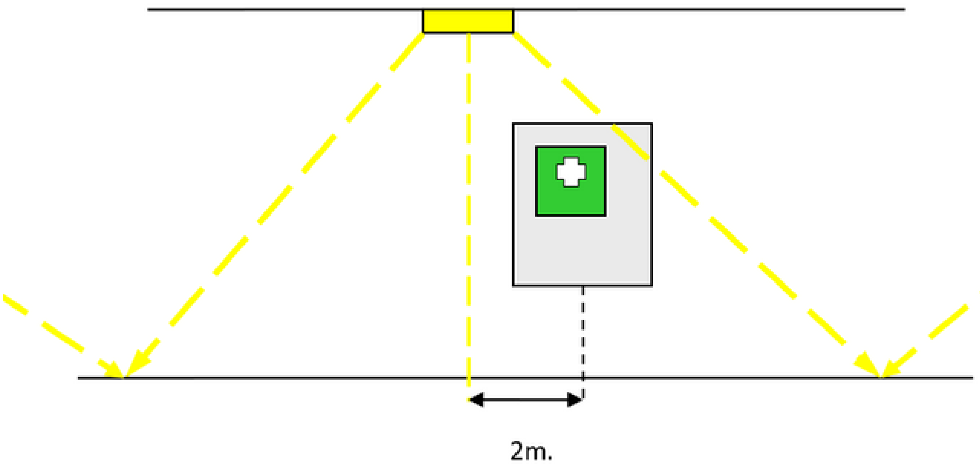


While this normally relates to exit direction and first aid signs the risk assessment may indicate that other safety signs such as a radioactive warning also need emergency illumination. Exit signs should not be used in the photometric calculations unless their characteristic has been tested and authenticated data is available.

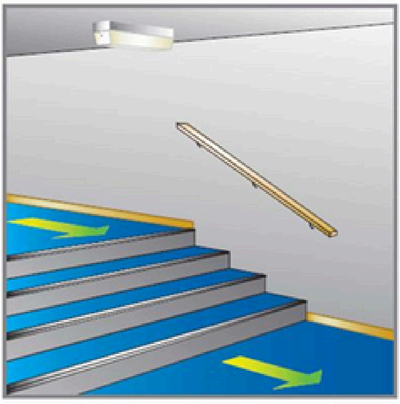
• At each change of direction,



• Near each first aid post,

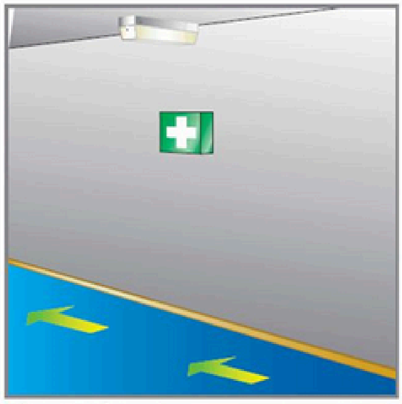


- Near any other change in level on the escape route,
- At each intersection of corridors,
- Near to firefighting equipment and fire alarm manual call points,



Near stairs so that each tread receives direct light

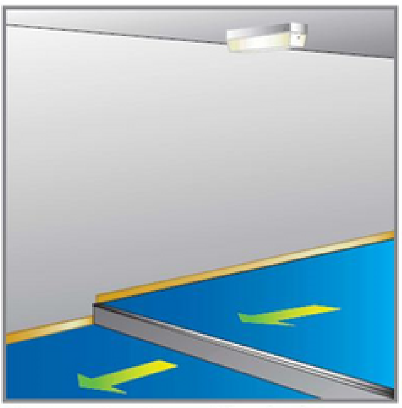
At each change of direction



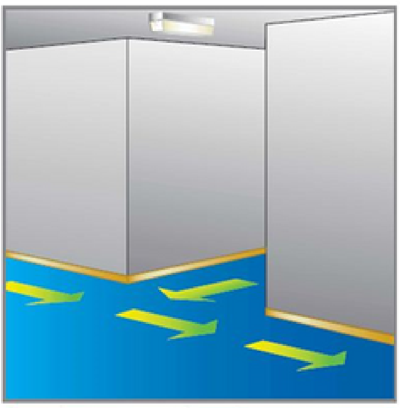
Near each first aid post

- Near each first aid post,

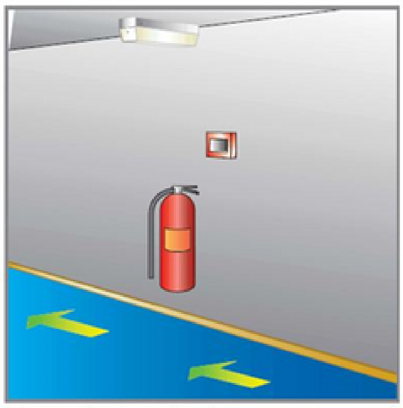
(Note - the term near means within 2 meters measured horizontally)



Near any other change of floor level



At each intersection of corridors



Near each piece of fire fighting equipment and call point

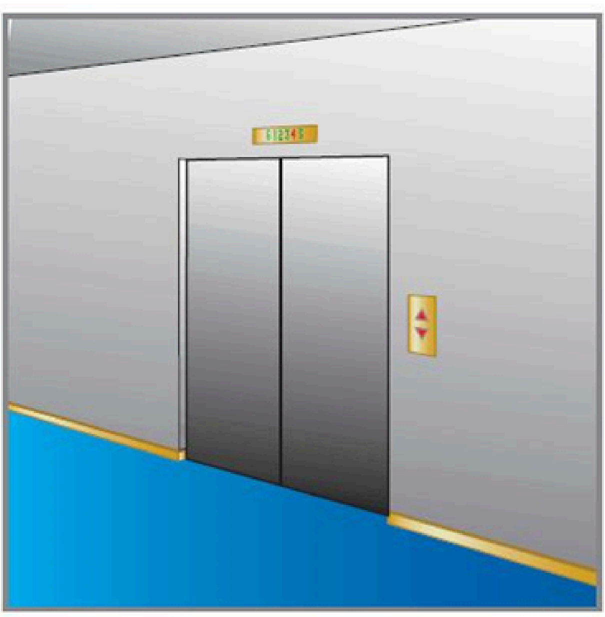
ADDITIONAL LOCATIONS

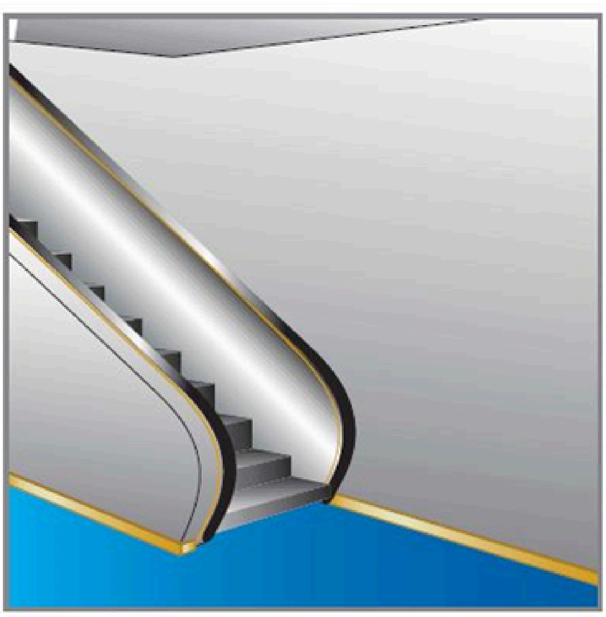
These locations are not part of the escape route but because of their risk they require protection by emergency lighting.

Lift cars – although only in exceptional circumstances will they be part of the escape route, do present a problem in that the public may be trapped in them in the event of a supply failure.

Escalators – to enable users to get off them safely.

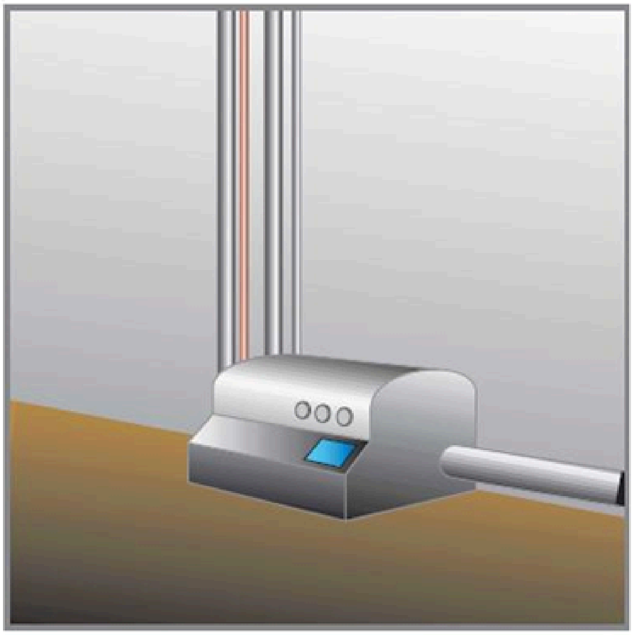
Covered car parks – the normal pedestrian routes should be provided with non-maintained luminaires of at least 1 hour duration.





Toilets – all toilets for the disabled and facilities exceeding 8m2 area or without borrowed lights.

Motor generator, control or plant rooms – require battery supplied emergency lighting to assist any maintenance or operating personnel in the event of failure.



ILLUMINANCE REQUIREMENTS FOR ESCAPE ROUTES

In addition to luminaires at the points of emphasis, it may be necessary to provide extra luminaires to ensure that minimum light (illuminance) levels are met along the whole escape route. For 2m wide escape routes, the illuminance is specified along the centre line with 50% of that illuminance over the 1 metre wide central band. Wider routes should be treated as open areas or as multiple routes.

ILLUMINANCE REQUIREMENTS

The European standard EN 1838 requires 1 lux along the centre line of escape routes including those with minor obstructions such as hotel trolleys. The UK has a National Exception, which recommends 1 lux but accepts 0.2 lux along the centre line for permanently unobstructed escape routes, with the points of emphasis illuminated to 1 lux. BS 5266: Pt 1: 1988 has been amended to reflect this requirement.

BS 5266 and EN 50172 recommend using a larger number of low power luminaires rather than a few high power units. Each compartment of the escape route should be lit by at least two luminaires thus, if a luminaire fails, the route will not be plunged into darkness.

Escape Routes

For escape routes up to 2m in width, the horizontal illuminances on the floor along the centre line of an escape route shall not be less than 1 lux and the central band consisting of not less than half of the width of the route shall be illuminated to a minimum of 50% of that value.

However If it is certain that the route will be permanently unobstructed the old level of 0.2 lux can be used for escape routes except for stairs and changes of level which must be to 1 Lux.

Illuminance Levels for Open Areas

Emergency lighting is required for:-

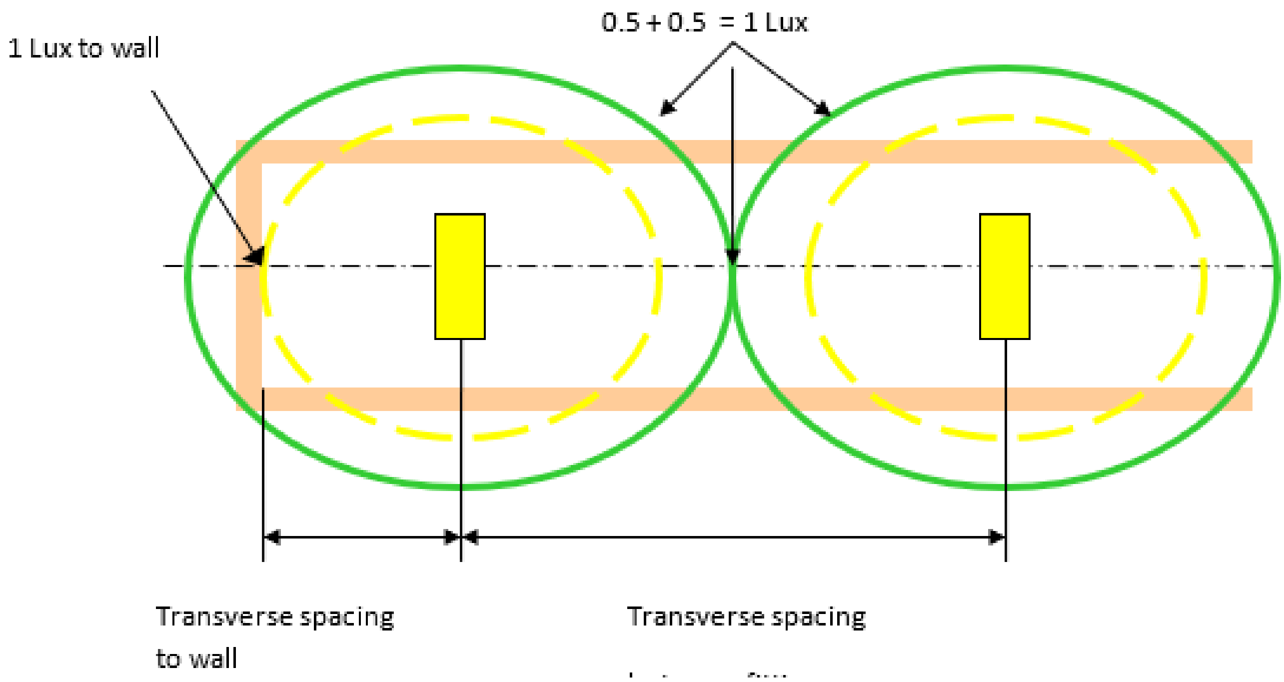
·Open areas larger than $60m^2$

·Areas of any size with an escape route passing through them.

·Any areas that the risk assessment has identified as requiring emergency illumination for example such as a school chemistry laboratory where students handling acids would be at risk if plunged into darkness

Open Areas

The standard BS EN 1838 (BS 5266-7) requires 0.5 lux minimum anywhere in the central core of the floor area. This core area excludes the 0.5m to the perimeter of the area. The shadowing effects of movable objects in the core area are all so excluded.

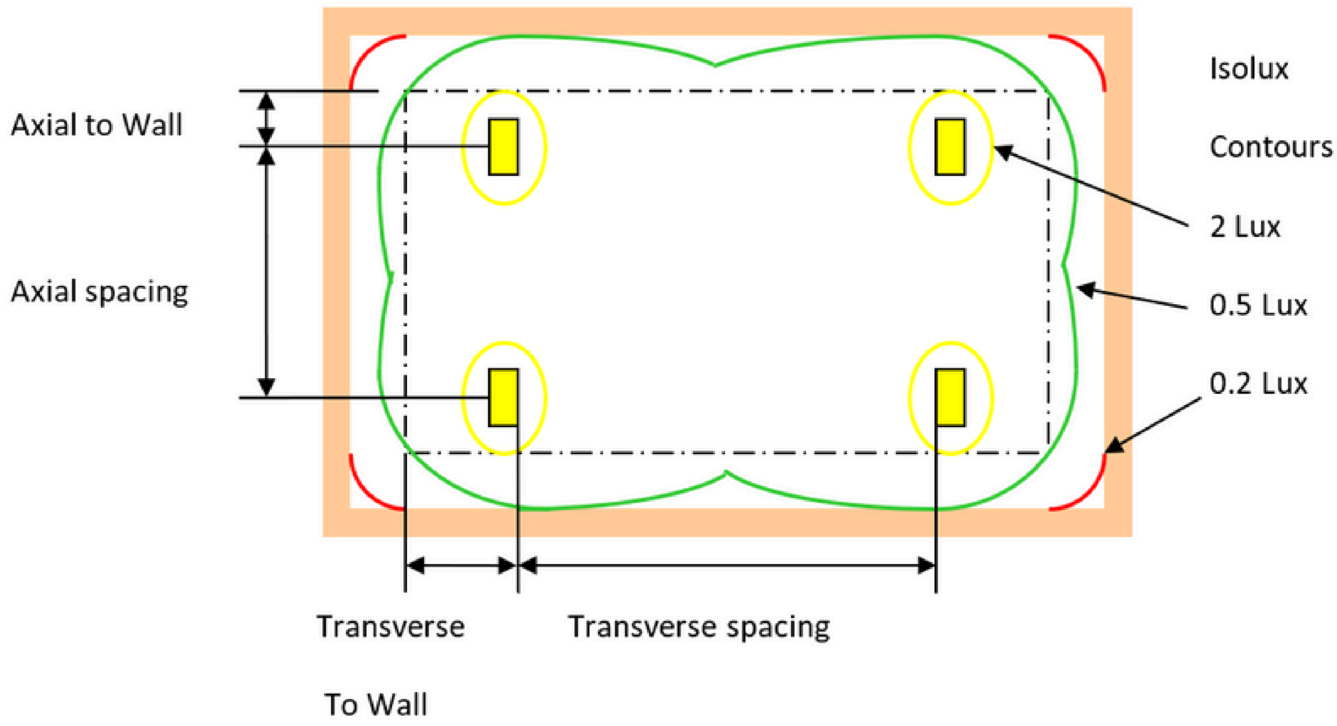


High Risk Task Area Lighting

BS 5266 requires that higher levels of emergency lighting are provided in areas of particular risk, although no values are defined.

The European standard EN 1838 says that the average horizontal illuminance on the reference plane (note that this is not necessarily the floor) should be as high as the task demands in areas of high risk. It should not be less than 10% of the normal illuminance, or 15 lux, whichever is the greater. It should be provided within 0.5 seconds and continue for as long as the hazard exists.This can normally only be achieved by a tungsten or a permanently illuminated maintained fluorescent lamp source.

The required illuminance can often be achieved by careful location of emergency luminaires at the hazard and may not require additional fittings.



lighting

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