Salahaddin University- Erbil

College of Engineering

Architecture Department

Third Year Students

Electrical Installation

Part Two

ILLUMINATION SCHEMES

Introduction:

In the beginning of the nineteenth century, it was not possible to do daytime work after Sunset, due to lack of adequate light.

During those days, Crude System of lighting was used, but during the middle of 19th century, a Gas Mantle was used as a source of light.

In the year 1900, electrical filament Lamps came into the field as a light source and they proved to be the best competitor to as a source of light.

Due to proper source of good Illumination much advancement has been made in the sphere of industrialization of countries as it has reduced differences between day and night.

The best illumination is that which produces no strain on the eyes.

Light Nature is a form of energy which is radiate by bodies whose Temperatures are increased. The main source of light is (SUN) which gives out energy in the form of heat and light at a very high rate (of order 50 thousand million billion horse power); But only a fraction of it reaches the earth (250 billion horse power)

Definitions

1- Light :

It may be defined as that radiant energy which produces a sensation of vision upon the human eye.

2 – Luminous Flux:

Is the light energy radiated per second from Luminous body ,for example , the Luminous body is a Lamp .The whole of electrical power supplied by the Lamp is not changed into Luminous Flux ,some of the Power is lost by heat conduction . The unit of Flux is LUMEN. Table (2.1) give the approximate overhaul Efficiency (η) of incandescent tungsten filament Lamp and Fluorescent Lamp.

Tungsten Lamps			Fluorescent Lamps			
Power input in watts	Luminous Flux in Lumens, app.	Efficiency Lumens per watt	Input in watts	Length in cm.	Luminous Flux in Lumens. app.	Efficiency Lumens app.
10	80	8	4	15.25	75	18.75
40	460	11.5	8	30.5	325	40.53
60	840	14.0	20	61.0	950	47.5
100	1630	16.3	30	91.5	1500	50.0
200	3660	18.3	40	122.0	2300	57.5
500	9950	19.9	100	152.5	4400	44.0

Table (2.1)

3 – Luminous Intensity:

Luminous Intensity in any particular direction may be defined as the luminous flux emitted by the source per unit solid angle from point Source, Fig (2.1)

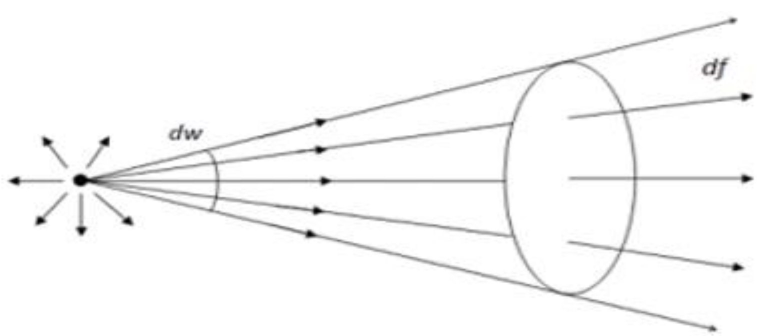


Fig (2.1) illumination from point Source

Let, a point **O** is a source flight.

dF = luminous flux crossing any section of a narrow cone of solid angle.

dw= Solid angle of the cone.

I= Luminous intensity.

Therefore, luminous intensity **(I)** in the cone direction is ratio of flux **dF** to solid angle **dw:** **I = dF / dw = ϕ / w = lumen /(steradian or Candle)** **…**(2.1)

4 – Lumen:

Is the Flux unit and defined as the luminous flux per unit solid angle from a source of 1 candle power. Therefore: **Lumens (L)**

L = Candle Power ×Solid angle = C.P×W → C.P = Lumens/ W … (2.2)

5 – Degree of illumination:

When the light falls on a surface, it is illuminated, the illuminance is defined as luminous flux received per unit area of the surface, Fig (2.2)

Let, incident luminous flux **(DF)** falls on a small area **(DA)**.Then: Illumination= **DF / DA** →= **Lumens / Area** As, **Lumen = C.P ×W**

Therefore: Illumination = (**C.P × W / Area) = (C.P ×Area/R^2) / Area**

(As, **W = Area/R^2**) →→→ Illumination = **C.P / R^2**

R - is distance between the area and the point where solid angle is formed. If area is in square ft. then unit of illumination is lumens per sq .Ft OR (foot-candle).

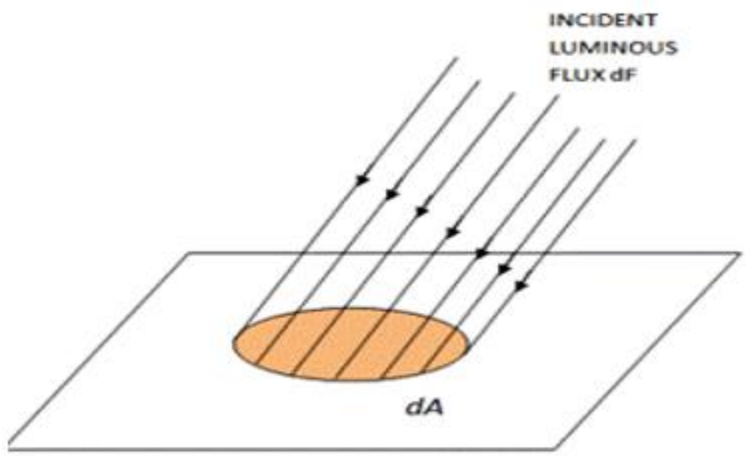


Fig (2.2) Representation of luminous flux on the area

6 – Mean Horizontal Candle power **M.H.C.P**:

is the mean of the candle power of source in all directions in horizontal plane.

7 – Mean Spherical Candle power **M.S.C.P**:

It is the mean of candle-power of a light source in all directions within the hemi – sphere either a BOVE Horizontal plane or BELOW Horizontal plane.

8 – Reduction Factor:

Of a light source is the ratio of its mean spherical candle power to its mean horizontal candle power. **Reduction factor** = **M.S.C.P. /M.H.C.P**.

9 – Foot candle:

It is a illumination unit and may be defined as the illumination of a sphere of radius 1 Ft, at the center of which there is a source of 1candela, (equivalent to one lumen per square foot or 10.764 lux). Now little used.

10 – Lux:

The lux is derived unit of illuminance, measuring luminous flux per unit area. It is equal to one lumen per square meter. In photometry, this is used as a measure of the intensity,

11 – Brightness:

Is the flux emitted per unit area of a Source in direction perpendicular to surface , Fig (2.3) , Imagine a light parallel beam with a rectangular cross section travelling through space in a given direction. We can measure luminous flux per unit area (known as luminous flux density) of this light beam at any point along its length and get the same result, because the beam is parallel - it neither converges nor diverges. What will happen if the beam is incident on a planar surface at angle.

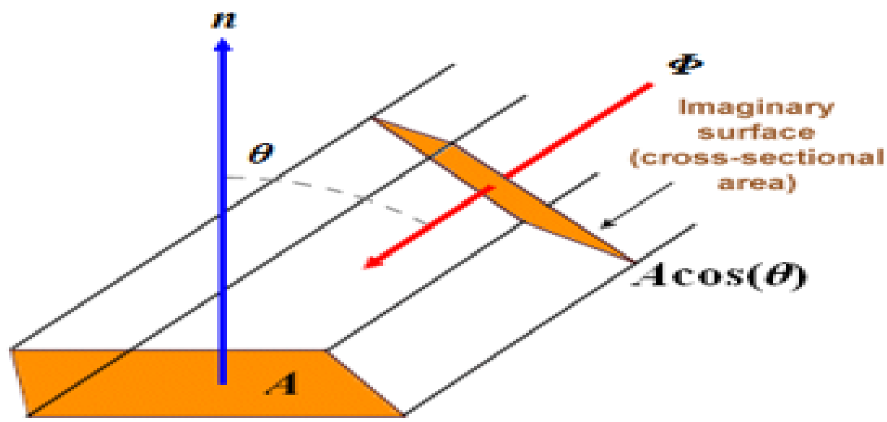


Fig (2.3) A parallel beam of light incident on a planar surface Area

A is area illuminated by the beam. The size **A**, and consequently the amount of luminous flux per unit area falling on area **A**, will depend on the angle of incidence **θ**. If the size of angle increases, size of luminated area increases.

The illuminance **E** falling on an imaginary surface consisting of the cross-sectional area of the beam at any point along its length is equivalent to the luminous flux density of the parallel beam of light, which is equal to the luminous flux **ϕ** (in lumens) divided by the cross-sectional area of the beam **A Cos θ** (in square meters):

Since the same amount of luminous flux falls on surface **A**, the illuminance E_θ on **A** is given by:

$$E_\theta = \phi / A \qquad \text{and therefore:} \qquad E_\theta = E \cos\theta$$

The unit of Brightness is candles per sq. meter or Candle / Ft^2.

12 – Illumination:

The luminous flux per unit area falling on a surface is called the illumination E of the surface, and is measured in lm/m^2. **A** lm/m^2 is called a lux

$$E = \phi / A \qquad \text{Lux} \qquad \ldots\ldots\ldots..(2.4)$$

Where: **Lux= Lumens /(Area in m^2)= Lumen/ m^2** OR (Meter Candle)

Law of Illumination

It is defined as; The illumination of a surface is inversely proportional to the square of distance of the surface from the source of light, it is true only if the source is a point source.

Lambert's Cosine Law

According to this law the illumination of a surface at any point is dependent upon the Cosine angle between Flux lines and the normal at this point .Fig (2.4). Let (**F**) be the total Light Flux falling on the area. Thus in Fig (2.4 a) the angle between normal to the surface and lines of Flux is ZERO:

Intensity of illumination = **F / Area (ABCD**).

In Fig (2.4 b) the angle between them is **θ** therefore:

Intensity of illumination = **(F × Cos θ) / Area (abcd**).

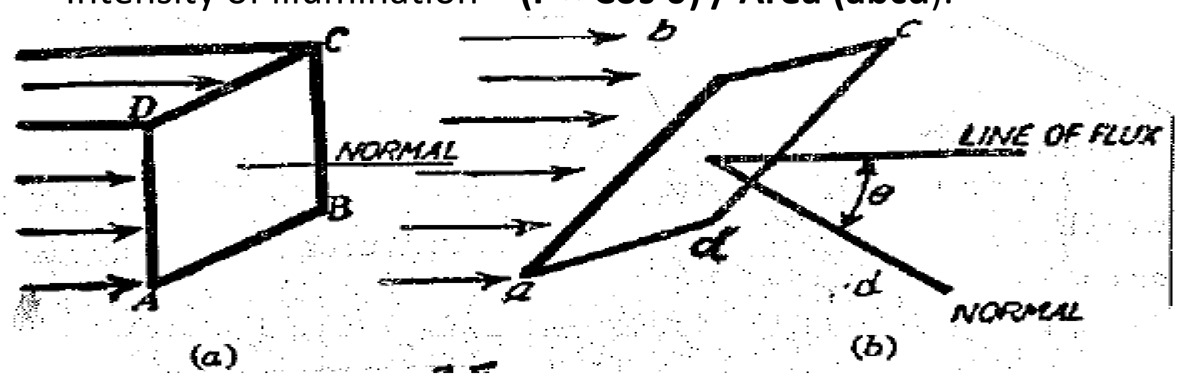


Fig (1.4) Lambert's Cosine Law

Quantity of light to be obtained from various devices

Luminous flux - lumen (unit)	
Bicycle Lamp	10 lm.
Incandescent lamp of 150 W	1940 lm.
Fluorescent lamp of 40 W	3000 lm.
Sodium lamp of 200 W	30000 lm.
Mercury vapor lamp 100 W	52000 lm.
Luminous Instensity - candela (unit)	
Bicycle lamp, straight ahead (without reflector)	—1 cd.
Bicycle lamp, straight ahead (with reflector)	—250 cd.
Light house light, centre of beam	20,00,000 cd.
Illumination – Lux (unit)	
Summer, midday (Cloudless sky)	—100,000 lux.
Winter, midday	10,000 lux.
Summer, midday under balcony	2000 – 5000 lux.
Summer, behind, window	1000–3000 lux.
Sun rise & Sun set	500 lux.
Full moon & bright sky	0.25 lux.
Living room table under good artificial lighting	200 lux.
Office with good artificial lighting	1000 lux.
Luminance – cd/m^2 (unit)	
Sun	— 16.5 cd/m^2
Moon	— 0.25×10^{-4} cd/m^2
Incandescent lamp	— 0.7 cd/m^2
Fluorescent lamp (lateral direction)	— 8.0 cd/m^2
Fluorescent lamp (longitudinal direction)	0.5 cd/m^2

Design of Lighting Scheme

For designing a Lighting Scheme following Factors should be taken into account:
i)Space Height Ratio (**SHR**); is ratio of the distance between adjacent luminaires (center to center), to their mounting height above the working plane, or :

SHR = Horizontal distance between Lamps **/**Mounting height of Lamps

In order to have a uniform illumination which can be only with Reflectors, it is necessary that the value of Space Height Ratio should properly chosen and it's range between **(2.5 → 3.0)** ground level.

ii) Utilization Factor (**U.F**); or Co-efficient of **utilization**. It may be defined as "the ratio of total lumens received on working plane to total lumens emitted by the light source". Also it defined as "the ratio of illumination under normal working condition to the illumination when everything is clean or new".

U.F = Total lumens utilized on working plane/ Total lumens Radiated by Lamp.

The value of this coefficient depends upon the following conditions;

A) The area to be illuminated. B) Height at which the Lamps are fitted

C) Color of surrounding Walls, Ceiling, and Fittings. D) Type of Lighting; Direct or indirect

iii)Depreciation Factor (**D.F**): is a factor used by lighting designers to predict the output light depreciation for a specific light source over a defined time period. When the Lamps are covered with dust, dirt, and smoke, they don't radiate out the same amount of Flux as when they do at fitting time of new Lamps.

The Depreciation Factor takes into account all such loss of Flux.

D.F =ill. Under normal working conditions/ill. When every thing is new (clean)

Table (2.2) indicates the light reflected from various colored surrounding

Table (2.2)

Colour of surface	*Light reflected in percentage*
Light White	81%
Light Cream	69% to 75%
Light Green	65%
Light Grey	58%
Medium Gray	55%
Dark Tan	46%
Dark Grey	25%
Dark Olive Green	15%
Dark Red	12%
Natural	23%

The total gross lumens output (O/P)

= { Area(sq.Ft) ×ILL. (Ft. Candles)}/{Co. of utilization × Dep. Factor} (for values <1) ..(2.5)

Illumination Required For Various Purposes:

The illumination is given in Table (2.3) and Table (2.4)

0.1 to 5 Ft. Candle	10 Ft. Candles	15 Ft. Candles	20 Ft. Candles	30 Ft.-50 Ft. Candles	Above 50 Ft. Candles
Corridors, Staircase, Storage Toilets, Auditoriums, Cinemas, Dancing Halls, Night clubs and Bars, Railway platforms and Hospital wards,	Restaurants, Lunch Rooms, Cafetaria, Dinning Halls, Conference Room, Reception Room, Waiting Room, Lobby and Museum etc.	Bank's Lobby, Railway Compartment, Street Lights.	For intermittent reading or writing, Filing clerk or Daftry's room, Store room of an industry offices, Class room, Library, Showrooms, Kitchen and operating room.	Steno-Typist room, Design Cabins, Drawing rooms, Office, Bank Counter and desks.	Used for person work where minute adjustment and rapid discrimination is required.

Table (2.3)

If the light requirement for reading a good print at 10 years of age 1 unit, then

For	22 years of age	... ...	1.5
For	30 years of age	... ...	2.0
For	40 years of age	... ...	3.0
For	50 years of age	... ...	6.0
For	60 years of age	... ...	15.0

Level of Illumination required for

Children upto	10 years of age	—200 lux.
Men & Women upto	40 years of age	—600 lux.
-do- upto	60 years of age	—3000 lux.

Table (2.4)

Lighting schemes

If the light from source falls on polished or metallic surfaces, it is reflected back, according to laws of reflection, reflection angle is equal to incidence angle, this is very good as far as illumination is concerned but only drawback is that it produces glare on the eyes If the light from the source falls on coarse surfaces, like painted ceilings, Frosted glass and paper, the light is diffused in all directions and NO glare or image is formed, this method is used for internal or external lighting.

Following lighting schemes type can be used in any construction. Fig (2.5)

i) **Direct Lighting**:

The light from source falls directly on the object or the surface to be illuminated. With the help of shades and globes and reflectors of various types, most of the light is directed in the lower hemisphere and also the brilliant source of light is kept out of the direct line of vision. Direct illumination by lamps in suitable reflectors can be supplemented by standard or bracket lamps on desk or by additional pendant fittings over counters. Such arrangement type is shown in Fig (2.5), Direct Lighting is very efficient but it causes shadows and glare.

Uniform light in a room is obtained by correctly lamps locating at different places.

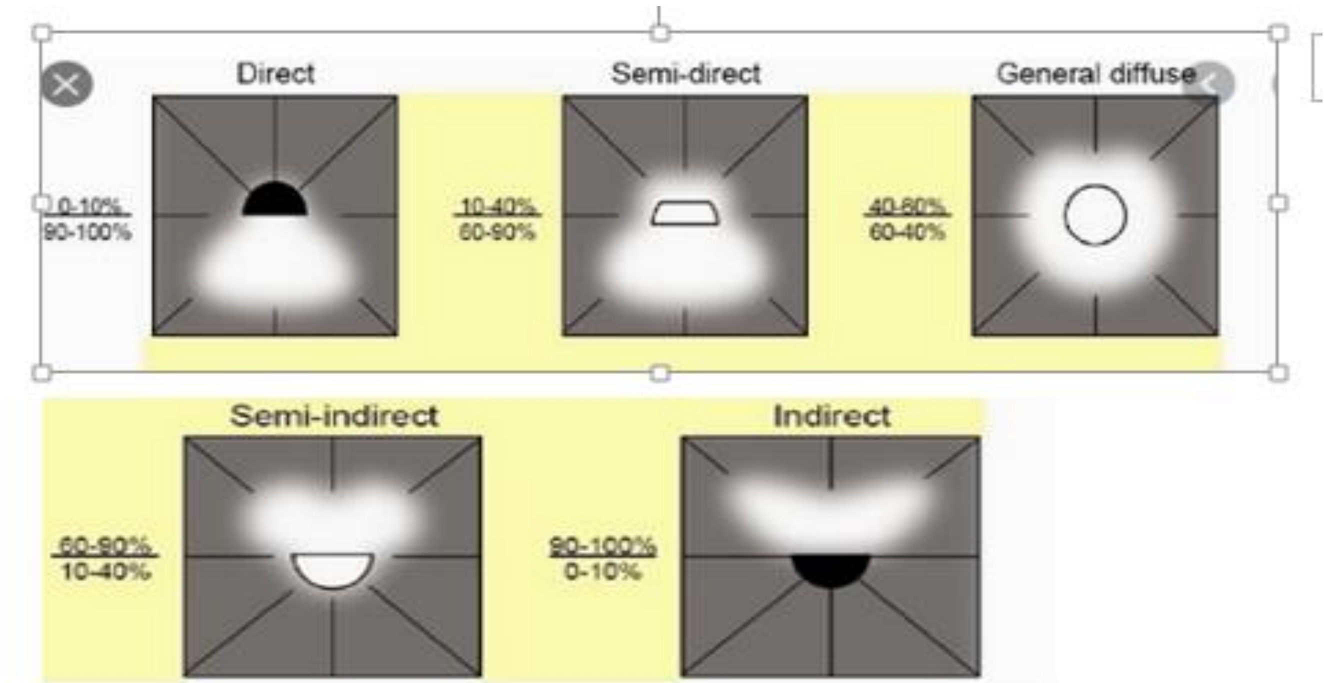


Fig (2.5) types of lighting scheme

(ii) Indirect Lighting

In this lighting form, light does not reach the surface directly from the source but indirectly by diffuse reflection. The lamps are either placed behind a cornice or in suspended opaque bowls. In this way, max. light is thrown upwards on ceiling from which it is distributed all over the room by diffuse reflection.

(iii) Semi-direct System

This system utilizes luminaries which send most light downwards directly on working plane but a considerable amount reaches the ceilings and walls also.

The division is usually 30% upwards and 45% downwards. Such a system is best suited to rooms with high ceilings where a high level of uniformly-distributed illumination is desirable. Glare in such units is avoided by using diffusing globes which not only improve the brightness towards the eye level but improve the system efficiency with reference to the working plane.

(iv)Semi- indirect Lighting

In this system which is, in fact, a compromise between the first two systems, the light is partly received by diffuse reflection and partly direct from the source. Such a system, therefore, eliminates the objections of indirect lighting mentioned above. Instead of using opaque bowls with reflectors, translucent bowls without reflector are used. Most of the light is, as before, directed upwards to the ceiling for diffuse reflection and the rest reaches the working plane directly except for some absorption by the bowls.

(v) General Diffusing System

In this system, luminaries are employed which have almost equal light distribution downwards and upwards.

Estimation of a lighting Scheme

Suppose it is desired to have **E** (Lumens/m^2) in a hall having area **A** (m^2), obviously total Flux (**ϕ**) required on the working plane is:

$$\phi = E \times A \quad \text{Lumens} \quad \ldots\ldots\ldots\ldots \quad (2.6)$$

To send this Flux (**ϕ**), the sources output should be much higher, taking into consideration Depreciation Factor, Coefficient of utilization, …etc.

If these Coefficient value is given **<** 1; Then output of the source necessary:

= **Lumens required / (Dep. Factor × Co. of utilization)**

Then Wattage of Lamps = **ϕ / Efficiency (η).** **……..** (2.7)

The Wattage per lamps is selected and accordingly N_o of lamps found out.

Example 2.1:

Determine the effective illumination of a room (12 ×15) m, illuminated by (15) Lamps of 200Watts each .The Luminous Efficiency of each lamp is given as 12 Lumens/watt. Given Coefficient of utilization as 0.4.

Solution:

Output (O/P) per watt = 12 Lumens

Total lamps wattage = 15 × 200 = 3000 watts

Total light output = (O/P) per watt × total watts= 12×3000 =36000 Lumens

Lumens utilized = Lumens emitted × Coefficient of utilization

= 36000 × 0.4 = 14400 Lumens

Room area = 12 × 15 = 180 m^2

Illumination = **ϕ / A** **=** 14400 / 180 = 80 lux.

Example 2.2:

It is desired to illuminate a drawing hall with an average Illumination of 200 Lux. The hall is (30×20) m^2. The lamps are to be fitted (4 m) from the ground floor. Find the lamps number and Wattage per lamps for the lighting scheme. Given the lamps Efficiency available as (25) lumens per watt. Depreciation Factor 0.8, and Coefficient of utilization 0.75, space height ratio between 0.8 and 1.2, give satisfactory spacing arrangement.

Solution:

E, required = 200Lux OR Lumens / m^2 : Floor area = 30 × 20 = 600 m^2

Total flux (**ϕ**) = **E** × **A** = 200 × 600 = 120,000 Lumens

Desired Light (ϕ_{REQ}) = Total flux (ϕ) /(Dep. Factor × Co. of utilization)

= 120000 /(0.8 × 0.75) =200,000 Lumens **Wattage of Lamps = Light output / Efficiency of the Lamps (Lumens/watt)**

= ϕ_{REQ} / η = 200000 / 25 = 8000 watts

NOW:

If take 200 Watt lamps, then; Number of lamps = 8000 / 200 = 40

Rating per lamp = 200 watt.

Taking (5) Rows of (8) lamps we have total distribution of 40 Lamps, see Fig (2.6).

Now; Lengthwise spacing comes to be: 30 / 8 = 3.75 m.

Width spacing comes to be: 20 /5 = 4 m.

Lamps near walls are kept at half the calculated spacing to keep light uniformity.

If for example this distance is kept equal, then light between two adjacent lamps will be more compared to illumination on the wall.

Now:

Space height ratio Lengthwise = 3.75 / height = 3.75/ 4=0.94 approx.

Widthwise space height ratio = space / height = 4/ 4 = 1

If we choose (80) lamps of 100 watts, let us make 8 rows of 10 lamps:

Widthwise space = 20 /8 = 2.5 m : Lengthwise Space = 30/10 = 3 m

Lengthwise Space height ratio = space / height = 2.5 /4 = 0.6

Widthwise space height ratio =3 /4 = 0.75, which does satisfy the condition.

If on the other hand we choose say 500 watt Lamps .N_O of Lamps comes to be:

8000 /500 = 16 Bulb. Let us make 4 rows of 4 lamps each:

Lengthwise Spacing: 30 /4 = 7.5 m: Widthwise spacing: 20 /4 = 5 m

Lengthwise S.H.R= 7.5 /4 = 1.87: Widthwise S.H.R = 5 / 4 = 1.25

So it also fails to satisfy the given conditions of Space height ratio (S.H.R) laying between 0.8 to 1.2 .Thus the scheme 5 rows of 8 lamps is correct.

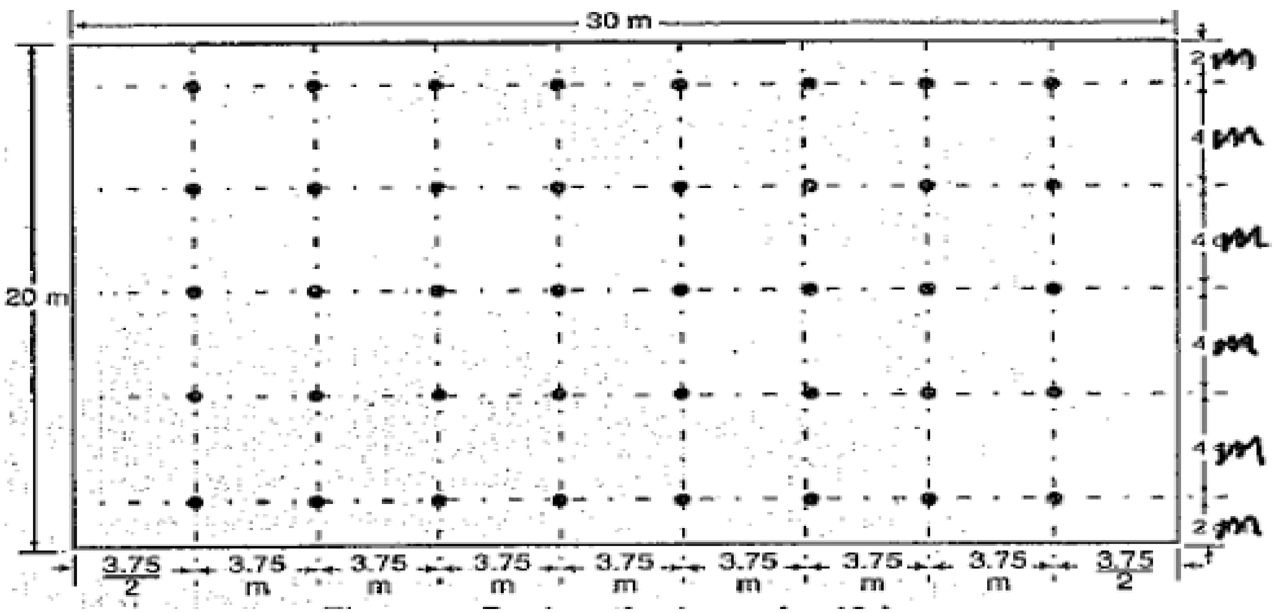


Fig (2.6) Design of scheme for 40 Lamps

Example 2.3:

A room of (12 ×12×4) m is to have direct lighting, giving illumination of 80 lux on a working plane 70 cm. above the floor. Coefficient of utilization is 0.5 and maintenance Factor 0.8. If efficiency of lamps available is 14.73(Lumens /watt). Find the number of lamps and their rating.

Solution: E = 80 Lux : Area (A) = 12 × 12 = 144 m^2

Flux (ϕ_{GEN}) = **E × A** →→ = 80 × 144 = 11520 Lumens.

Light required (ϕ_{REQ}) = Flux (ϕ_{GEN}) / (Co. of utilization × M. Factor)

= 11520 /(0.5 ×0.8) = 28800 lumen .

Wattage = Lumens / lamps efficiency= Lumens /**η**= 28800/14.73 = 1955 watts

We can use 100 watts lamps, and number of lamps will be:

= 1995 / 100 = 19.95 →→ (say = 20)

Note: Since required lighting is 70 cm. above floor level, and if we use 30 cm. suspension wire for each lamp effective height will be:

= 4 m – (70 cm. + 30 cm.) = 3 m.

If we use 4 lamps per row, we have 5 such rows, i.e 5 rows &4 column

The spacing can be worked as:

Lengthwise =12 /5= 2.4m & Widthwise =12 /4=3m

The space height ratio comes as: 2.4 /3 = 0.8 and 3/ 3 =1

i.e between 0.8 & 1 which is normal . spacing arrangement shown in Fig (2.7) .

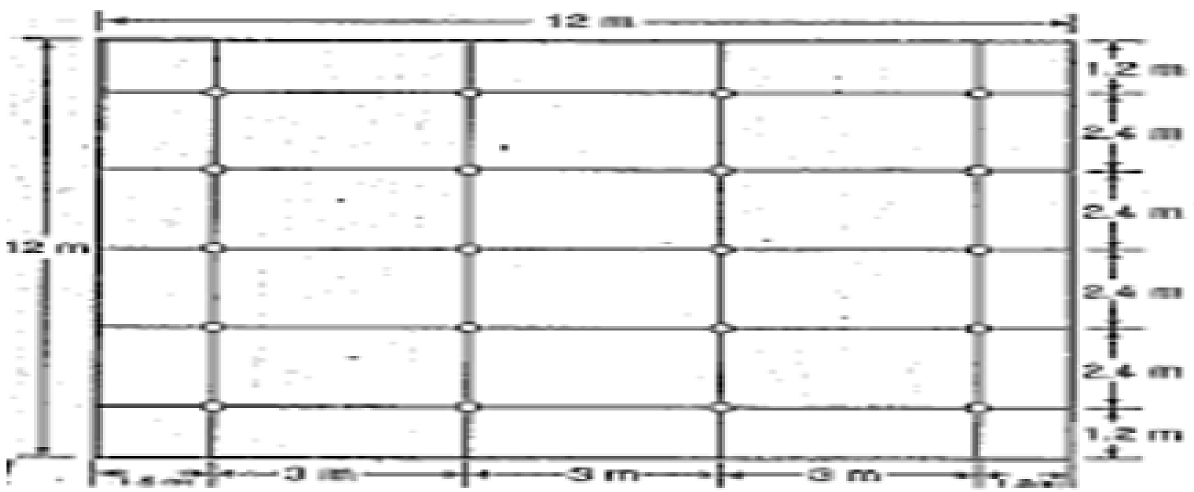


Fig (2.7) 4 Lamps in each rows and 5 rows lenghwise

Example 2.4:

It is required to provide an illumination of 100 Lumens / m^2 in a workshop hall (40*10) m. Assume depreciation Factor 0.8, Coefficient of utilization 0.4 and efficiency of Lamps (= 14 Lumens per watt.). Calculate number of lamps and their positions, when 7 trusses are provided at a mutual distance 5 m.

Solution:

E, desired = 100 Lumens / m^2 Area (A) = 40 ×10 = 400 m^2

Lumens generated (ϕ_{GEN}) = **E ×A = 100 * 400 = 40,000** Lumen

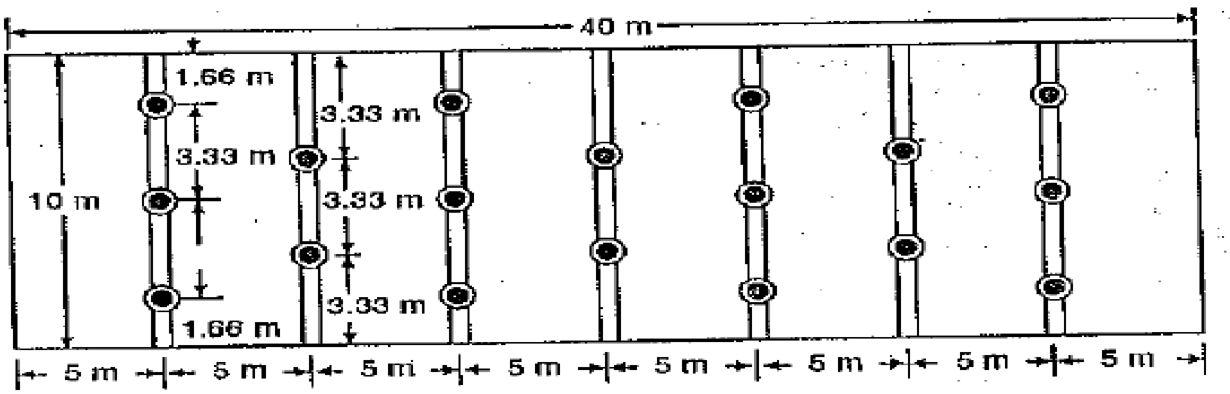
Lamps (o/p) (ϕ_{REQ}) = ϕ_{GEN} /(C. U × D.F) = 40,000 /(0.4×0.8) =125000 Lumen

(η) Efficiency / Watt = 14 Lumens

Therefore: →→ Wattage = Lumens / **η =** 125000/ 14= 8929 watts

If we take 500 watt Lamps, the number of Lamps: 8929 /500 = 18 lamps.

Since breadthwise trusses are provided, we have to use these trusses for fixing these bulbs .A scheme of Fixing these Bulbs shown in Fig(2.8).



Fig(2.8) Lamps fixed on Trusses

Example 2.5:

A Lamp of 100 C.P is suspended 3 meter above the horizontal Plane. Calculate the illumination at a point on horizontal Plane:

i) Directly below the Lamp ii) 3 – m away from the vertical axis.

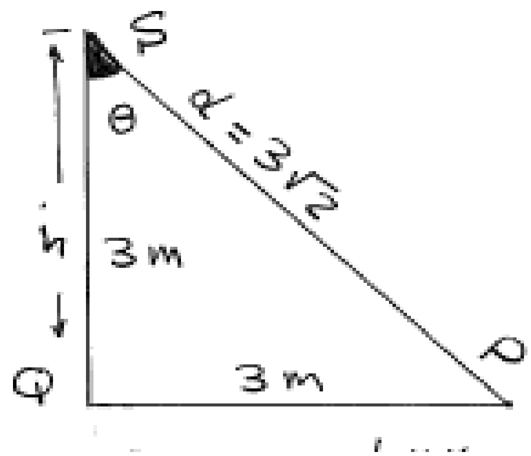
Solution: i) Now illumination at a point **Q** Directly below the Lamp ;

C.P =100 : height (**h**) = 3m →→ **= C.P / h =** 100/ 3^2 = 11.11 lux

ii) Illumination at point **P: = (C.P × Cos θ / d²**) = 100 /(3√ 2)^2 × 3/ 3√ 2

= 100 / 18 × 1/ √ 2 = 3.928 Lux

Where $d = \sqrt{(3^2 + 3^2)} = \sqrt{18} = 3\sqrt{2}$.



Example 2.6:

A reading room (50×15 ×6) m, requires an illumination of 40 meter – Candle on the reading table. Assuming a space height ratio of 1.2. Calculate:

i) The number of lamps required   ii) C.P. of each lamp.

Assuming the utilization Factor as 0.4, Depreciation Factor as 0.75, efficiency of each lamp as 0.75 per Candle Power and the height of Lamps above the reading Table as 4 m. draw a sketch of Lamps arrangement.

Solution;

Area of the room $A = 50 \times 15 = 750 \quad m^2$

E, desired $= 40$ meter – Candle = 40 Lux = 40 Lumens / m^2

Flux generated (ϕ_{GEN}) = **E** × **A =** 40 × 750 = 30,000   Lumens

Coefficient of utilization (C.U) = 0.4: Depreciation Factor (D.F) = 0.7

Therefore; Flux necessary to be produced **(ϕ_{REQ}) =** (ϕ_{GEN}) / (C.U * D.F)

$= 30{,}000 / (0.75 \times 0.4) = 100{,}000$ Lumens

C.P desired = **(ϕ_{REQ}) / 4 π** = 100,000/ **4 π**   …….. (2.8)

1 Lamp efficiency (**η**) = 0.75 watts / C.P

Total wattage required = C.P × **η = (**100,000 / **4 π)** × 0.75 = 5965 Watts

If we use 200 watts lamp: → N_o of lamps= 5965 / 200 = 30

ii) C.P of each lamp = Wattage / **η =** 200 /0.75, when **ϕ = watts** / C.P.

= 200 × 4/3 = 266.67 C.P

Height above working surface = 4 m.

Therefore space between adjacent Lamp = 1.2 × 4 =4.8 →→ say 5m.

Since length and breadth of the hall is 50 m. and 15 m. respectively, we have to take 5m. For proper distribution instead of 4.8 m.

Lighting scheme Design shown in Fig (2.9), by keeping 5 m. distance between adjacent lamp.

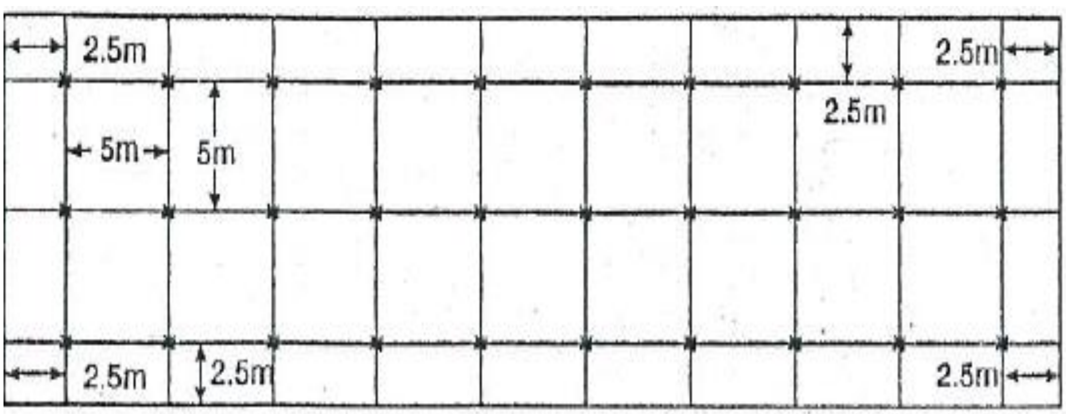


Fig (2.9)

Example 2.7:

An illumination of 300 Lux is to be provided in a class room (20 ×10), with 40 Watt Fluorescent Lamps .Determine the number and layout of Lamps in the Lighting installation.(Assume data not given).

Solution;

Given room area (A) = 20 × 10 = 200 m^2

E, required = 300 Lux ; wattage of Tubes = 40 Watt.

Assumed: Coefficient of utilization =0.5; Depreciation Factor =0.75

Efficiency of Tubes (η) = 40 Lumens / Watt.

Now: (ϕ_{GEN}) = **E** × **A =** 300 × 200 = 60,000 Lumens.

Flux necessary **(ϕ_{REQ}) = ϕ**$_{GEN}$/(C.U×D.F) =60000 /0.5 ×0.75 = 4000 watt.

Number of Tubes = 4000 /40 = 100: Thus N_o of pairs = 100 /2.

Let us take 5 rows, so that N_o of pairs in each Row: 50 /5 =10.

The lighting scheme design shown in Fig (2.10)

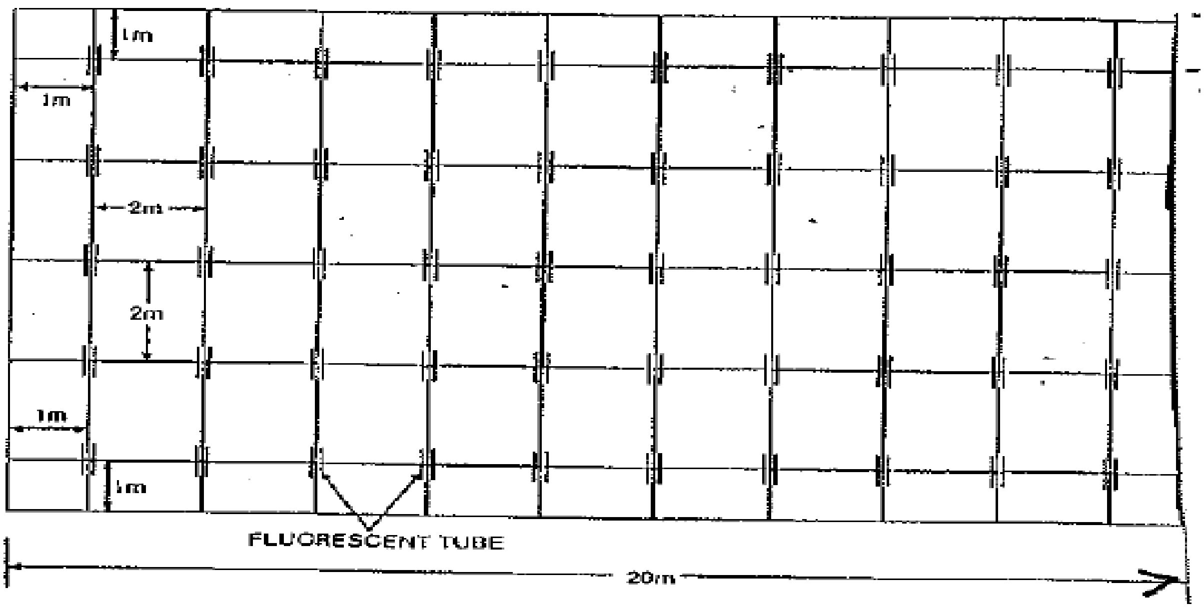


Fig (2.10) lighting layout

Methods of Lighting Calculations

Methods have been employed for lighting calculations, are given below:

1- Watt per square meter method;

Basically it is a (THUMB RULE) method, very handy for rough calculation or checking. It consists in making an allowance of watts per square meter of area

to be illuminated according to the illumination desired on the assumption of an average figure of overall the system efficiency.

2- Lumens or light Flux method :

This method is applied to those cases where the sources of light are such as to produce an approximate uniform illumination over the working plane or where an average value is required.

From lamp size or lamps employed and from their efficiency total lumens output are determined. Multiplying total lumens output from the source by coefficient of utilization, the lumens received on the working plane are determined. If the lamps and surroundings are not perfectly clean, then in determination of lumens received on working plane, the depreciation factor or maintenance factor should be included, i.e.:

Lumens received on working plane = N_o of lamps× Wattage of each Lamp× **η of each** Lamp in terms of (Lumens / watt) **/(C.U × D.F)**

Also Lumens received on working plane = Number of lamps × wattage of each lamp × efficiency of each lamp in terms of lumens per watt × coefficient of utilization × maintenance factor. If(C.U & M.F > 1)

Coefficient of Utilization or Utilization Factor

The whole light radiated by the lamps does not reach the working plane. The ratio of lumens reaching the working plane to the total lumens given out by the lamp or lamps, is known as utilization factor or coefficient of utilization. Higher the value of utilization factor, more lumens will reach the working plane for the given lumens output of the lamps.

The value of utilization factor depends upon:

(i) The mounting height of lamps—utilization factor decreases with the increase in mounting height of lamps.
(ii) (ii) Area to be illuminated—for given height, proportion of direct light becomes more and more if floor area increases, i.e., utilization factor increases with the increase in area to be illuminated

(iii) Type of lighting—more for direct lighting and low for indirect lighting

(iv) Colors of surroundings ; it is more for light colors and less for dark colors. Its value varies from 0.25 to 0.5 and from 0.1 to 0.25 for direct and indirect lighting schemes respectively.

Maintenance Factor

The illumination produced by a lighting installation decreases considerably after a year or two partly due to the aging of Lamps and partly to the dust accumulation on the lamps.. This fact is taken into account by including the maintenance factor, which is defined as the ratio of ultimate maintained meter-candles on the working plane to the initial meter- candles. Its value is more if the lamp fittings are cleaned regularly, say 0.8, and less if there is much dust etc. say 0.6.

Depreciation Factor:

This is merely the inverse of the maintenance factor and is defined as the ratio of the initial meter- candles to the ultimate maintained meter-candles on the working plane. Its value is less than unity.

3 – Point to Point OR Inverse – Square law Method:

This method is applied where the illumination required at a point due to one or more sources of light, the candle powers of the sources in the particular direction under consideration being known.

If a polar curve of lamp and its reflector giving candle powers of the lamp in different directions is known, the illumination at any point within the lamp range can be calculated from the inverse square law. If two or more than two lamps are illuminating the same working plane, the illumination due to each can be calculated and added. This method is not commonly used due to more complications involved in its calculation. However it is used in some special problems, such as flood lighting, yard lighting etc.

To calculate the illumination in a room or to know the number of Tube/Lamps when the level of illumination is to be maintained is given, then the formula given below is to be used:

$$N = (E \times A) / (\phi \times C.U \times M.F) \qquad \text{........(2.9)}$$

Where:

N – Number of fittings required. : **E** –Required illumination in Lux.

A – Working area in square – meter. : **C.U –** Coeff, of Utilization**.**

M.F Maintenance Factor (it is normally taken as 0.8).

Consideration Points for a Lighting Installation

i) Good illumination.

ii) Suitable colors of Light.

iii) Proper and right choice of Lighting source and Fittings.

iv)Spatial distribution of Light , which includes combination of diffuse and directional Light adjustment of the direction of incidence ,distribution of Luminosity and a voidance of glare .

In designing a good Lighting scheme, we have to consider the following points:

1 –The intensity of illumination required.

2 – The selection of the required Fitting and Lamps. 3 – Room size.

Example 2.8:

A modern small shop (16 × 10) m. and 3 meter up to trusses need to be illuminated to a level of 200Lux. The Maintenance Factor is 0.8, Coefficient of Utilization is 0.75. Calculate the number of Lamps required to illuminate the complete area, if the output Lumen of the Lamp selected is 3000 Lumens.

Solution:

Area of working: **A** = 16 × 10 = 160 m^2

Illumination required: **E** = 200 Lux.

Output Lumen of one Lamp: **ϕ** = 3000 Lumens

Coefficient of Utilization (**C.U**) = 0.75: Maintenance Factor (**M.F**) = 0.8

Required Number of Lamps: N = (E * A) /(**ϕ * C.U * M.F)**

= (200 × 160) /(3000 × 0.75 × 0.8) = 17.77 →→ **=** 18

Sources of Light

Various Sources of light can be divided into Two groups;

i) Natural sources:

Natural sources of light include sun, stars. Main source of light in nature is Sun

ii)Artificial Sources:

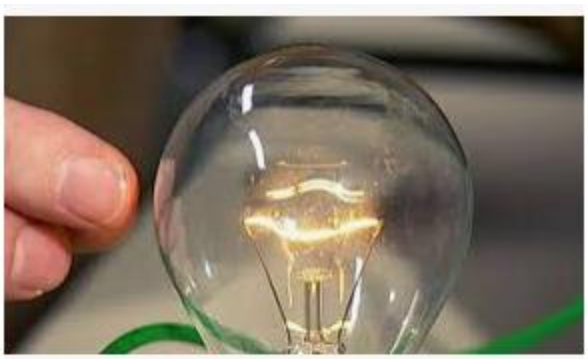
Artificial Sources can be further divided into Two groups:

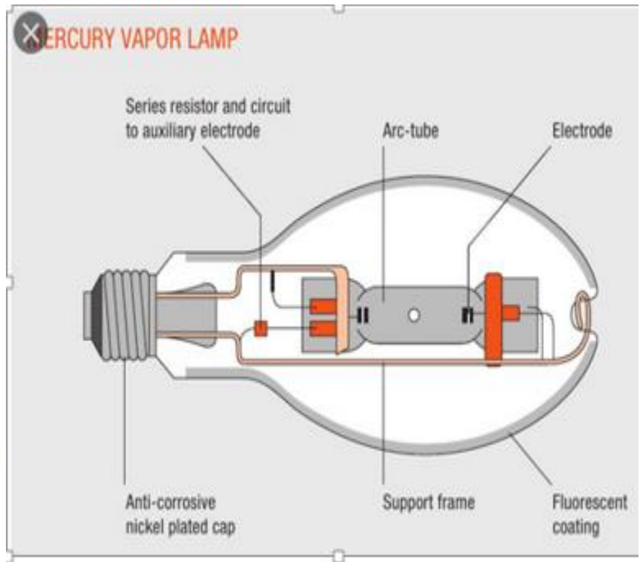
1 – Non electrical sources of light:

The Non electrical sources of light are Candles , Kerosine Lamps Petromax Lamps …etc .

2 – Electrical Sources of Light :

are Incandescent lamps , Mercury vapur Lamps , Fluorescent tubes,Soudium Lamps ,Compact Fluorescent Lamps(C.F.L),…etc ,Fig (1.11). The quality , colour , and quality of light emitted by above various sources aredifferent


Incandescent lamp | lighting | Britannica




Sodium-vapour lamp | instrument ...


Compact Fluorescent Lamp ..

Fig (1.11) Different typs of Lamps

Electrical sources of light (Incandescent Lamps),Contain the following elements ;

i)filament Materials;

These are of coiled-coil Carbon and Tungsten, when temperature increases wave – length decrease, till it reach 7 $*10^{-5}$cm. and falls in the visible range.

The light emitted is proportional to 12^{th} power of absolute Temperature and this is the reason why lamps are run at a high Temperature as far as possible.

ii) Filament design:

It has been already established that the current through the lamp is proportional to $\mathbf{(D)^{3/2}}$. We can find the resistance of the Filament by using the rated Voltage:

Thus: $\mathbf{R = V / I}$ ……….. (2.10)

Also : $\mathbf{R = (\rho L) / \pi D}$ ………. . (2.11)

Where: ρ -Resistivity of Filament; L - Filament Length; D-Filament Diameter
Thus for selected Filament diameter, we can find the length of the Filament.

iii) Construction of the Lamps:

If the space in the Lamp is replaced within inert gas, Tungsten Filament can reach a Temperature of 2400 K(Kelvin)without melt . Due to higher Temperature, loss heat will be occurs, so the heat is reduced by gases like Nitrogen or Argon
The convection loss is minimized by coiled – coil Filament .Spiral Filament are used now to prevent heat loss .Fig (1.12)

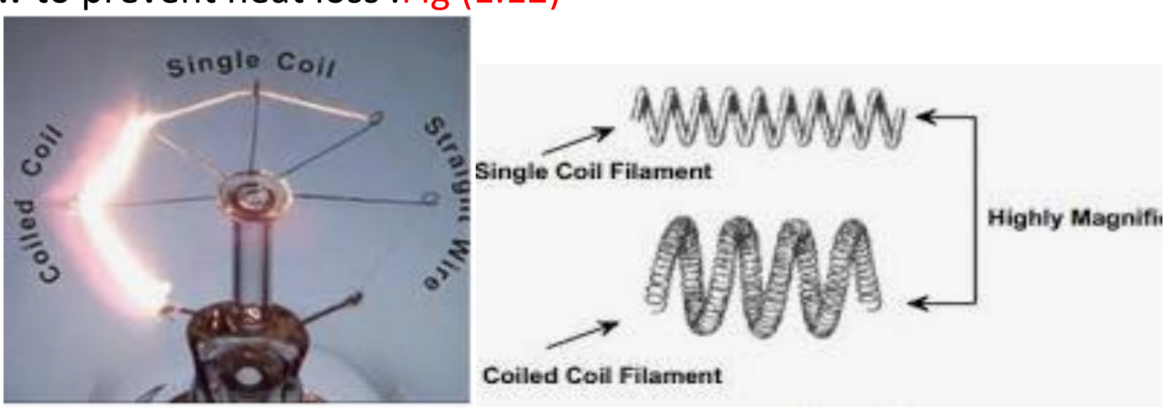


Fig (1.12) Filament Coil

In the case of tungsten Filament:

Light output: (O/P) α E^n →→ where (n = 4 or 5)

And Light input: (I /P) α E^n →→ where (n = 1.8) E –Is the Voltage

During manufacture, all air is pumped out of glass envelope to prevent Filament burning up when operating. Lamps larger than 40 Watts are filled with inert gas (Argon and Nitrogen) to retard melt of tungsten .However ,gradual melt causes a dark deposit on the inner side of the bulb blocking light , see Fig (2. 13)

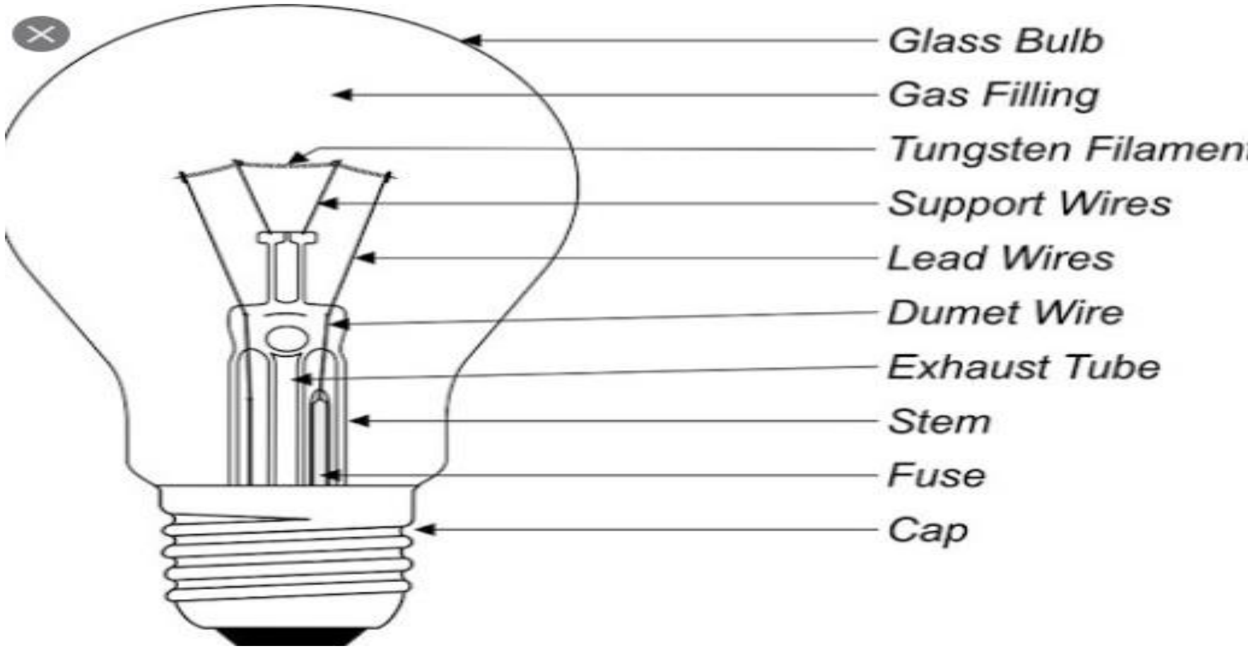


Fig (2. 13) Incandescent Lamp

iv)Effect of voltage variation on the life of Lamps

The Filament Lamps are operated under constant supply Voltage. But a variation of ± 10 % Voltage at consumers is permitted , further drop of Voltage in the electrical wiring may be occur. Thus a Voltage variation from 10 % to 15% will roughly decrease the lamp life, Fig (1.14) shows the relation between supply voltage variation and the performance of gas-filled incandescent lamps.

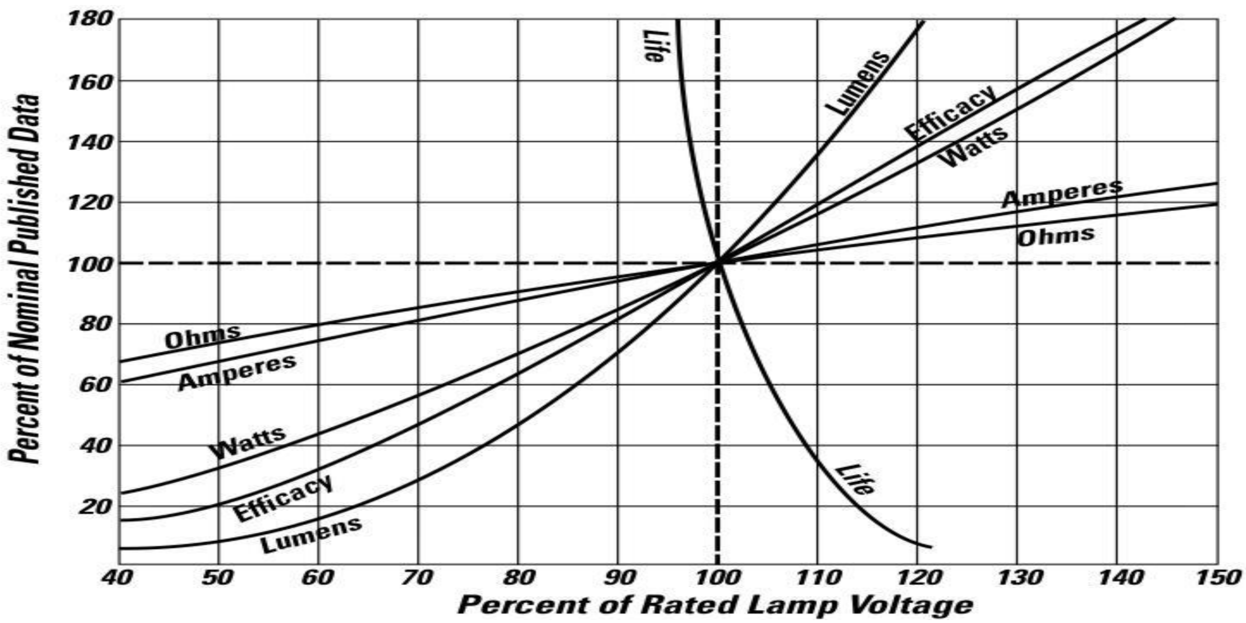


Fig (1.14) **Graph of Lumen (O/P) Power, and (η) of Incandescent Lamps**

Design of Interior Lighting Schemes:

Following points should be kept in mind while designing interior Lighting:

1 – Provision of adequate Illumination level:

Is the most important Factor. Different places need different Light It is to be done in that room or place. Drawing works need more (Lumens /meter) than Gallery or Verandah. Similarly moving objects need more Illumination. The light should also give proper color sense of the object. Table (2.5) shows the Illumination level required for different rooms and places.

S.NO.	Place	Lm per m^2
1.	Drawing room	200
2.	Shop	500
3.	Hotel (Eating place)	250
4.	School (office)	150
5.	Machine room	250
6.	Lathe/Bench work	150
7.	General lighting	20
8.	Proof reading	100
9.	Bed room	20
10.	Railway station	15
11.	Aerodrome	15
12.	Drawing office	350
13.	Normal office work	250
14.	Class rooms	250
15.	Watch/radio repair	1000
16.	Show rooms	500
17.	Hotels	80
18.	Hospital (General)	50
19.	Operation room	4000
20.	Laboratory	150
21.	Table Tennis Court	1000
22.	Workshop	400
23.	Kitchen	150
24.	Toilet	50
25.	Dining room	150

Table (2.5)

2 – Uniform Illumination:

Uniform illumination over a certain target area is a common requirement in many applications, and oftentimes schemes must be devised to ensure that this requirement is achieved. In display systems, for example, light that illuminates a viewing interface such as a screen must appear uniform and devoid of any distracting image artifacts. Depending on the particularities of the system, different approaches must be developed to provide uniform illumination without sacrificing efficiency.

3 – Color of light:

The illumination should provide original color sense .The color of object is the same as that of the light color. If the lamp is covered with a green paper, objects of the room look green. To observe original color of the objects, Fluorescent tubes should be used which give day light.

4 – Shadowless illumination

There should be no shadow in the room ,otherwise the illumination is said to be defective .The shadow can be avoided by using more number of lamps ,keeping more height of the lamps and using glass over the lamp .For having shadowless illumination , general lighting system should be used .

5 – Glare free illumination:

There should be NO glare in the room. It be direct from light source or it may be through reflection from polished objects .Both, the glares are to be avoided as it gives a discomfort to eyes. Glare can be eliminated by proper designing.

6- Mounting height:

It is an important Factor in the designing. Mounting height should be kept about 3.75 m. from the ground. The light should be installed at the horizontal run of the wiring which is kept about 3.0, otherwise they should hanged from ceiling so that lamp height become not more than 3.0 meter.

7 – Space height ratio:

Ratio of distance between two adjacent light, to their height above working plane. Proper designing permits this ratio between 1 and 1.5. For example if height of the room is 3 m., the spacing between light may be either 3 m. or maximum as 4.5 m.

8 – Utilization Factor:

The all light emitting from a lamp is not utilized but some is wasted through door, windows. Light is also wasted by absorption of ceilings, Floors, curtains, distemper, …etc . This Factor is taken as 50 % for calculation purposes .In other words only 50 % light is utilized and remaining is wasted.

9 – Deprecation Factor:

Lamp lumen **depreciation** is a **factor** used by **lighting** designers to predict the **depreciation** in light output for a specific light source over a defined period of time, or when it is covered by dust or dirt. The Factor is taken as 80 % for calculation purposes. In other words there is 20% of depreciation in light with time. This is due to weakening of Lamp filament, blackening of interior surface of the Lamp, …etc .

The Deprecation Factor has to kept in view which is:

=Illumination under normal working condition/ Illumination under ideally clean conditions

10 – Efficiency of lamps

The Efficiency of a lamp to convert input power to output in lumen is called as efficiency. It is measured in Lumens per watt. If a lamp has an efficiency of 10 Lumen / Watt, a 100Watt Lamp exit 1000 Lumen.