Lighting Design

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2. What is Light ?
3. Fundamentals and Terminologies
4. Luminaire Construction
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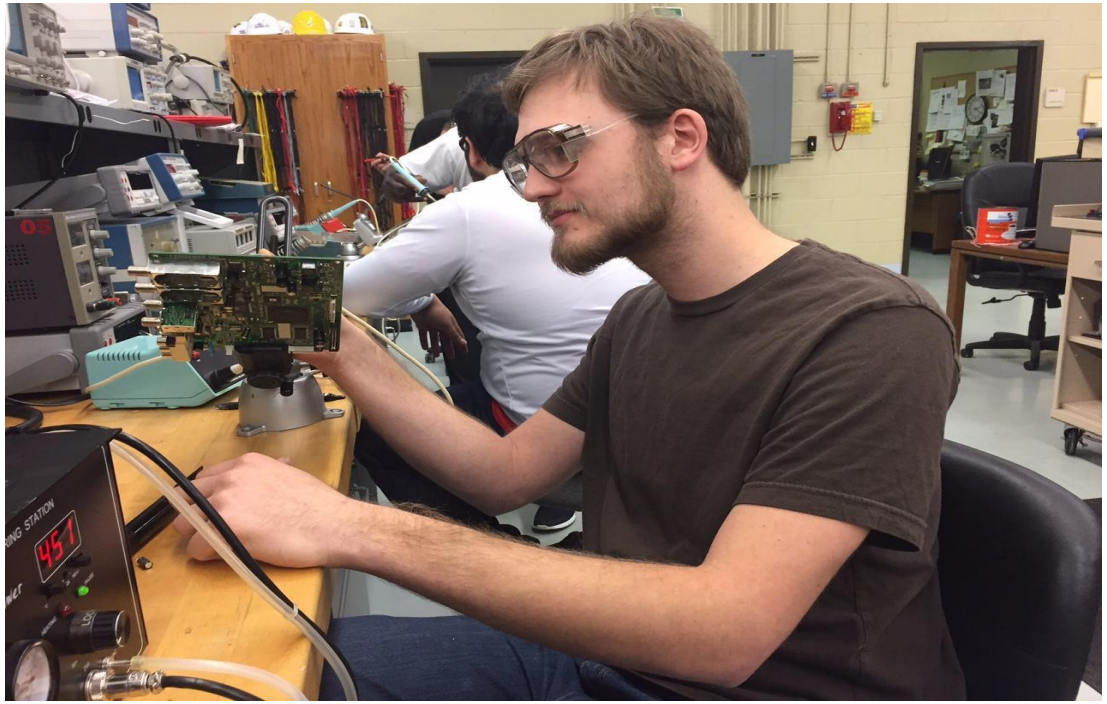
1. Main parameters for good lighting design

1. Visibility
2. Mood Atmosphere
3. Visual comfort
4. Safety

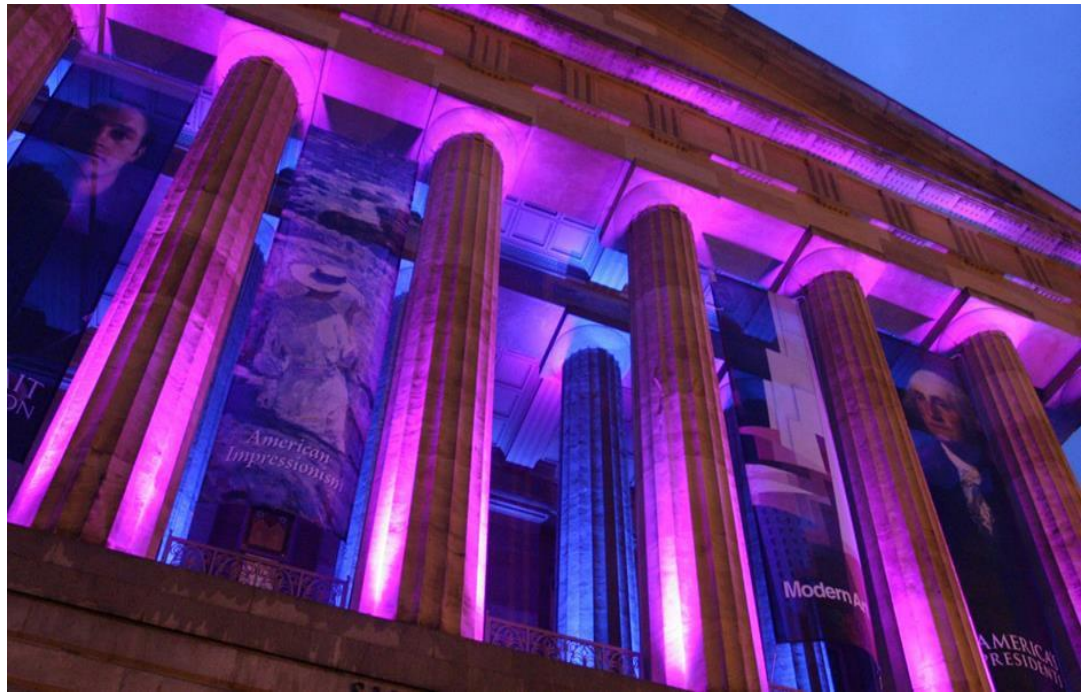
1.1. Visibility

- The smaller the detail the higher illuminance is required to see the subject



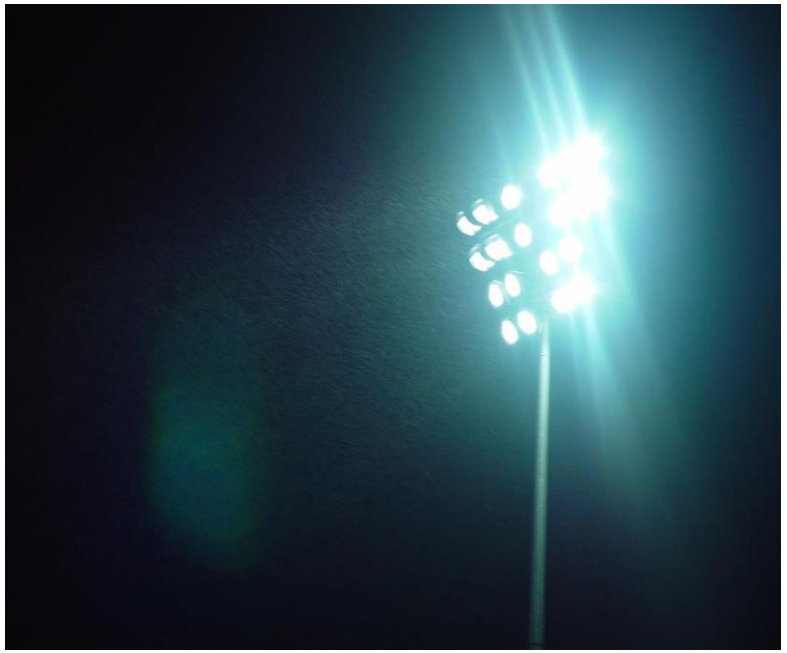
1.2. Mood Atmosphere

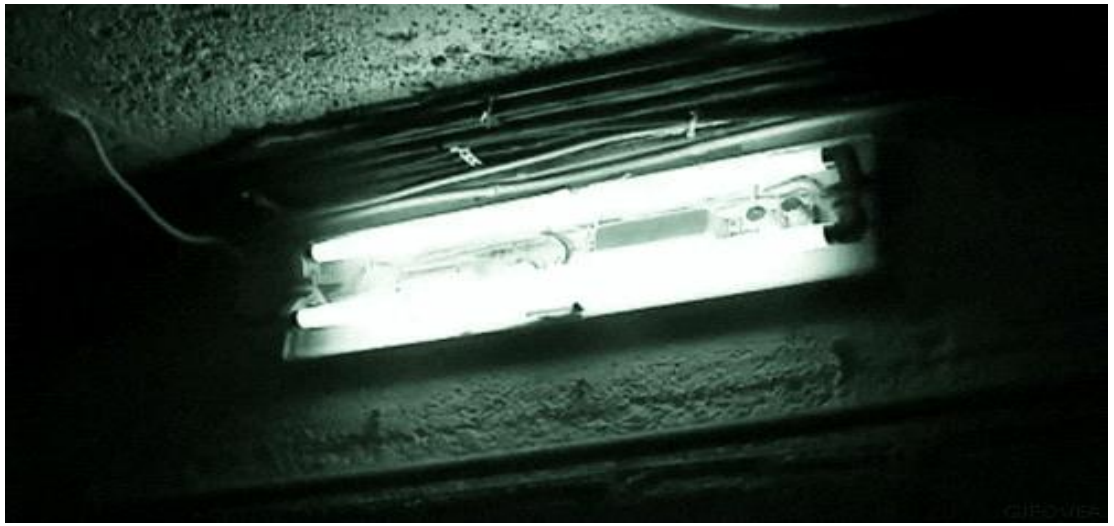
- Light can create relaxing ambient temperature, Highlight a room element or mellow a setting



1.3. Visual comfort

- Flicker, low illuminance , harsh glares are some of the suspects that causes fatigue





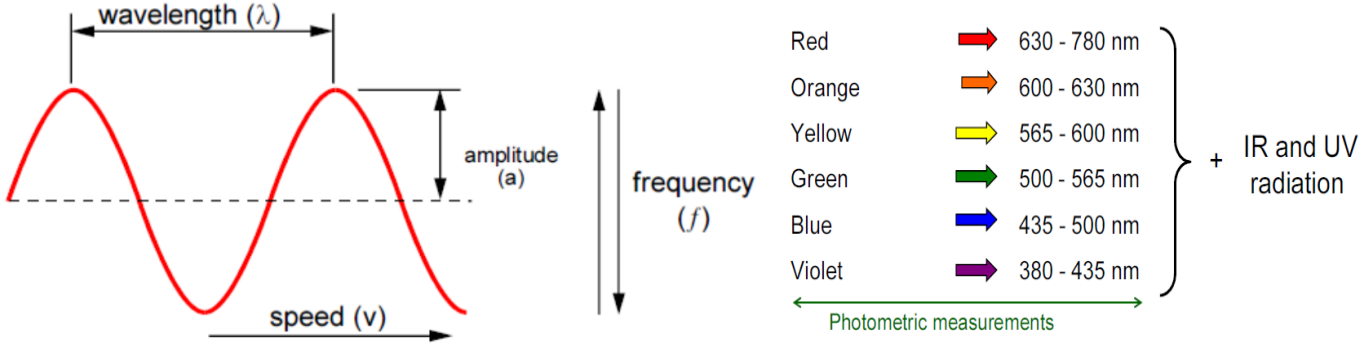
1.4. Safety

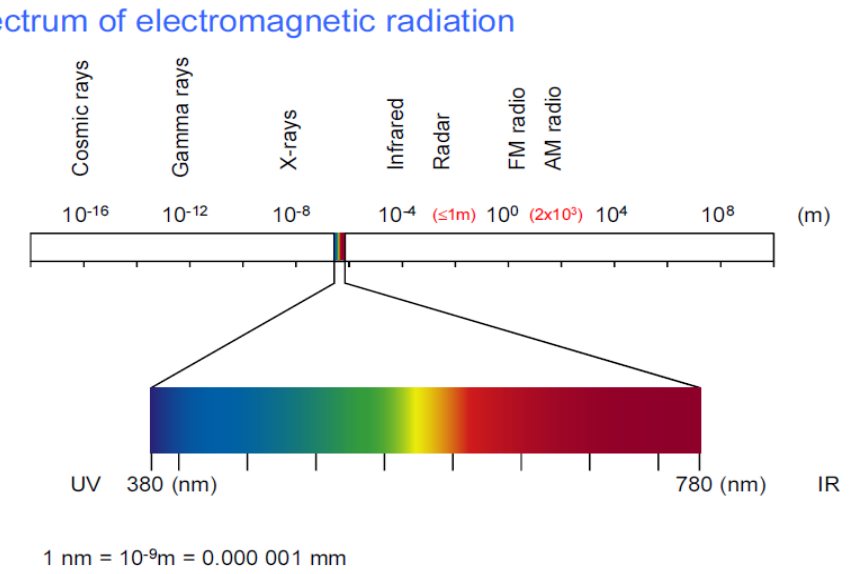
- It is a national and local concern that all public places would have easily recognizable escape plan whether in emergency or not

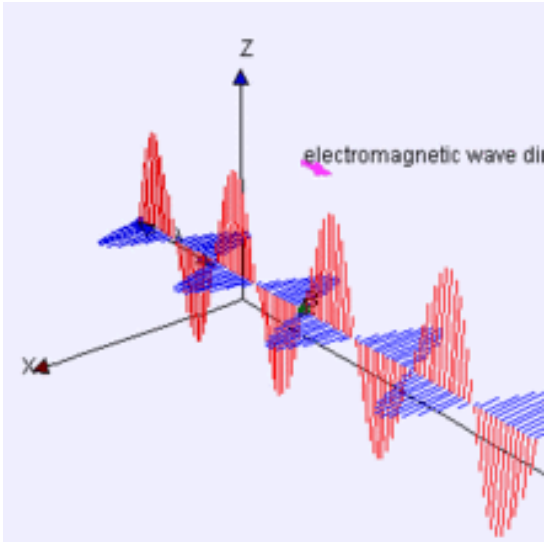
2. What is light ?

- Wave phenomenon

Light is a kind of electromagnetic radiation that consists of ripples or waves that are propagated in an omnipresent electric and magnetic field, and travelling away from its source uniformly in all direction.







3. Fundamentals and Terminologies

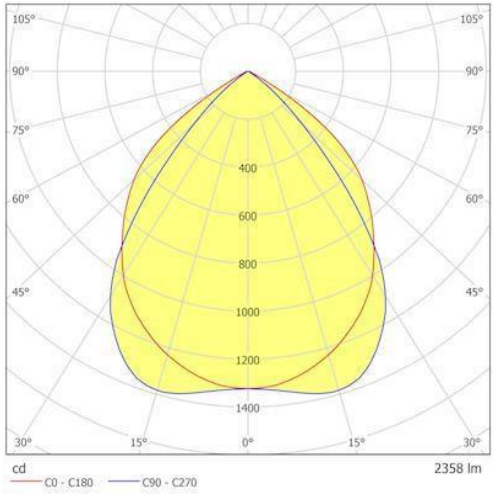
1. Luminous Flux (lumen)
2. Luminous Intensity (candela)
3. Illuminance (lumen/m2 = Lux)
4. Luminance (cd/m2)
5. Luminous Efficacy (lumen/watt)
6. Color Temperature
7. Color Rendering Index

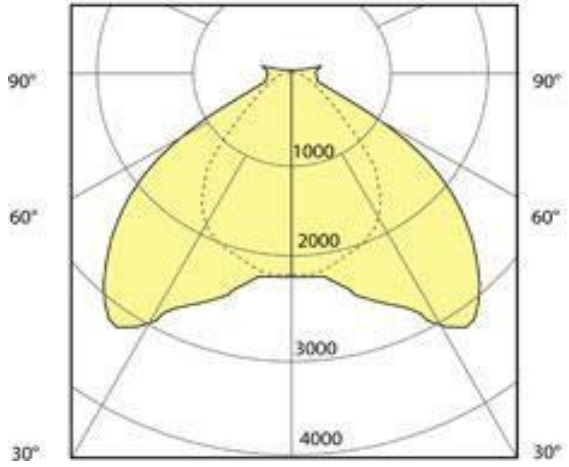
3.1. Luminous Flux

- It is the amount of light emitted in all directions from the light source.
- Measuring unit: lumen (lm)

3.2. Luminous Intensity

- The power of a light source or illuminated surface to emit light in a given direction.
- Measuring unit: candela (cd)





3.3. Illuminance

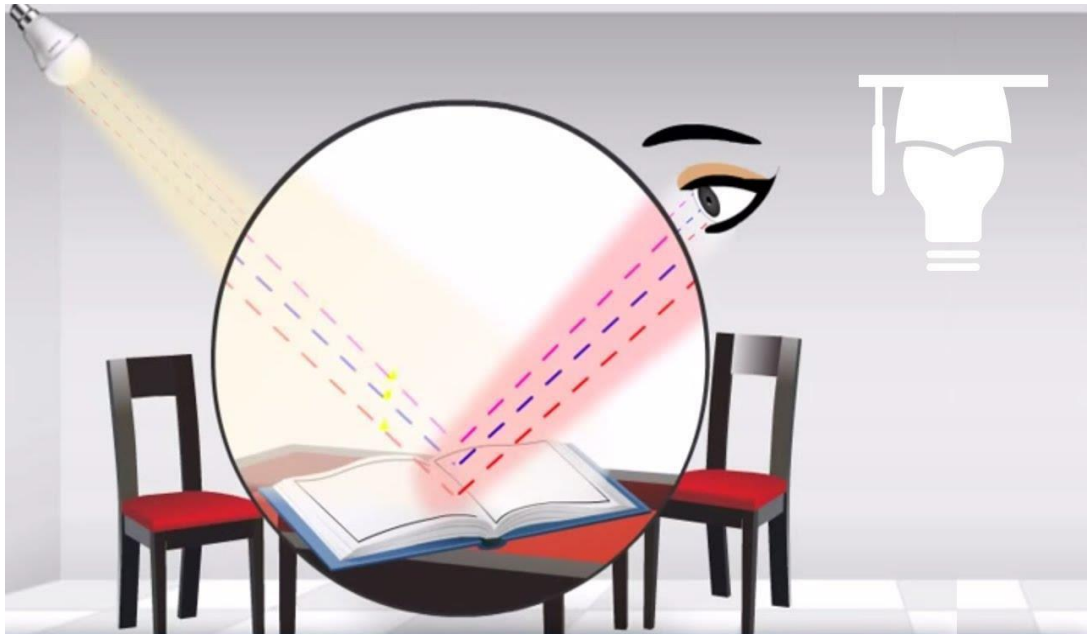
- It is the amount of light falling on a certain area or the luminous flux density at a surface.
- Measuring unit: lm/m² (lux)

Lux meter

3.4. Luminance

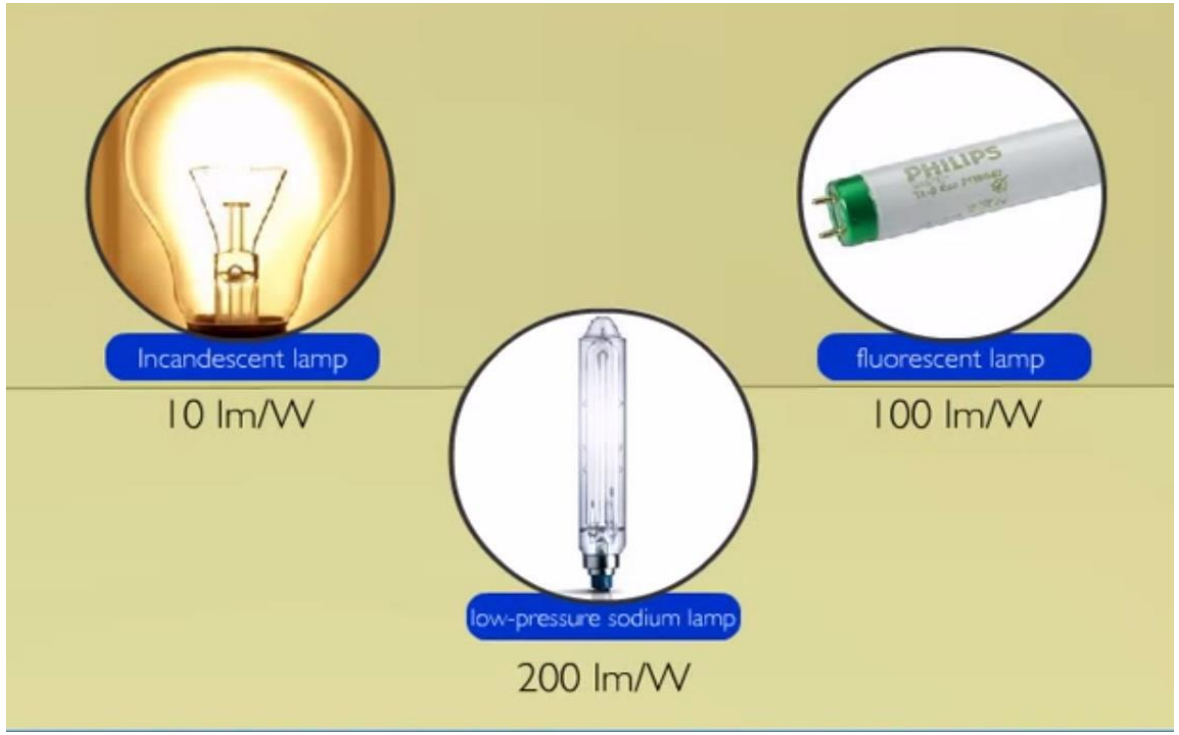
- The perceived brightness of a surface, measured by the intensity of light emitted or reflected from a surface area in a given direction.
- Measuring unit: luminous flux per unit solid angle per unit area. (cd/m2)

Luminance meter



3.5. Luminous Efficacy

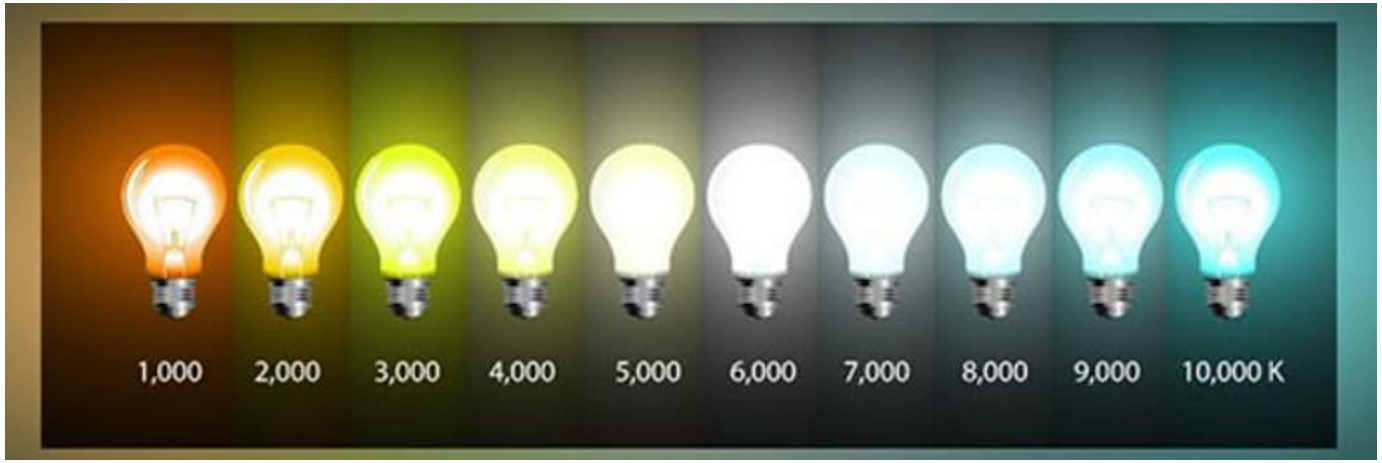
- It’s the ratio of light emitted, to the power consumed by a lamp.

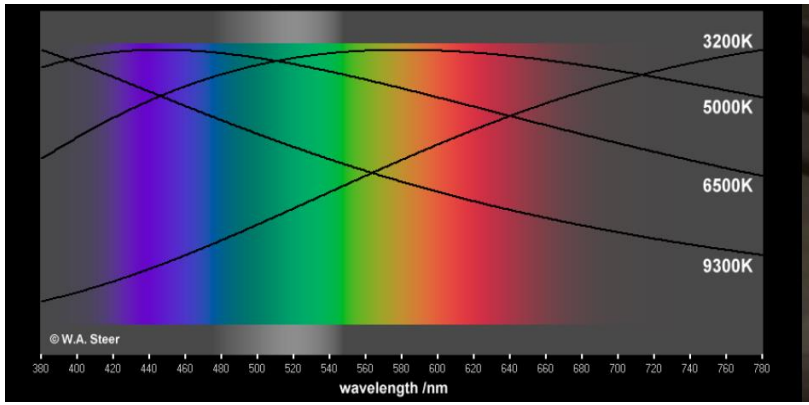


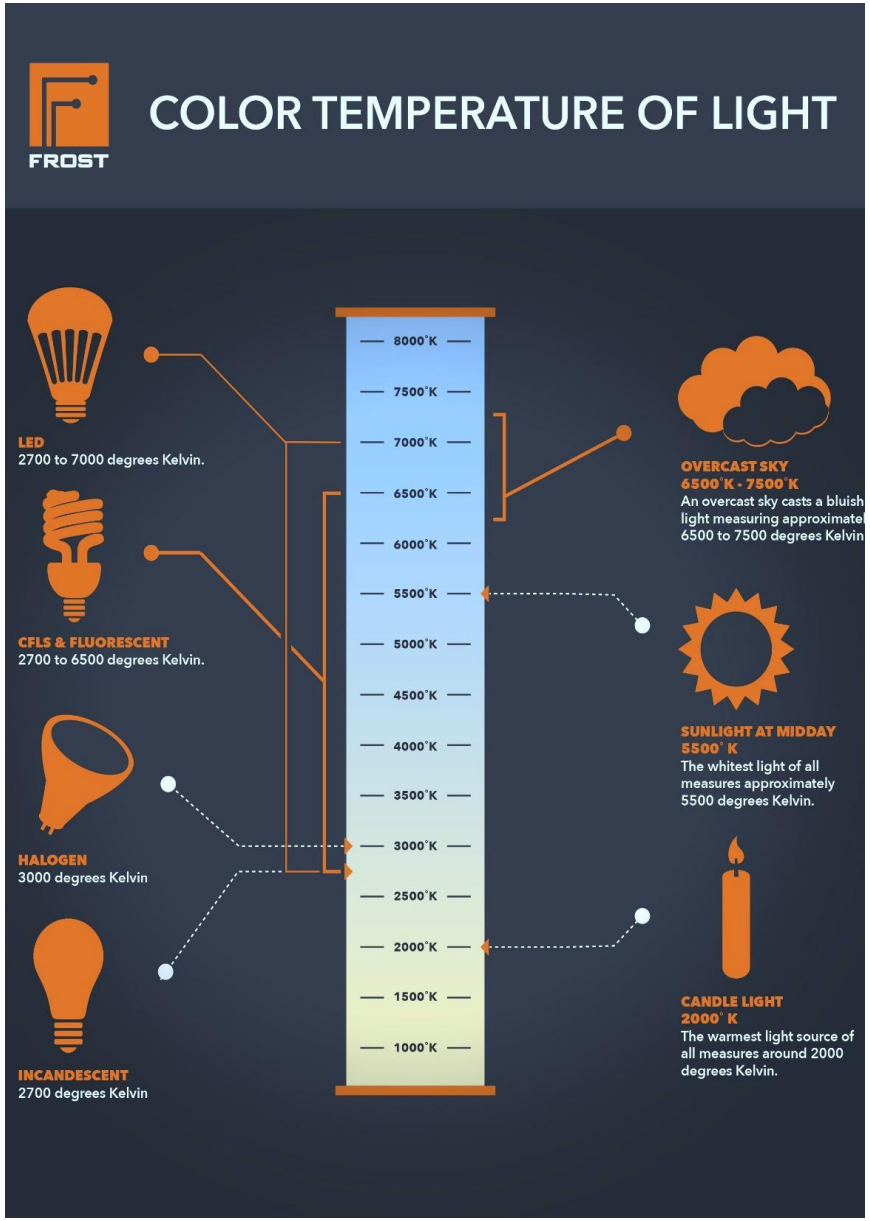
3.6. Color Temperature

- All materials emit light when heated (e.g. metal glows red through to white as the temperature increase).
- The temperature to which a full radiator (or ‘black body’) would be heated to achieve the same chromaticity (color quality) of the light source being considered, defines the correlated color temperature of the lamp, quoted in degrees Kelvin.
- Measuring unit : (°K)

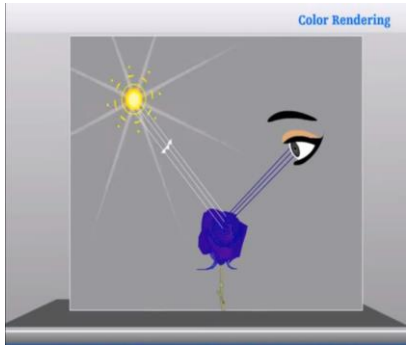
3.6. Color Temperature continue,

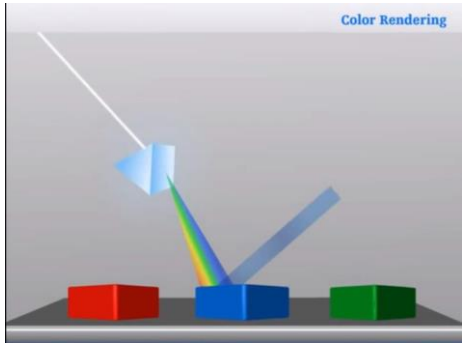


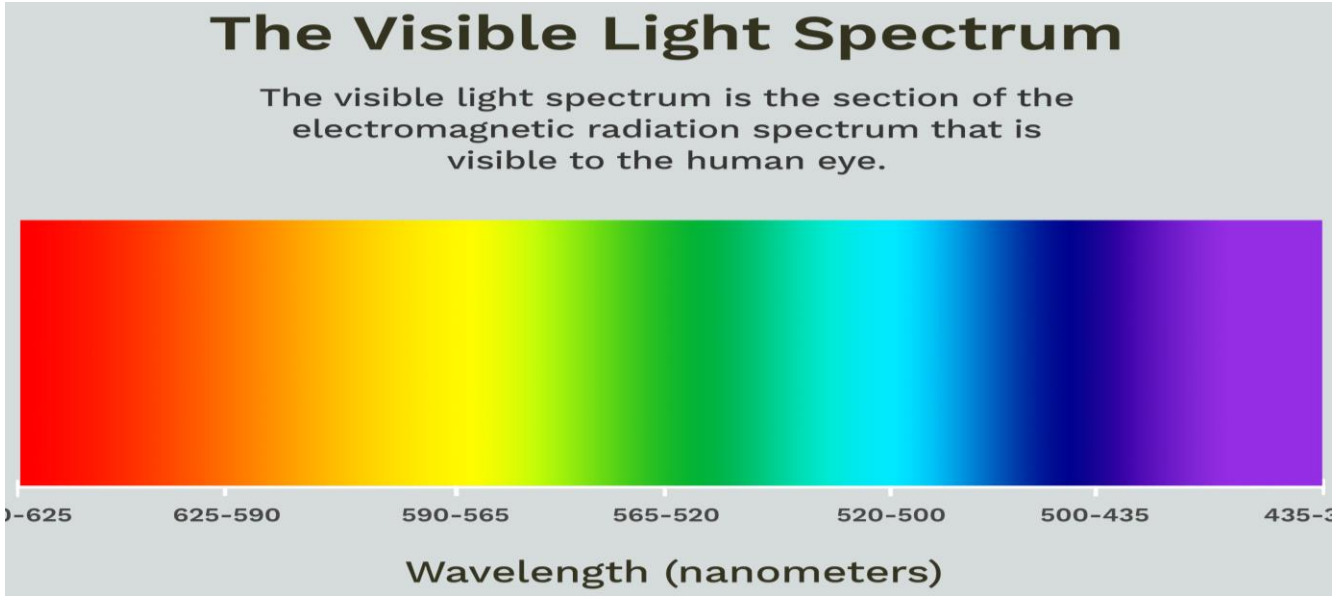


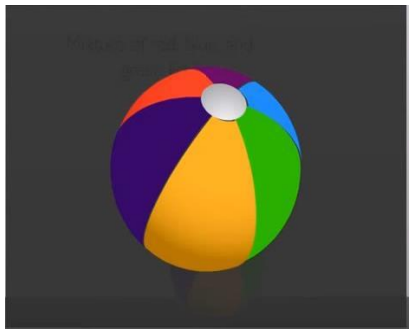


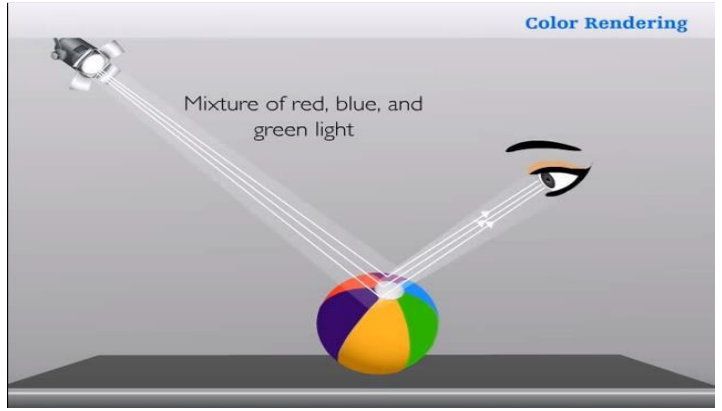
3.7. Color Rendering Index





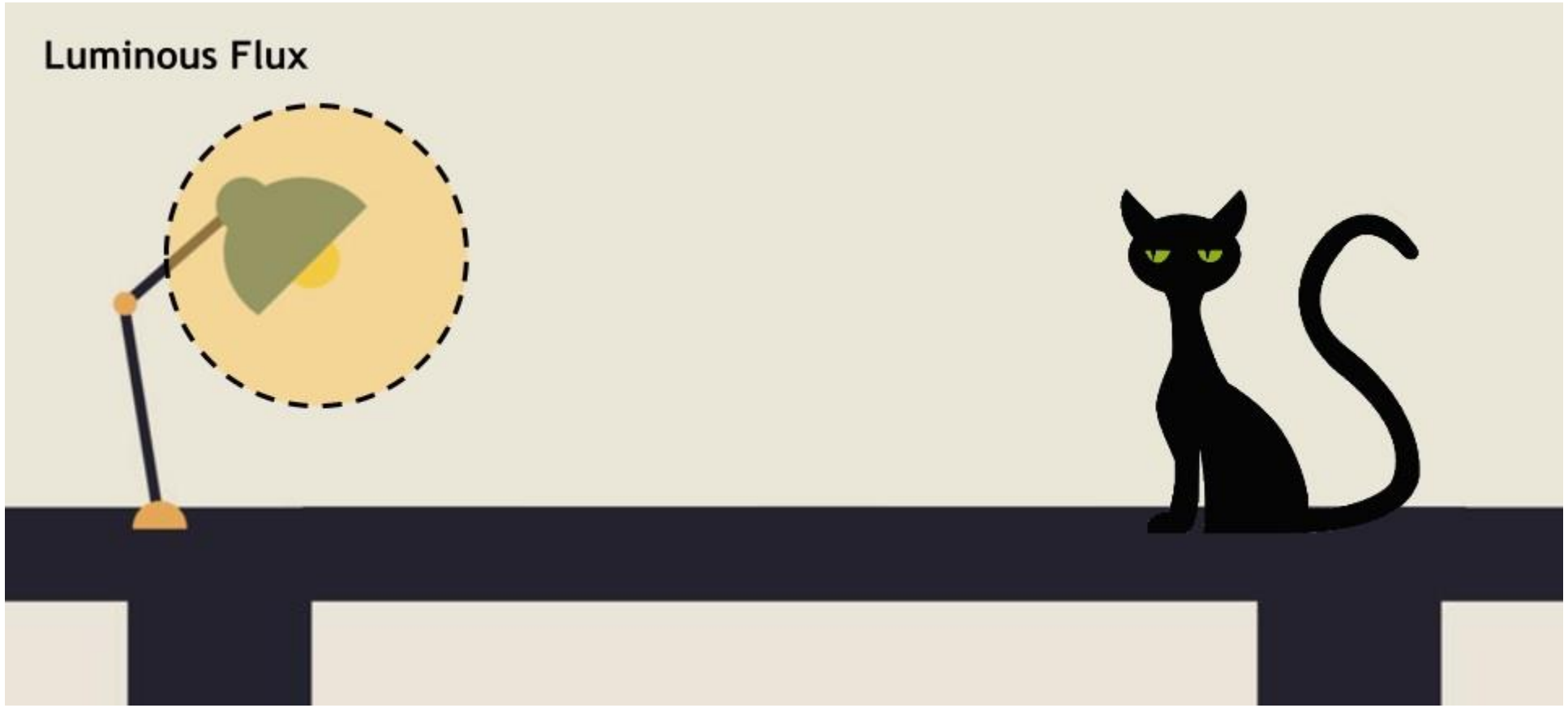






3.8. Summary

How much light comes out of the light bulb?



The total amount of power of visible light emitted from the light source

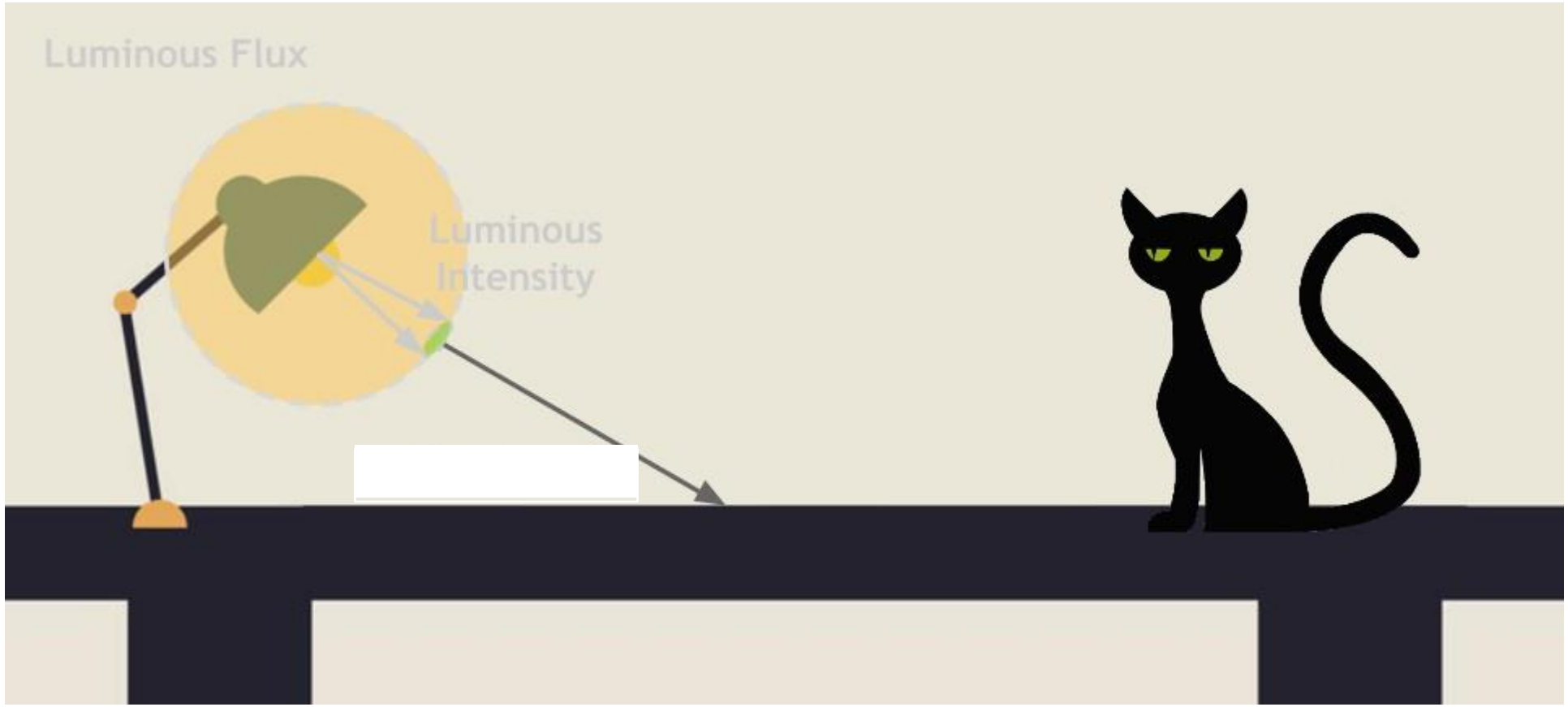
3.8. Summary continue,

How much light emitted at a particular direction?

Luminous flux per unit solid angle

3.8. Summary continue,

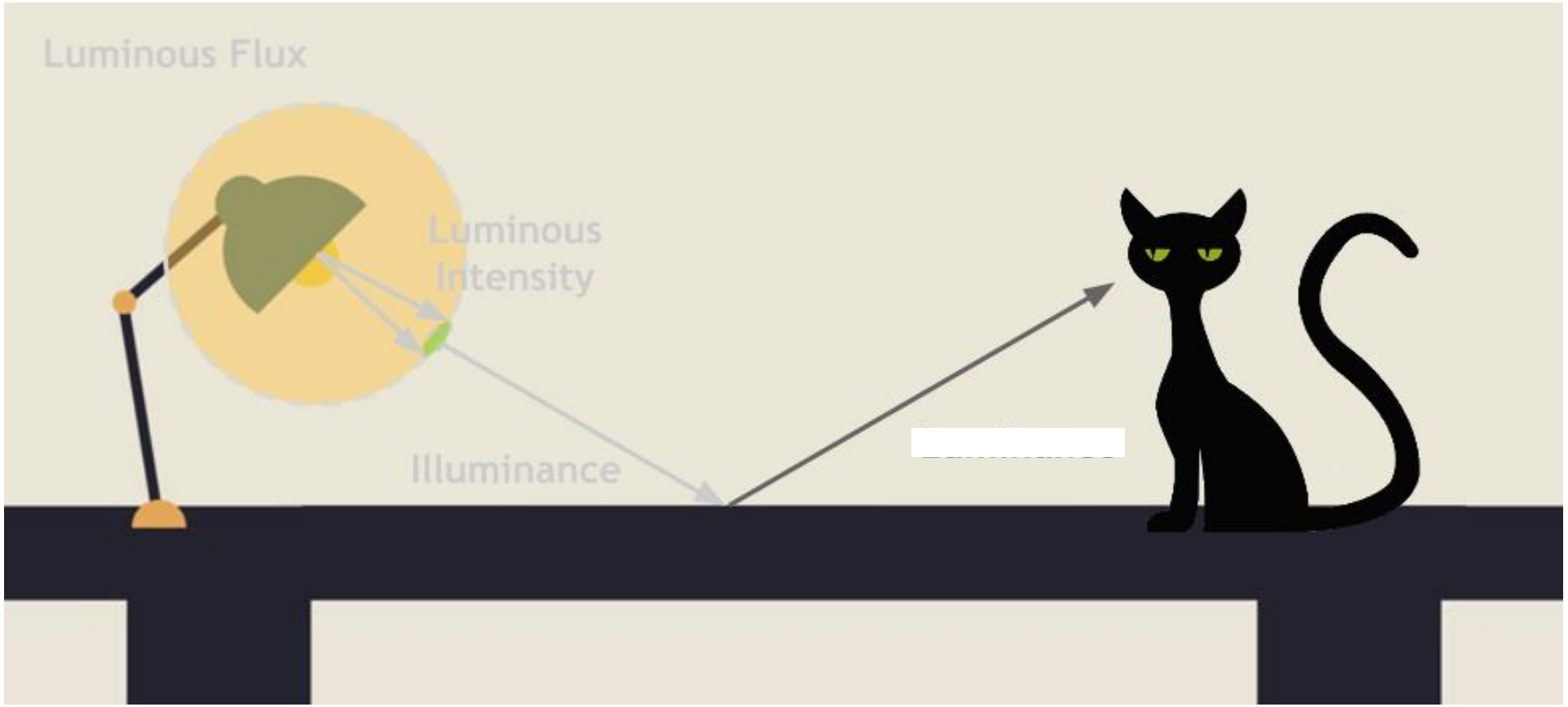
How much light fall on the desk?



Luminous flux per unit area

3.8. Summary continue,

How bright the surface appear?

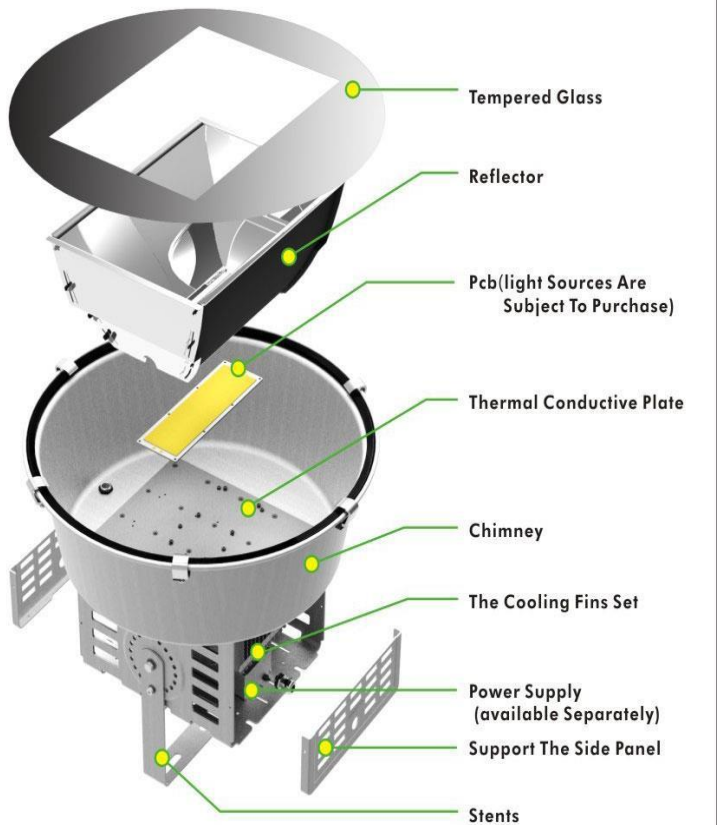


Luminous flux per solid angle per unit area

4. Luminaire Construction

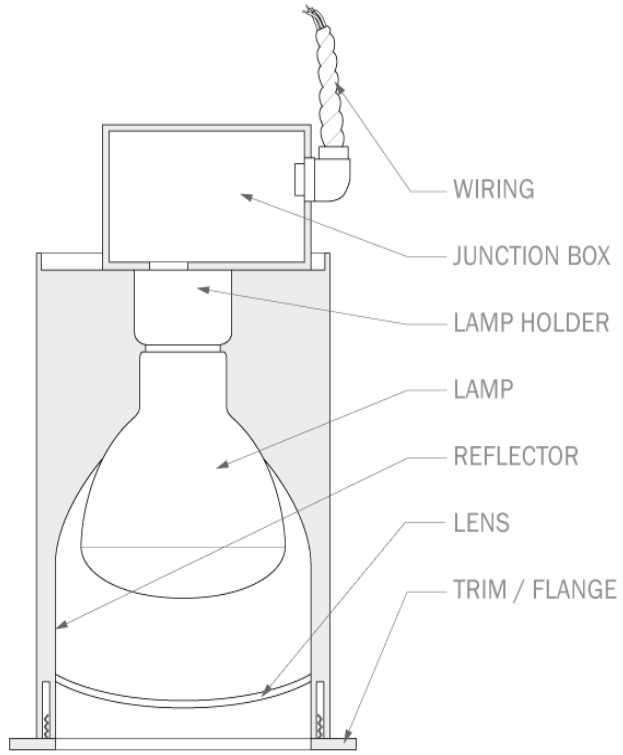
- Connect the light source to the electricity supply.
- Protect the light source from mechanical damage.
- Control the distribution of light be efficient.
- Withstand the expected conditions of use.

1. Body material.
2. Protection class
3. Artificial light source.
4. Control gear
5. Flux control

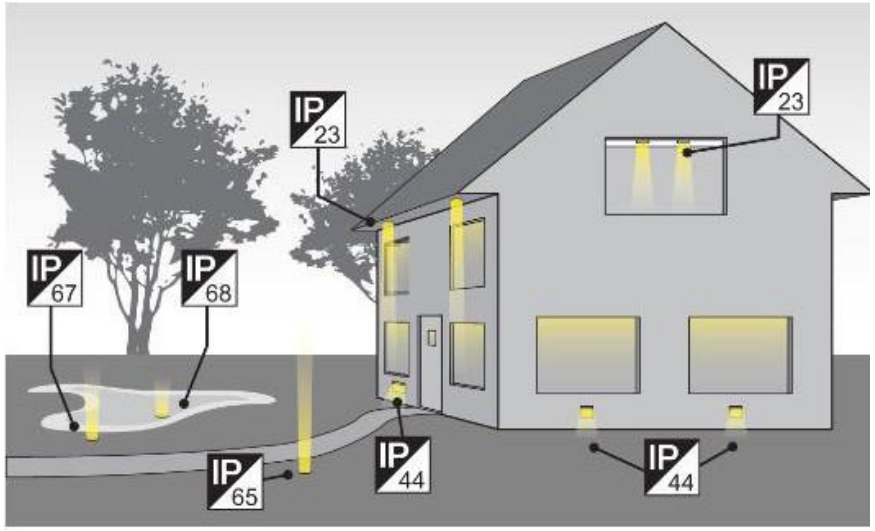


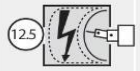
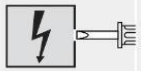
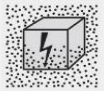
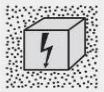
4.1. Body Material

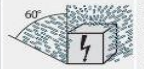
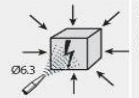
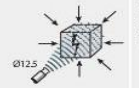
- **Steel :** Many interior lighting luminaires are made from ready-painted sheet steel, white being the usual paint color.
- **Stainless steel :** is rarely used for luminaire bodies but it is widely used for many small, unpainted luminaire components that have to remain free from corrosion.
- **Aluminum sheet :** is mainly used for reflectors in luminaires. It can have good reflection properties and the physical strength to form stable reflectors of the desired form.
- **Cast aluminum:** is widely used for floodlight housings. Such housings are light in weight and can be used in damp or corrosive atmospheres.



4.2. IP classification system



IP No.	Example	Protection against contact and ingress of objects	Tests	Symbol
IP 1X		Protected against solid objects greater than 50mm ø	A large surface of the body, such as a hand (but no protection against deliberate access). Solid objects exceeding 50 mm in diameter.	
IP 2X		Protected against solid objects greater than 12mm ø	Fingers or similar objects not exceeding 80 mm in length. Solid objects exceeding 12mm in diameter.	
IP 3X		Protected against solid objects greater than 2.5mm ø	Tools, wires, etc., of diameter or thickness greater than 2.5mm. Solid objects exceeding 2.5mm in diameter.	
IP 4X		Protected against solid objects greater than 1.0mm ø	Wires or strips of thickness greater than 1.0mm. Solid objects exceeding 1.0 mm in diameter.	
IP 5X		Dust protected	Ingress of dust is not totally prevented but dust does not enter in sufficient quantity to interfere with satisfactory operation of the equipment.	
IP 6X		Dust tight	No ingress of dust.	

IP No.	Example	Protection against contact and ingress of water	Tests	Symbol
IP X1		Protected against dripping water	Dripping water (vertically falling drops) shall have no harmful effect	
IP X2		Protected against dripping water when tilted up to 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at any angle up to 15° from its normal position	
IP X3		Protected against spraying water	Water falling as a spray at an angle up to 60° from the vertical shall have no harmful effect	
IP X4		Protected against splashing water	Water splashed against the enclosure from any direction hall have no harmful effect	
IP X5		Protected against water jets	Water projected by a nozzle against the enclosure from any direction shall have no harmful effect	
IP X6		Protected against heavy seas	Water from heavy seas or water projected in powerful jets shall not enter the enclosure in harmful quantities	
IP X7		Protected against the effects of immersion	Ingress of water in a harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time	
IP X8		Protected against submersion	The equipment is suitable for continuous submersion in water under conditions which shall be specified by the manufacturer. NOTE Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects.	

4.3. IK classification system

Walk over **IK09**

Drive over **IK10**

IK Codes

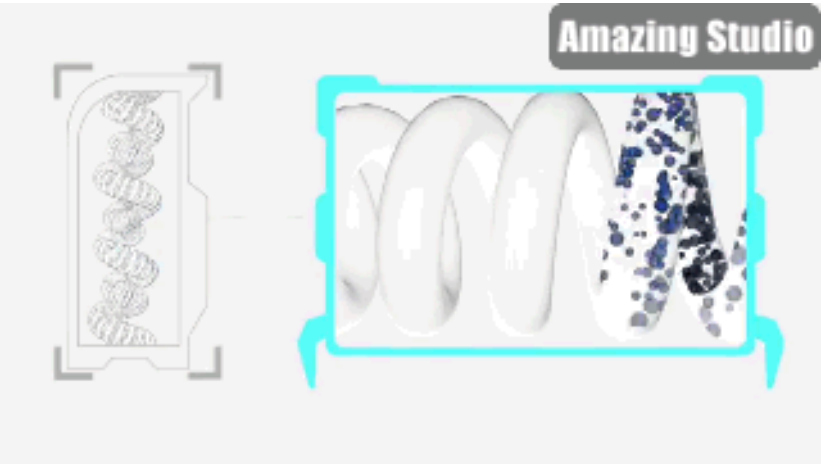
IK Code	Impact energy (J)	Equivalent impact
IK00	(no protection)	(no test)
IK01	0.14	Drop of 200 g object from 7.5 cm
IK02	0.2	Drop of 200 g object from 10 cm
IK03	0.35	Drop of 200 g object from 17.5 cm
IK04	0.5	Drop of 200 g object from 25 cm
IK05	0.7	Drop of 200 g object from 35 cm
IK06	1	Drop of 500 g object from 20 cm
IK07	2	Drop of 500 g object from 40 cm
IK08	5	Drop of 1700 g object from 29.5 cm
IK09	10	Drop of 5000 g object from 20 cm
IK10	20	Drop of 5000 g object from 40 cm

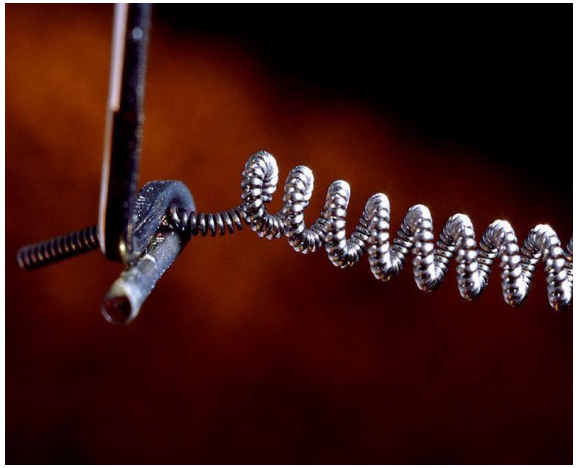
4.4. Artificial light sources

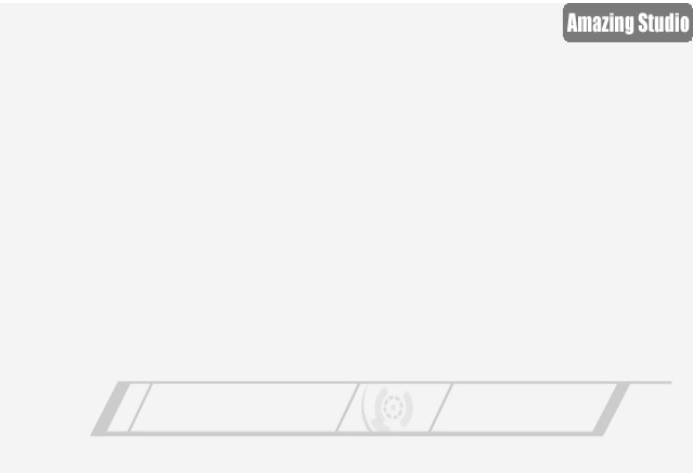
1. Filament lamp
2. Gas discharge lamp
3. LED

4.4.1. Filament Lamp

- It is an electric light with a wire filament heated to a high temperature, by passing an electric current through it, until it glows with visible light (incandescence).





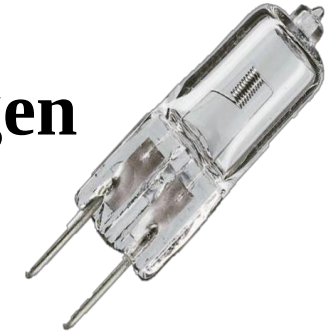


4.4.1. Filament Lamp continue,

1) Incandescent

- Filling gas is an inert gas (argon or nitrogen). Glass bulb.
- Warm white light (2600-2900° K). Dimmable.
- Short life time 1500hr

2)Halogen

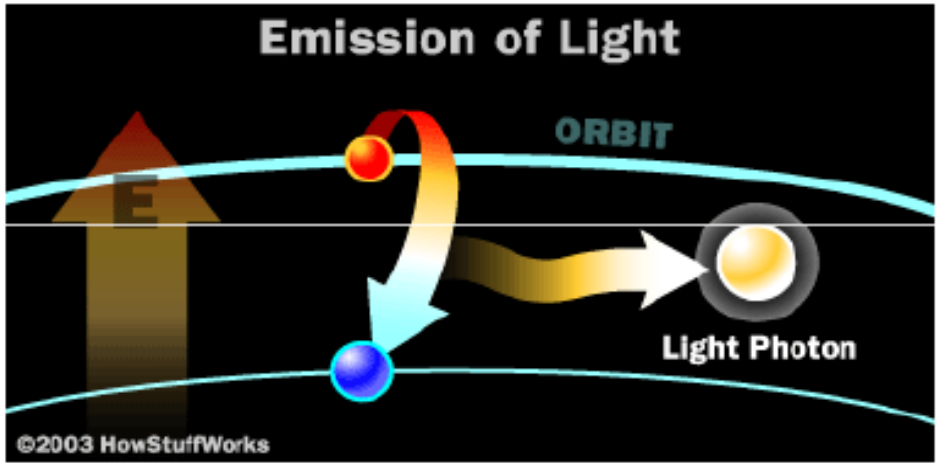


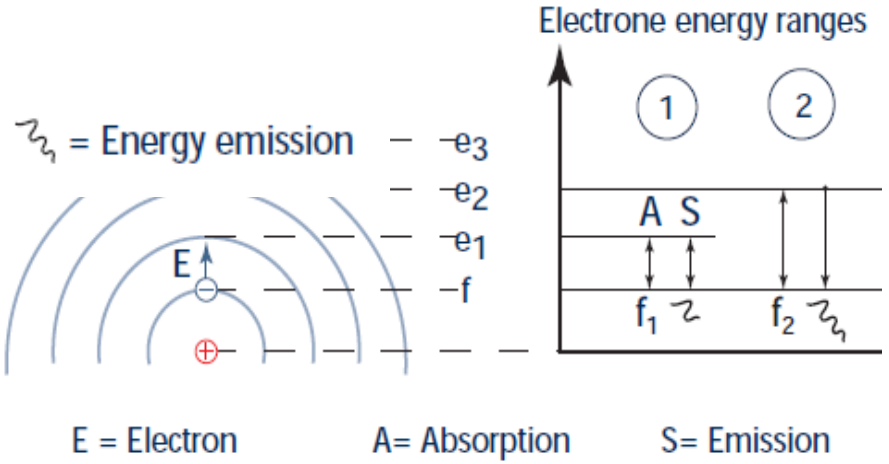
- Filling gas is an inert gas with halogen gas.
- quartz or hard glass.
- Warm white light (3200°K). Dimmable.
- Short life time 2000hr

Low efficiency - possibly the biggest drawback of filament lamps is their short efficacy which averages only about 15-20 lm/w.

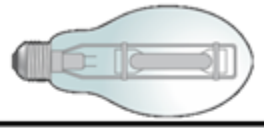
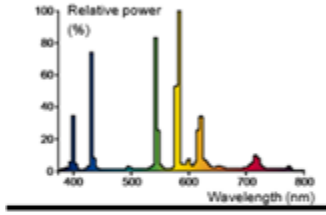
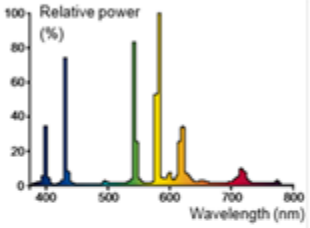
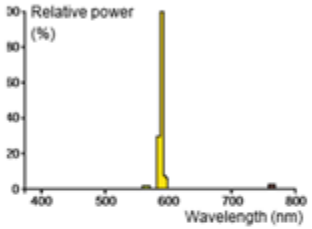
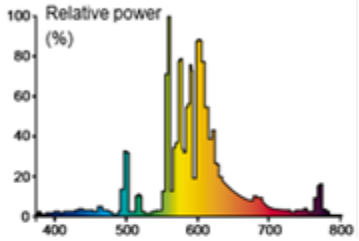
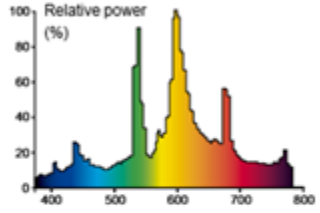
4.4.2. Gas Discharge Lamp

- If a certain amount of energy is administered to the electron , electron “e” is excited and moved from its regular orbit to the next one or to another more external one. After a short time in this level, the electron returns again to its regular initial position and emits the amount of energy usually in the form of electromagnetic radiation.



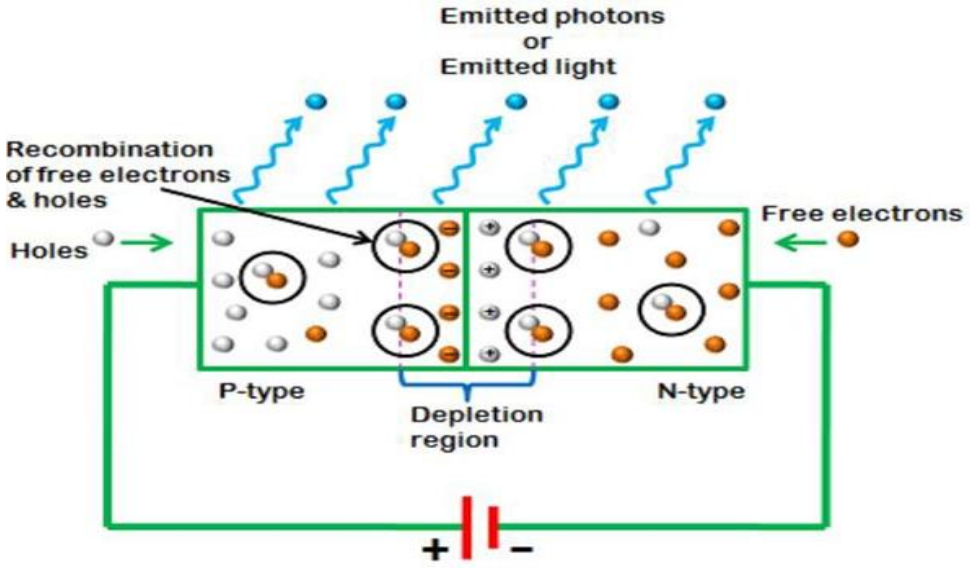


4.4.2. Gas Discharge Lamp continue,

Fluorescent	High pressure mercury	Low pressure sodium	high pressure sodium	Metal halide
				
				
Variable from neutral to rather warm	Cool white	Monochromatic orange.	Dominant yellow	Dominant white
A few seconds (almost instantaneous with electronic ballasts)	Several minutes to reach the nominal illumination level.	Several minutes to reach the nominal illumination level.	Several minutes to reach the nominal illumination level.	Several minutes to reach the nominal illumination level.
40 to 100 lm/w	30 to 65lm/w	110 to 200 lm/w	40 to 140 lm/w	70 to 120 lm/w
Ferromagnetic ballast + starter or electronic ballast	Ferromagnetic ballast + starter	Ferromagnetic ballast + starter	Ferromagnetic ballast + starter	Ferromagnetic ballast + starter
7500 to 20,000 hr	8,000 to 20,000 h	12,000 to 24,000 h	10,000 to 22,000 h	5,000 to 20,000 h

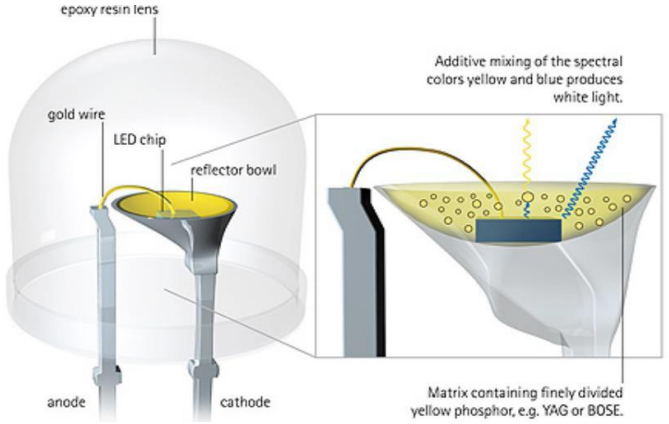
4.4.3. LED

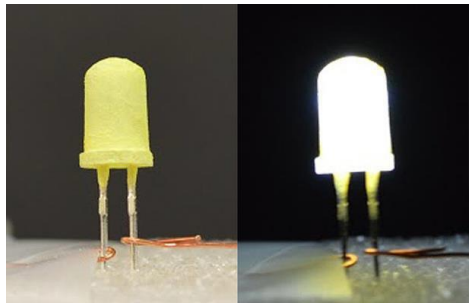
- LEDs are simply diodes that are designed to give off light. When a diode is forward-biased so that electrons and holes are zipping back and forth across the junction, That makes an atom complete and more stable and it gives off a little burst of energy (a kind of "sigh of relief") in the form of a tiny "packet" or photon of light.



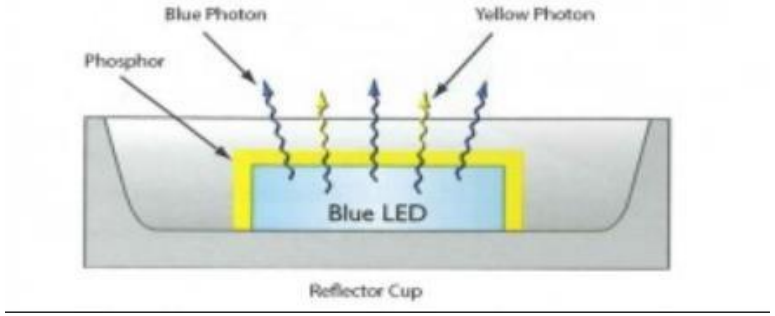
4.4.3. LED continue,

- (Conventional / Indicator) type



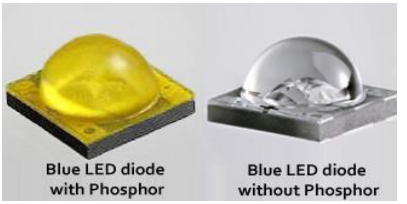


- Illuminatortype




(a)


(b)



4.5. Control Gear

1. Magnetic Ballast and Electronic Ballast
2. HID Ballast
3. LED Drivers

4.5.1. Magnetic Ballast and Electronic Ballast

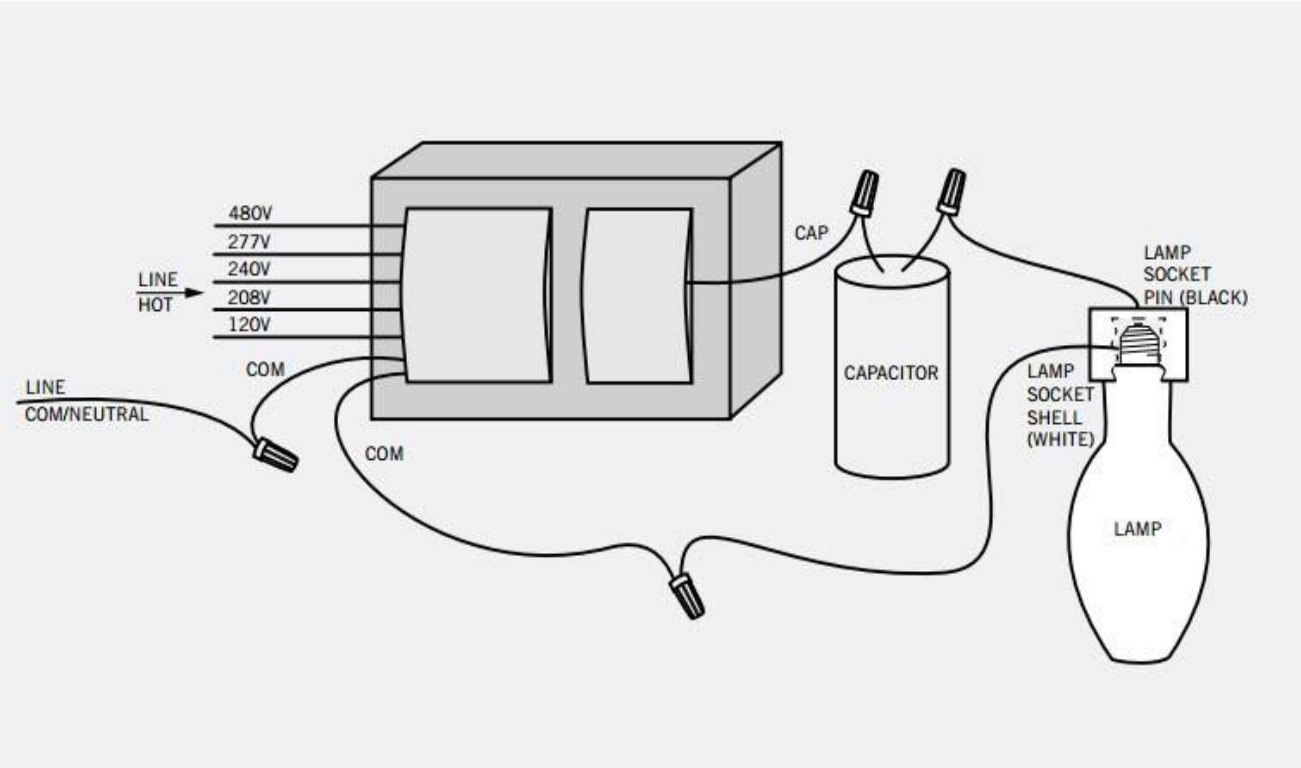
- Magnetic ballasts use a magnetic transformer made of a steel core and copper windings, along with a simple bi-metal switch for thermal protection and a simple capacitor.
- They are larger and heavier than electric ballasts.
- Lower costs.
- Require a starter.
- Operating frequency is 50HZ.
- Produce flicker.

- Electronic ballasts use circuits to control the flow of current. These use a magnetic output transformer, an EMI filter, a rectifier and integrated circuitry to manage the flow of current very precisely.
- Higher costs.
- No Starters Required.
- Operating frequency of 20 ~ 50KHZ.
- Eliminates the flicker.

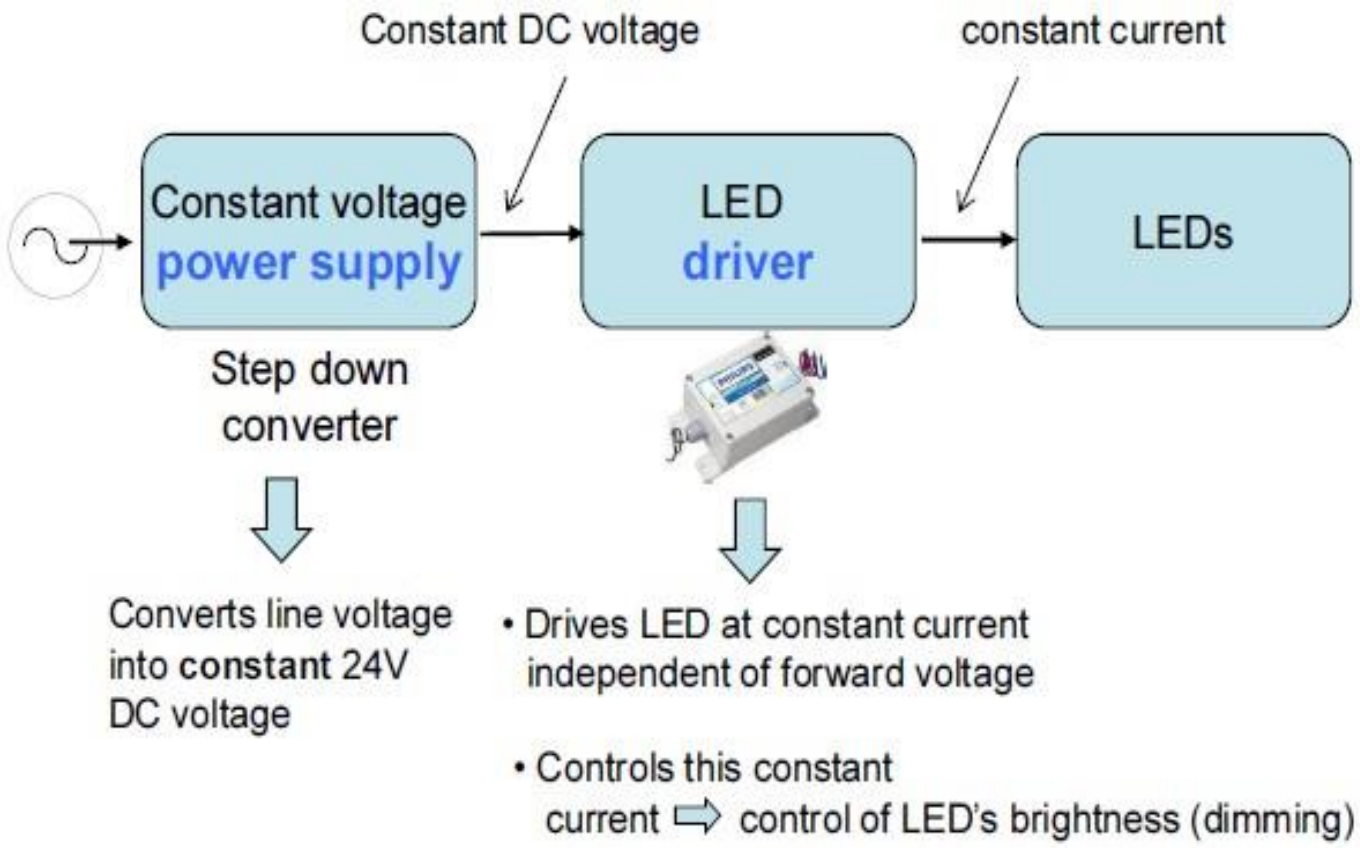
This leads to high efficiency for electronic ballast due to higher brightness and less power consumption.

Magnetic Ballast will produce stroboscopic phenomenon and noise due to low frequency operation.

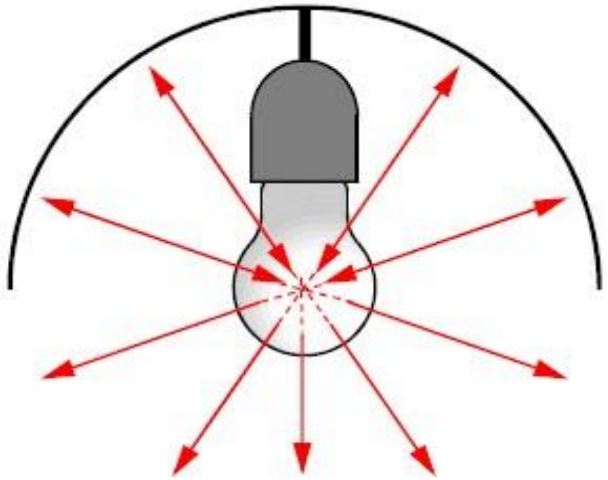
4.5.2. HID Ballast



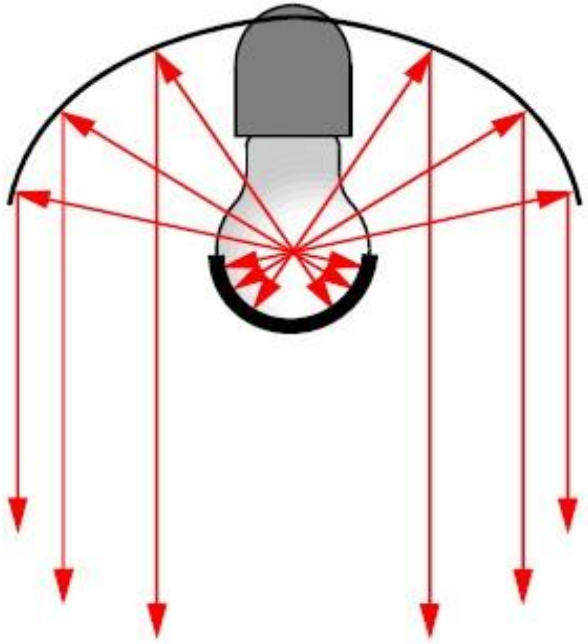
4.5.3. LED Drivers



4.6. Flux Control

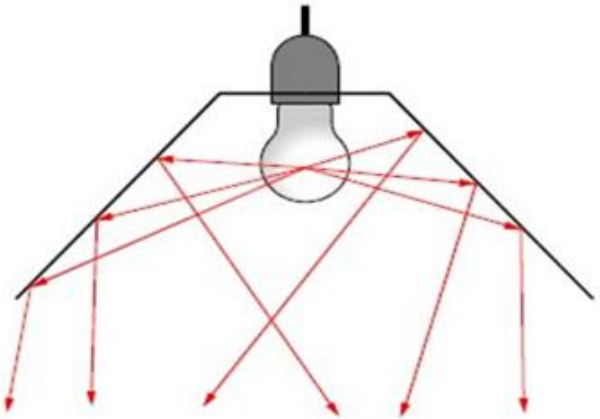


Spherical

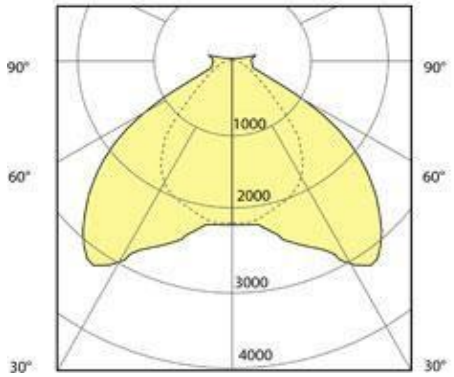


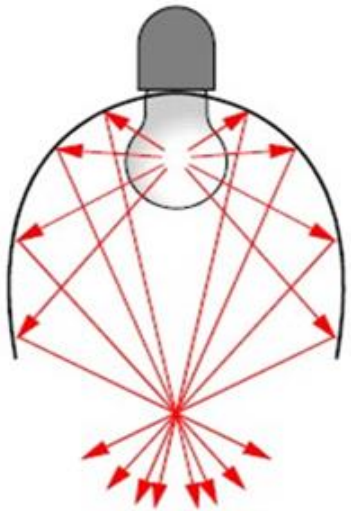
Combination of
spherical and parabolic reflector

4.6.1. Reflector

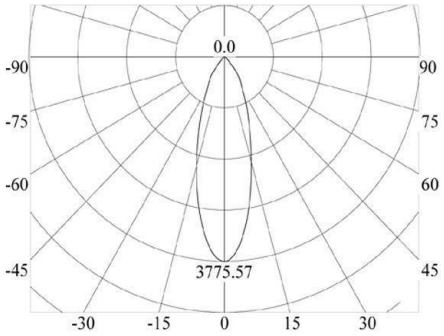


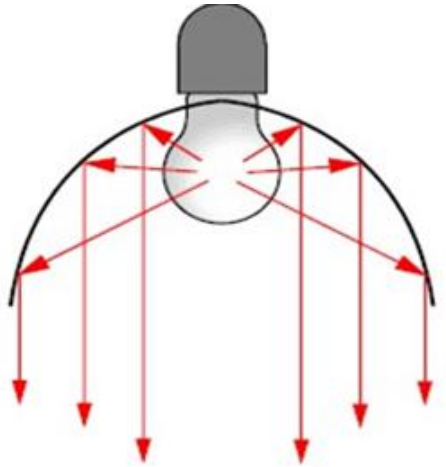
Plane



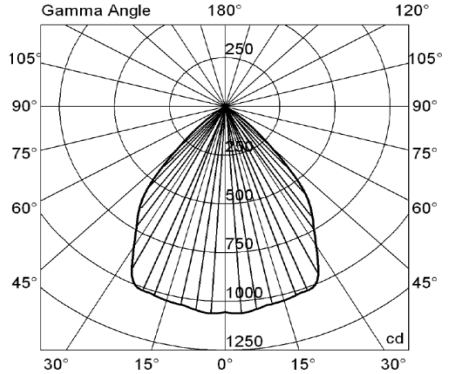


Elliptical



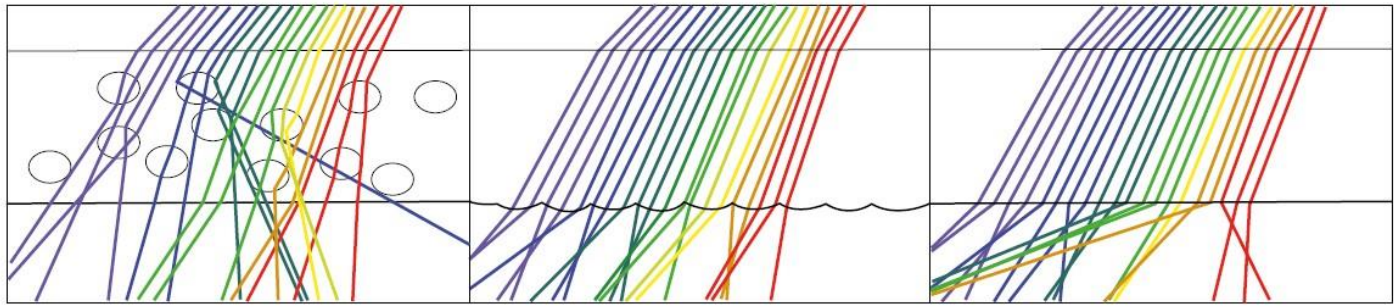


Parabolic



4.6.2. Refractors

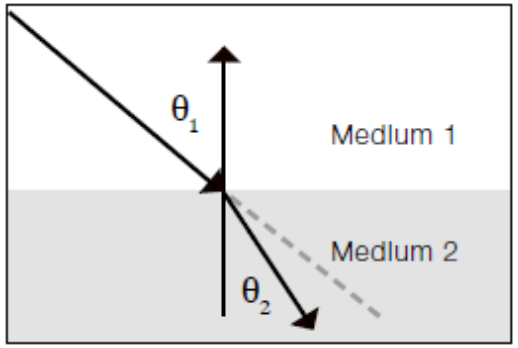
- Refractors control light distribution by turning the incident light ray through a desired
- Angle following Snell's Law
- This can be done using either prisms or lenses.

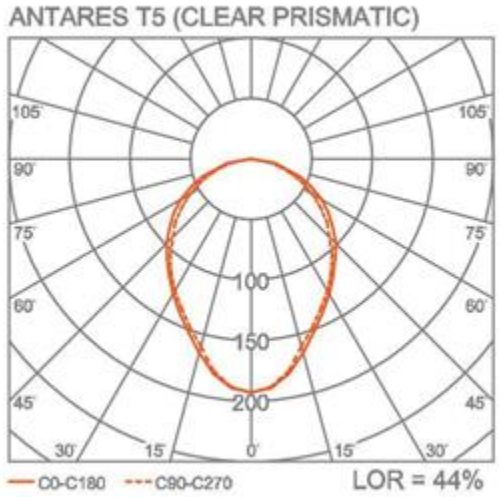


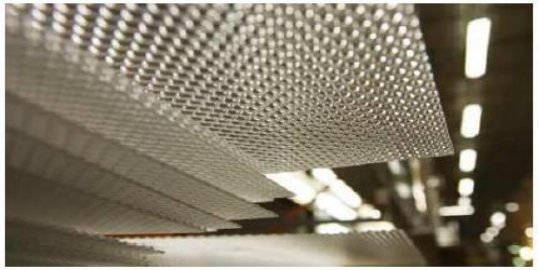
Light refraction in materials with different optical properties

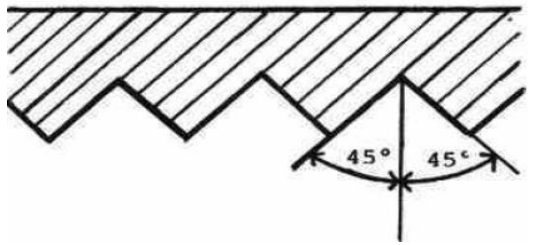
Light refraction against structures such as microprisms or microlenses

Light refraction against very fine structures for thorough mixing of light









5. Classifications of Luminaires according to manufactures

1. Surface mounted luminaire
2. Recessed mounted luminaire
3. Suspended luminaire
4. Wall mounted luminaires
5. Weather proof IP65
6. Downlight
7. High bay
8. Uplight
9. Under water fixture IP68
10. Flood light

5.1. Surface Mounted Luminaire

5.2. Recessed Mounted Luminaire

5.3. Suspended Luminaire

5.4. Wall Mounted Luminaires

5.5. Weather Proof IP65

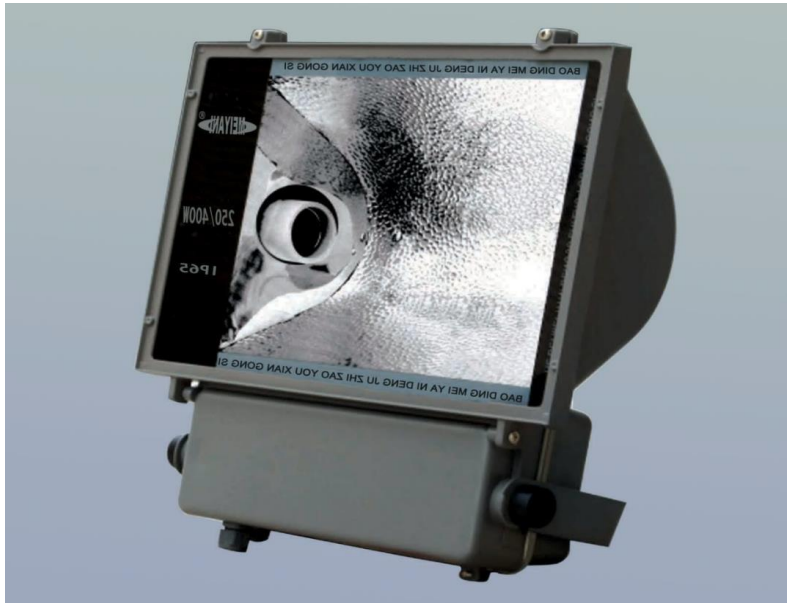
5.6. Downlight

5.7. High Bay

5.8. Uplight

5.9. Under Water Fixture IP68

5.10. Flood Light

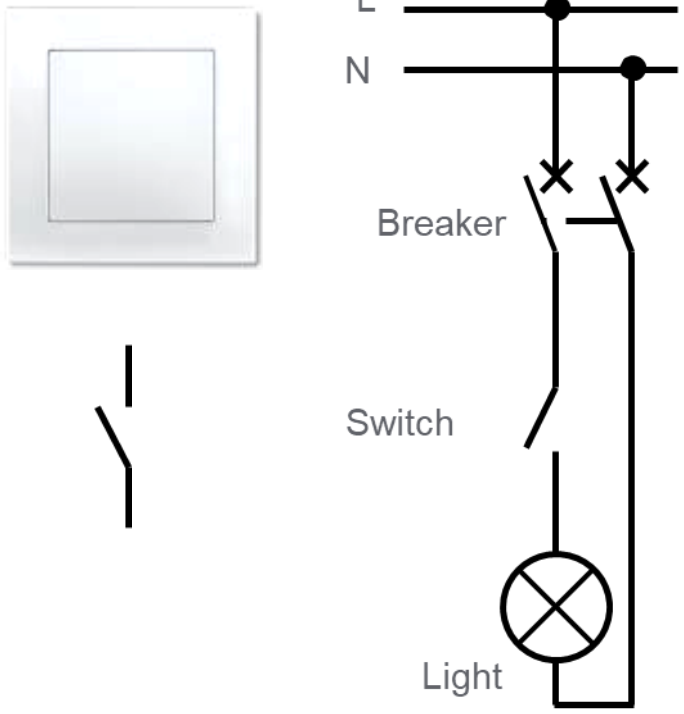


6. Lighting Control

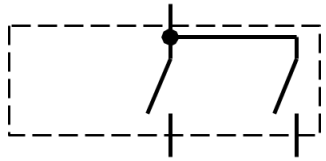
1. Manual Control
2. Automatic Control
3. Smart Control

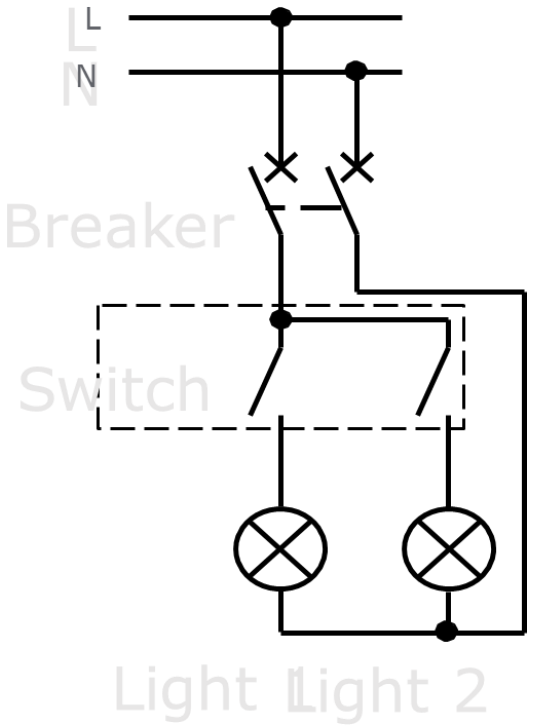
6.1. Manual Control continue,

- One-Way Circuit



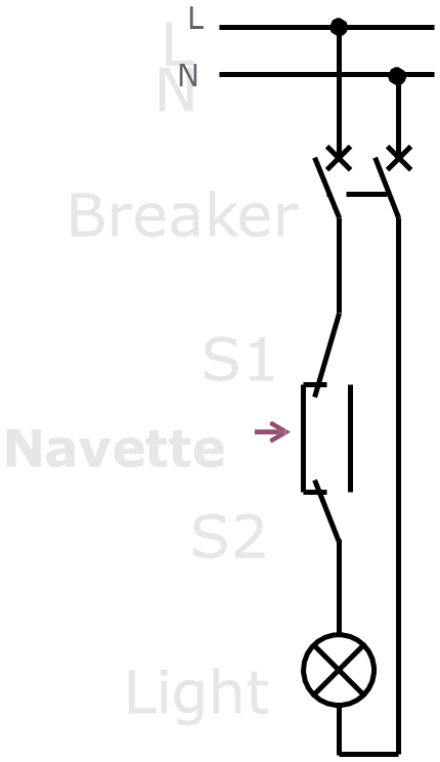
- Double “One-Way Circuit”



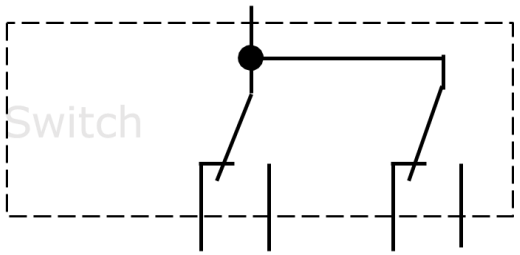


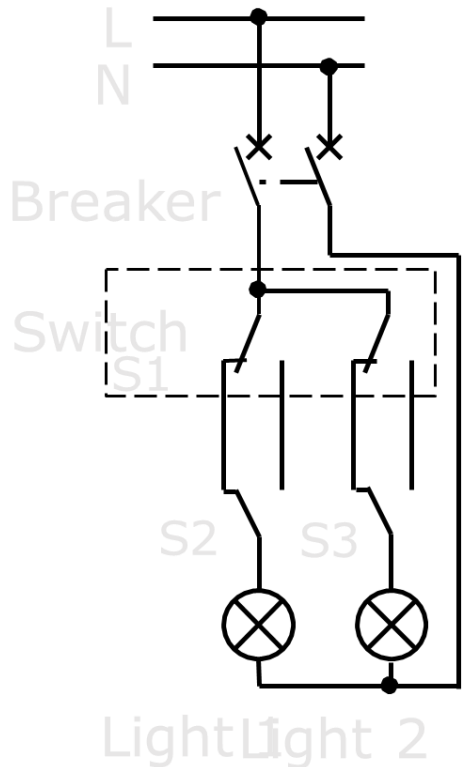
6.1. Manual Control continue,

- Two-Way Circuit



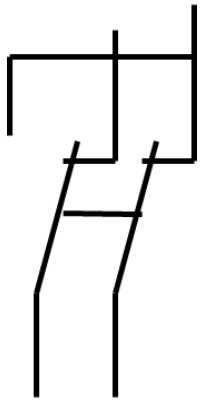
- Double "Two-Way Circuit"

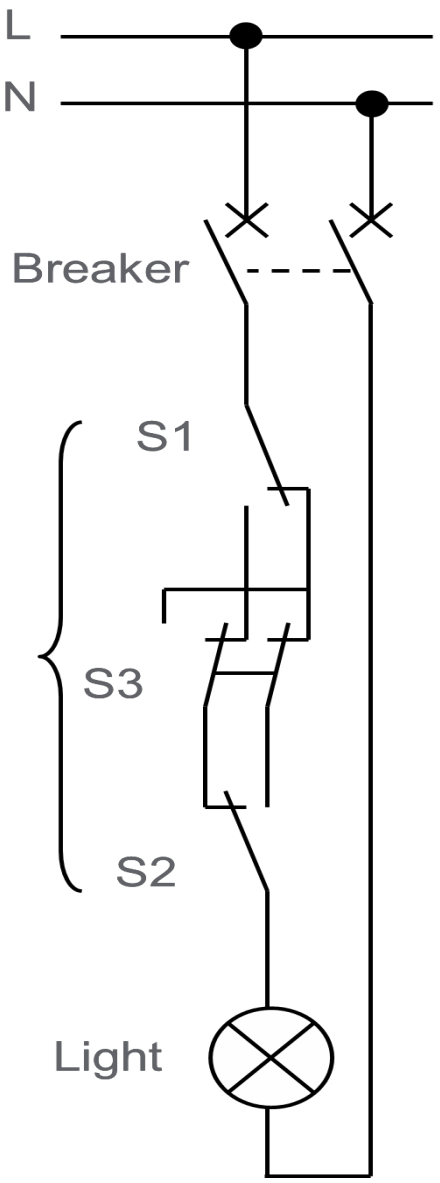




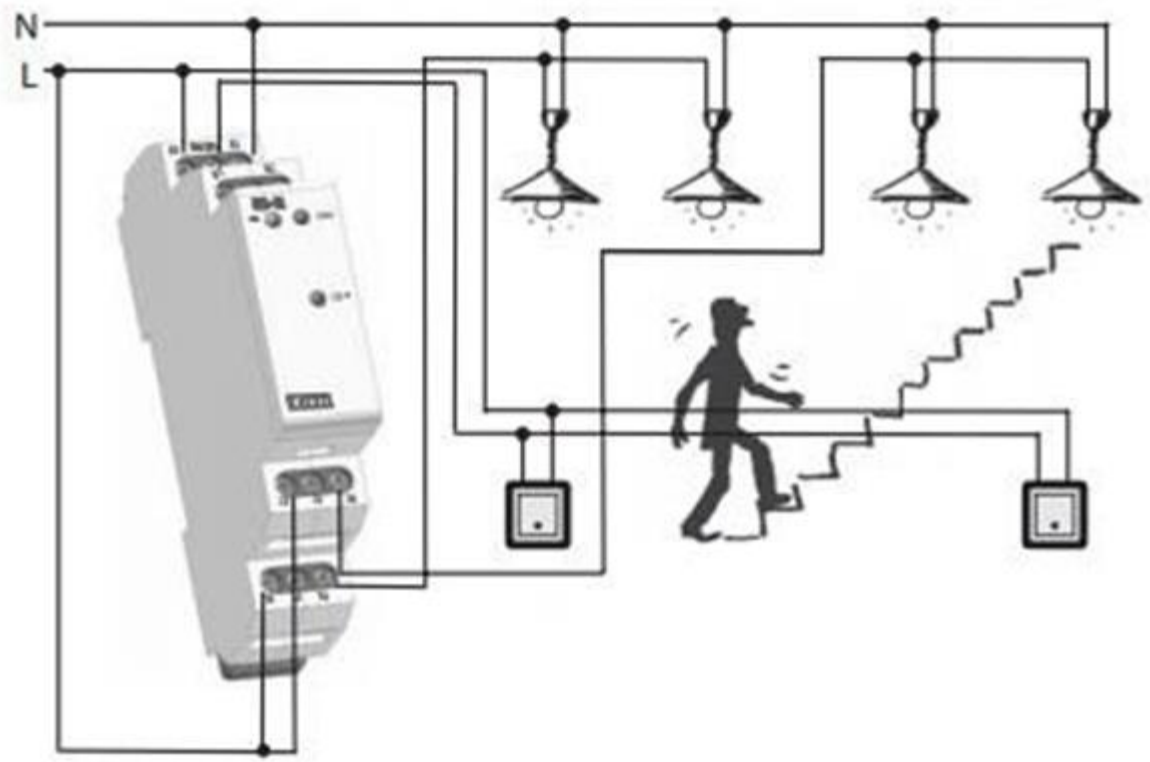
6.1. Manual Control continue,

- Intermediate Switch





6.2. Automatic Control

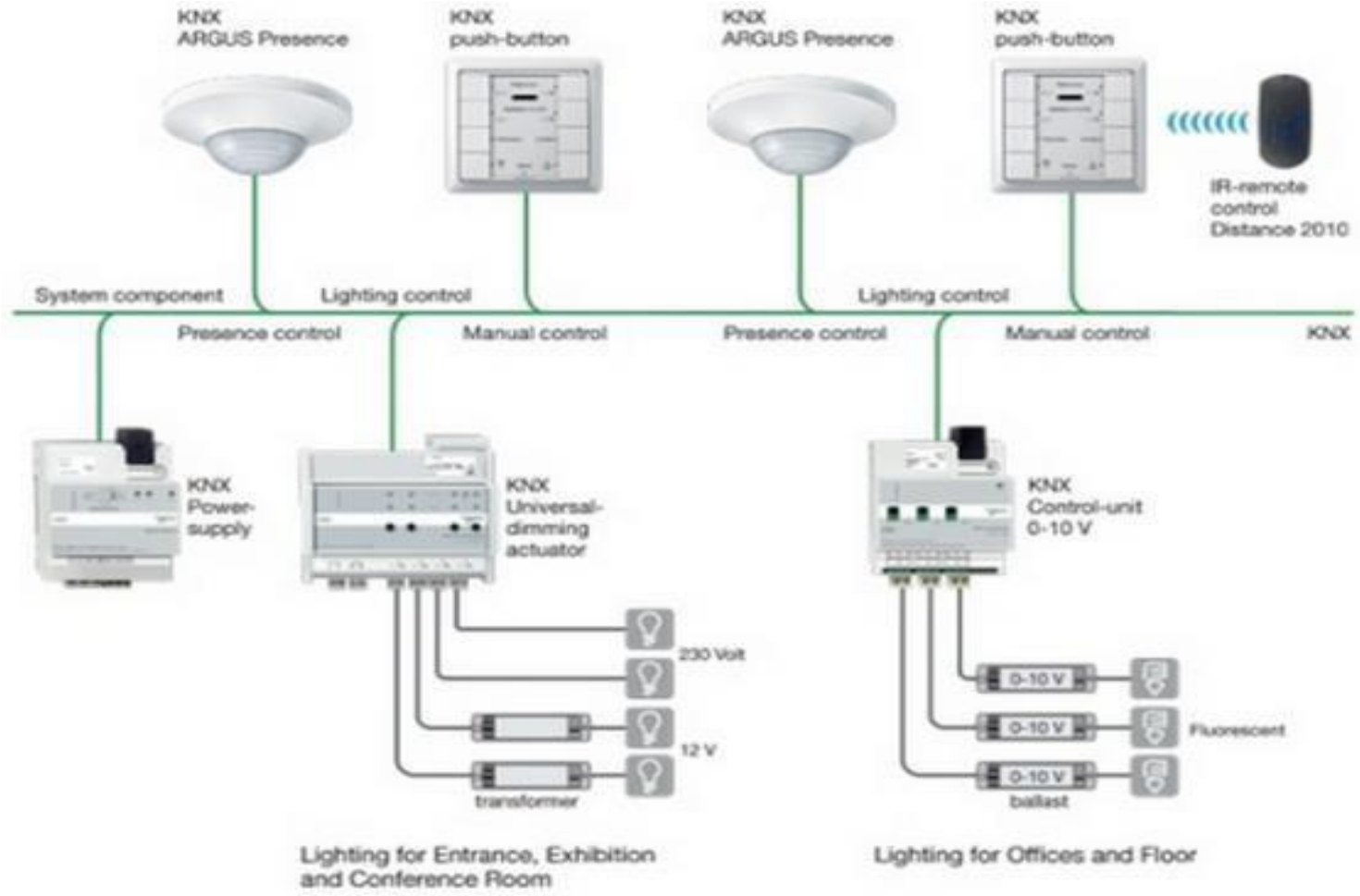


Impulse relay

Timer

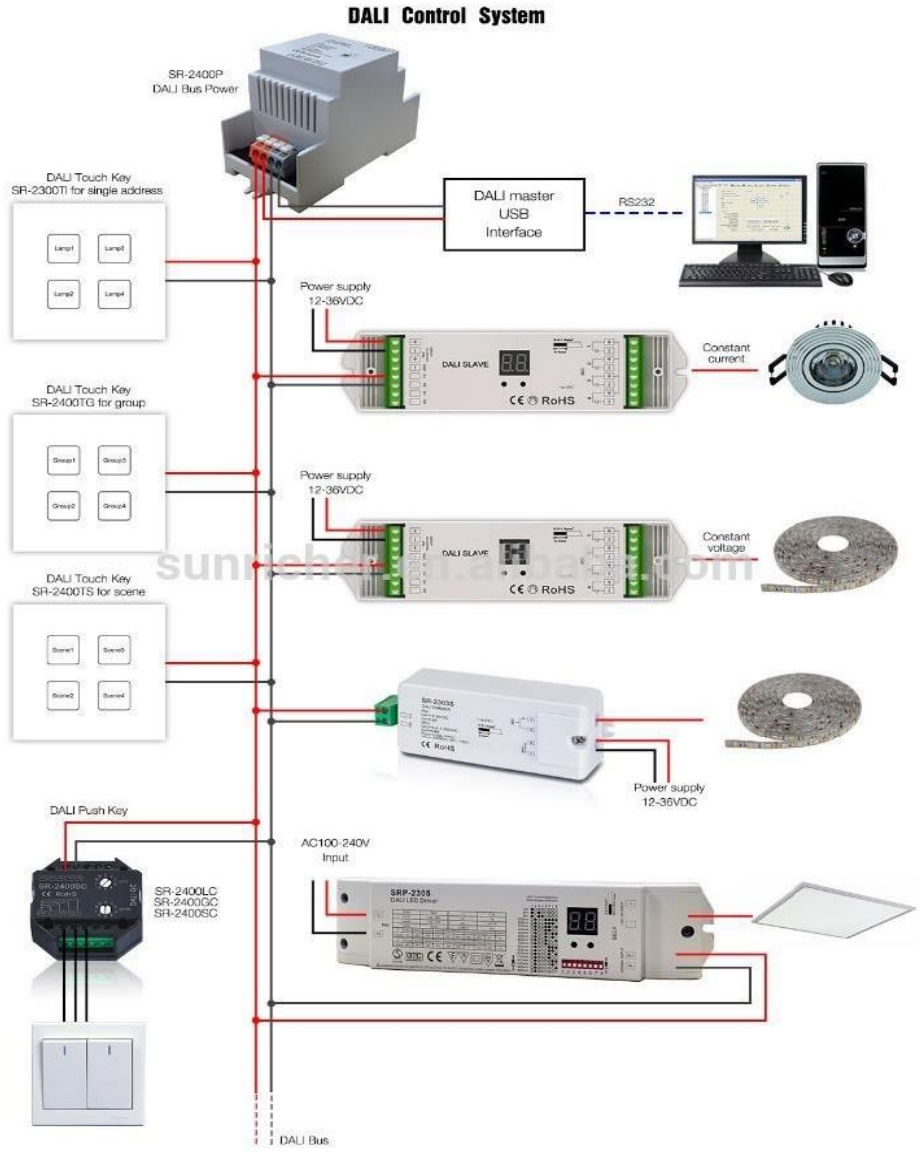
6.3. Smart Control

- KNX



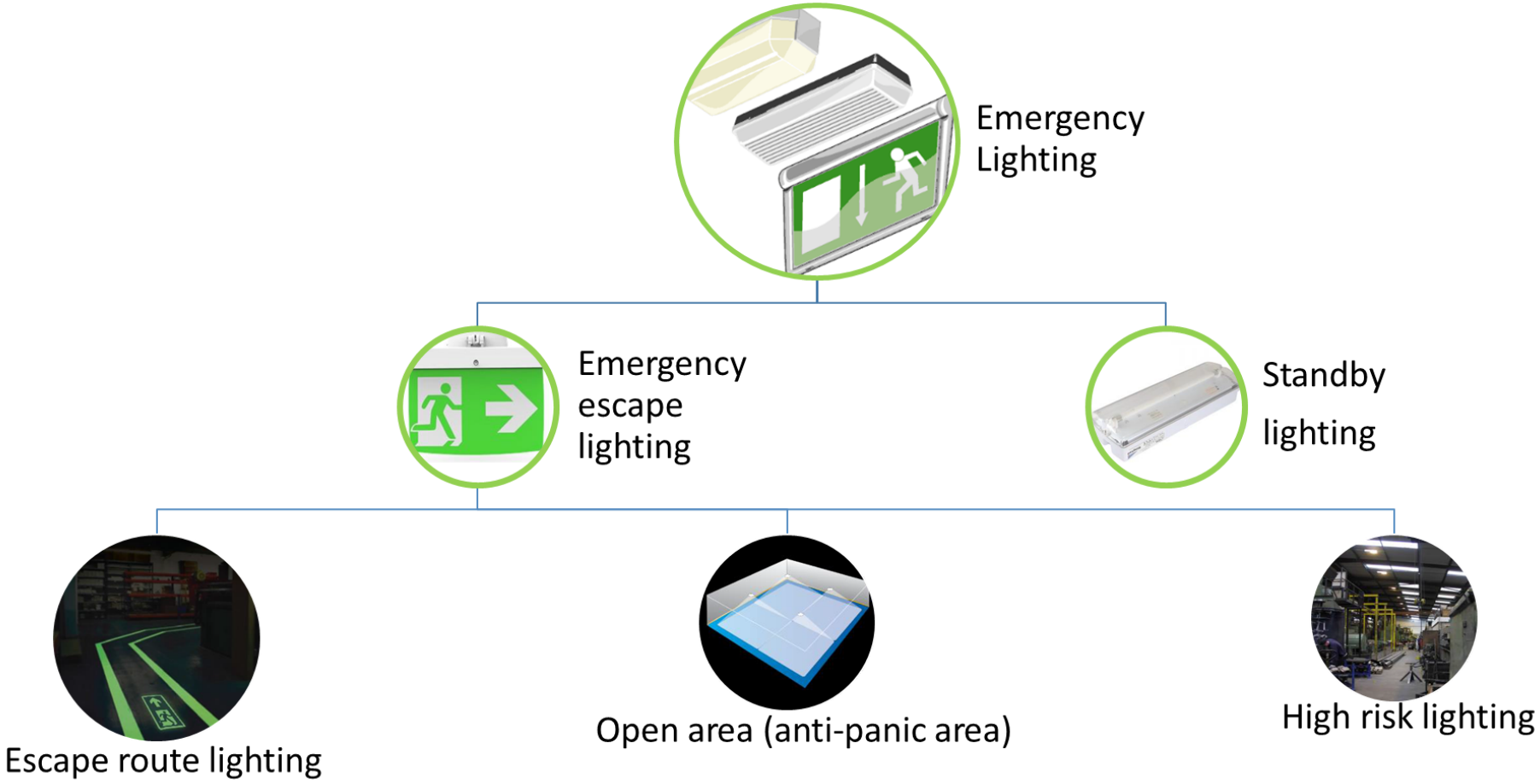
6.3. Smart Control continue,

- DALI

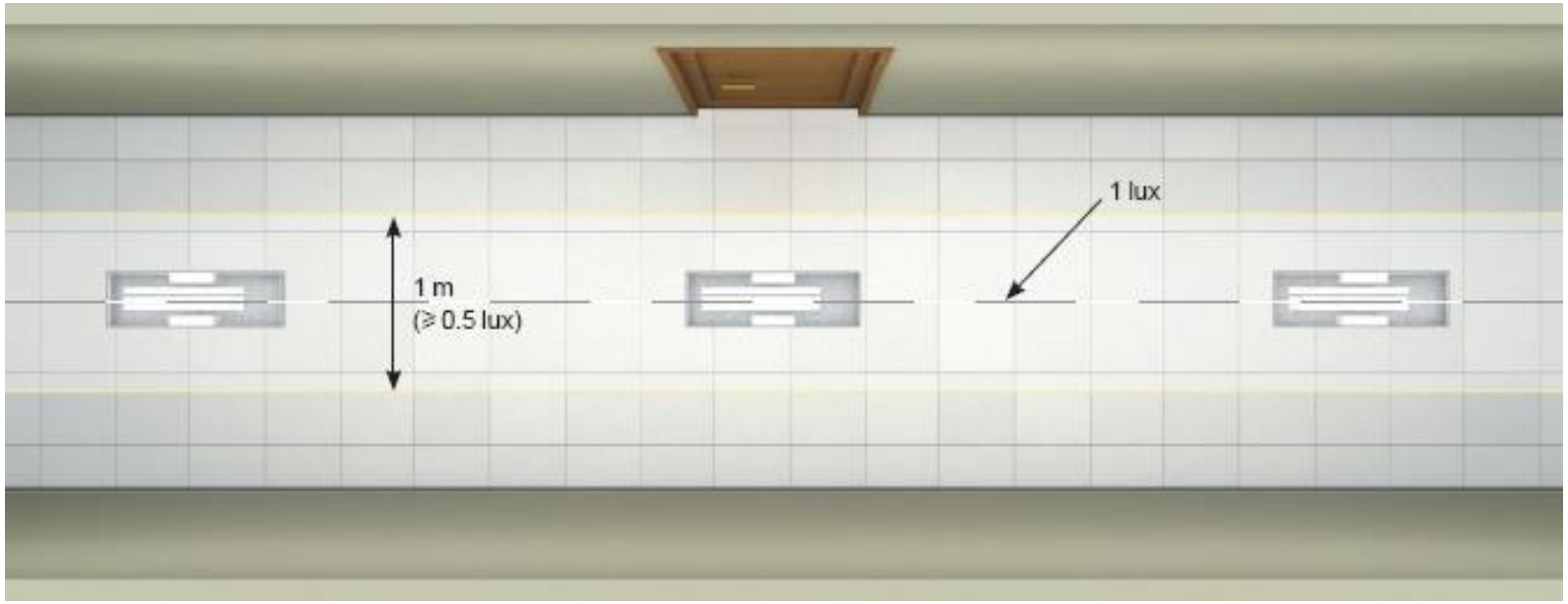


7. Emergency Lighting

Specific Forms of Emergency Lighting



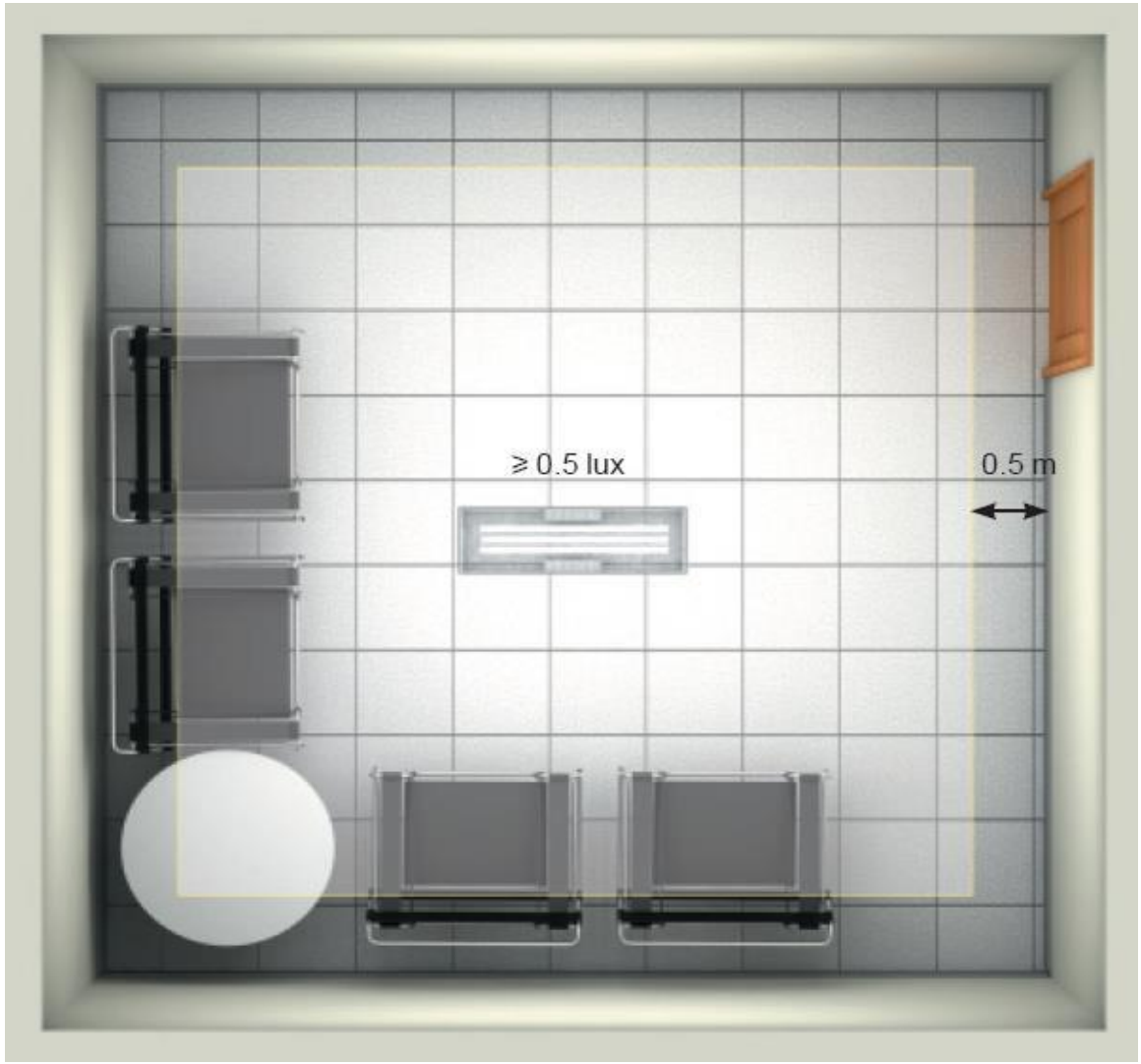
7.1. Escape Routes



- If Escape routes wider up to 2 m, luminaries must be installed to ensure a minimum level of lighting (1 lux) on the floor along the central line of the escape route.
- 50 % of the route width should be lit to a minimum of 0.5 lx.
- Uniformity > 1:40

7.2. Anti-panic Area

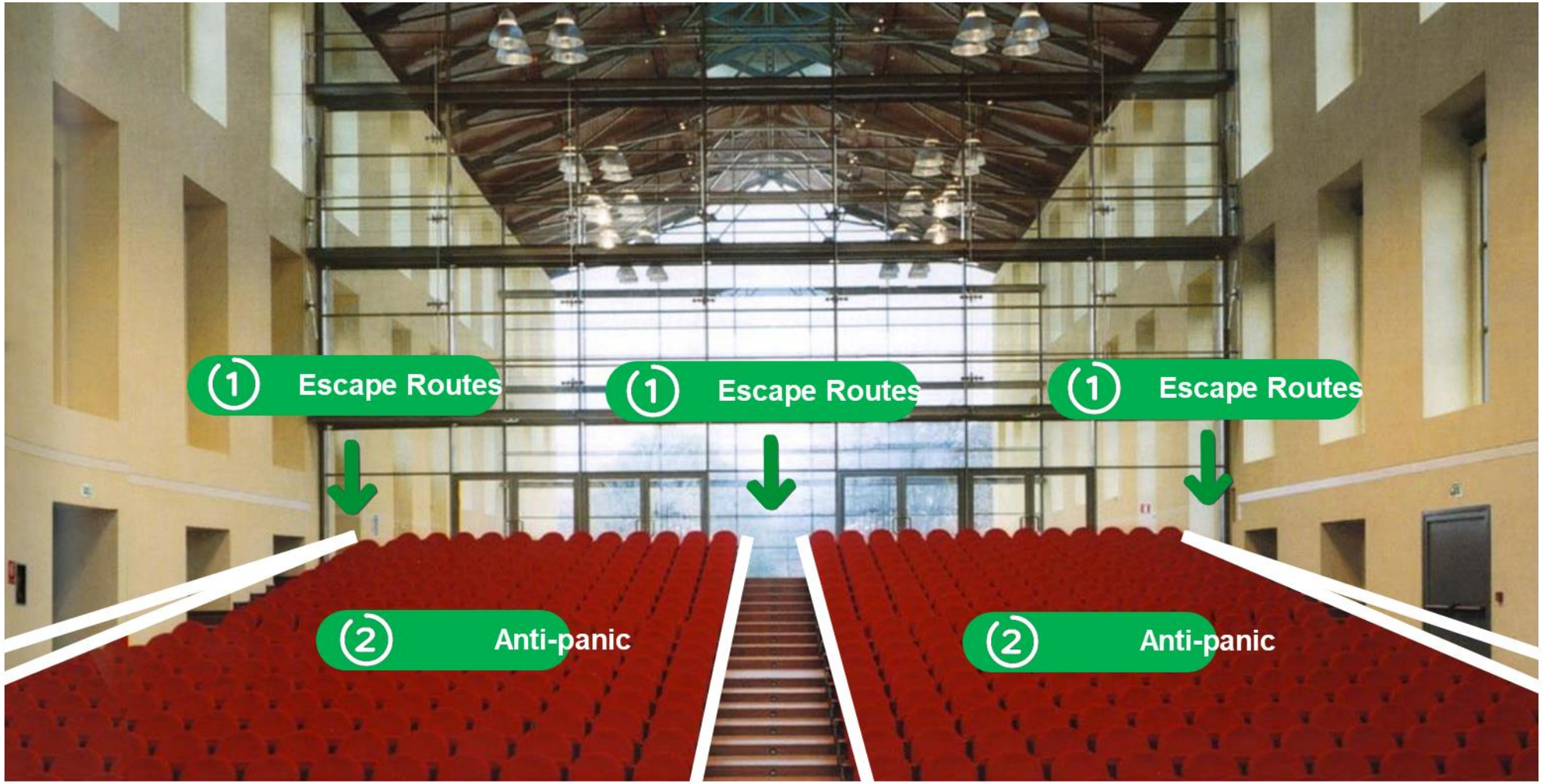
- The horizontal illumination level shall not drop below 0.5 lx.
- An 0.5 m strip next to the wall does
- not require this light level.
- Uniformity > 1:40



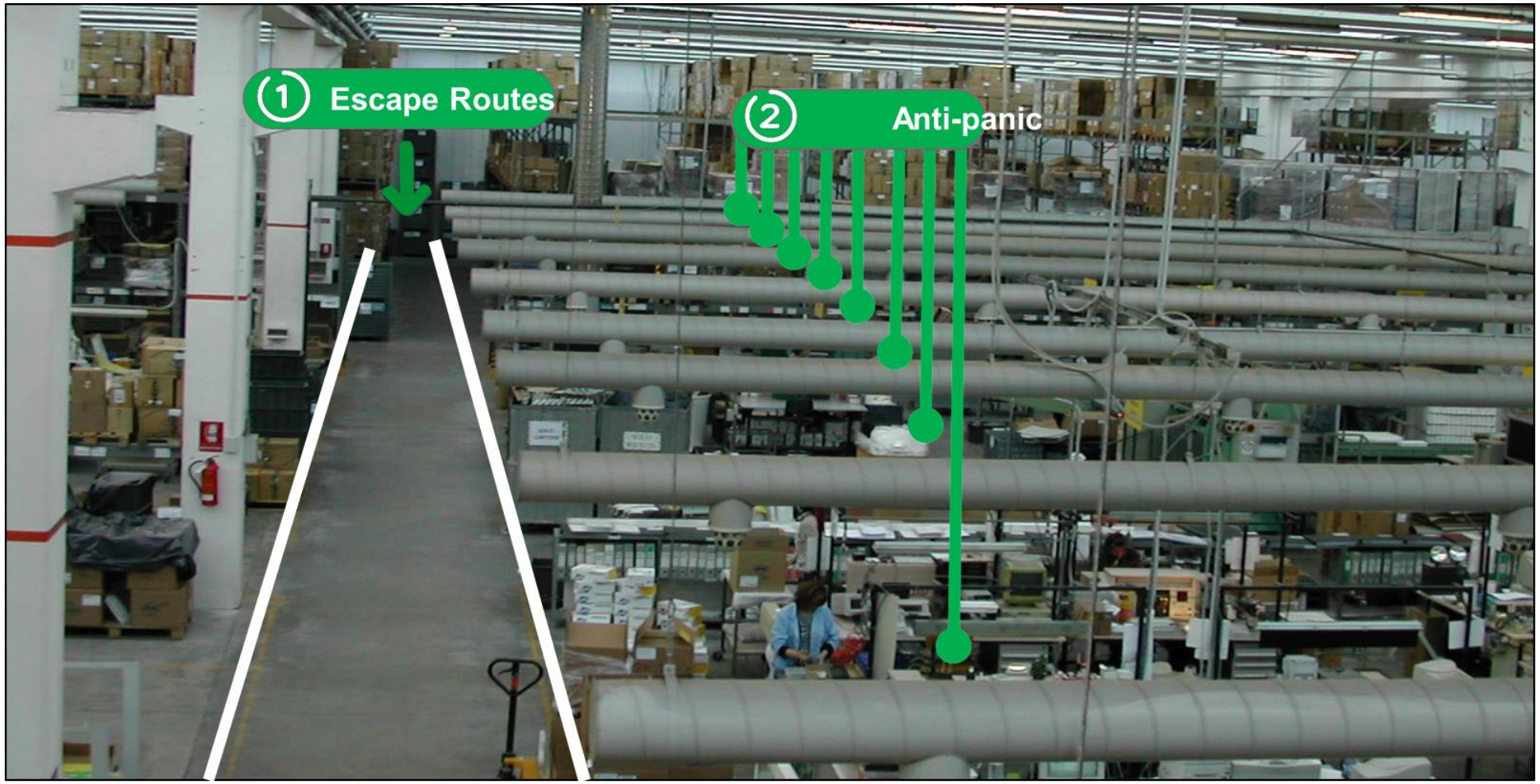
7.3. High Risk Area

- The horizontal illumination level shall not drop below 15 lux
- An 0.5 m strip next to the wall does not require this light level.

7.4. Examples


1 Escape Routes
1 Escape Routes
1 Escape Routes
2 Anti-panic
2 Anti-panic

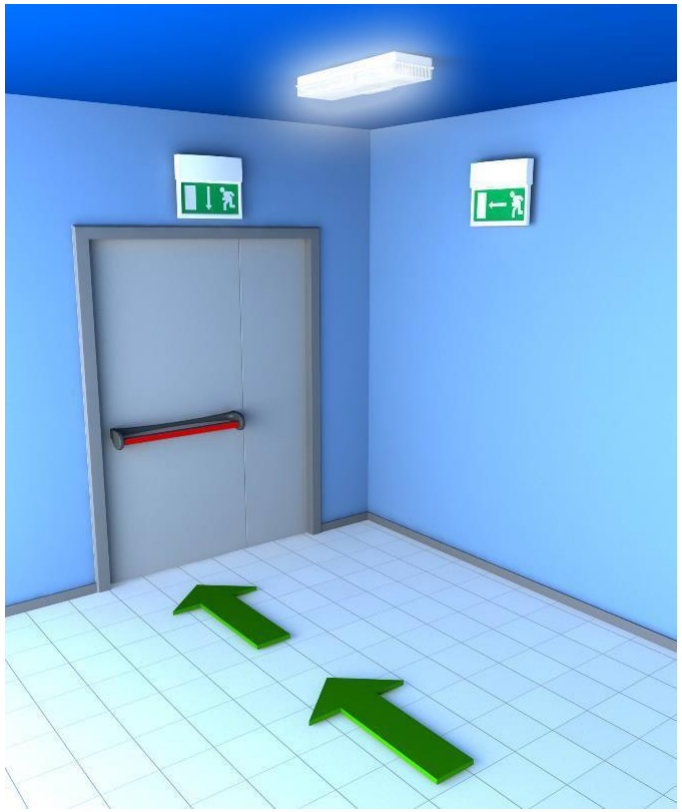
7.4. Examples continue,



7.5. Location of the Luminaires

At each Door

Signs are required whenever the direction of escape is ambiguous



Near changes of direction

7.5. Location of the Luminaires continue,

Near each
flight of stairs

At each change of floor level

Near each intersection

7.5. Location of the Luminaires continue,

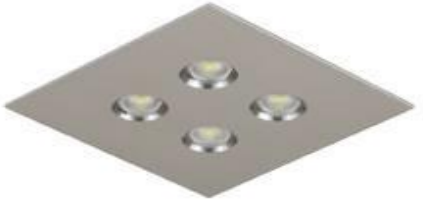
Near each Fire Alarm call point
- fire fighting equipment

Near first aid posts

Outside each final exit

7.6. Modes of Operation

- Maintained Emergency Luminaire
  - ➢luminaire is illuminated permanently (Normal or Emergency Mode).
  - ➢Exit signs.
- Non-Maintained Emergency Luminaire
  - ➢luminaire is only illuminated in emergency mode.
  - ➢SL safety lights.
  - ➢illumination of rescue ways or open area illumination.



- Switched-Non-Maintained Emergency Luminaire
  - ➢luminaire can be switched on/off in Normal mode.
  - ➢permanently on in Emergency mode.

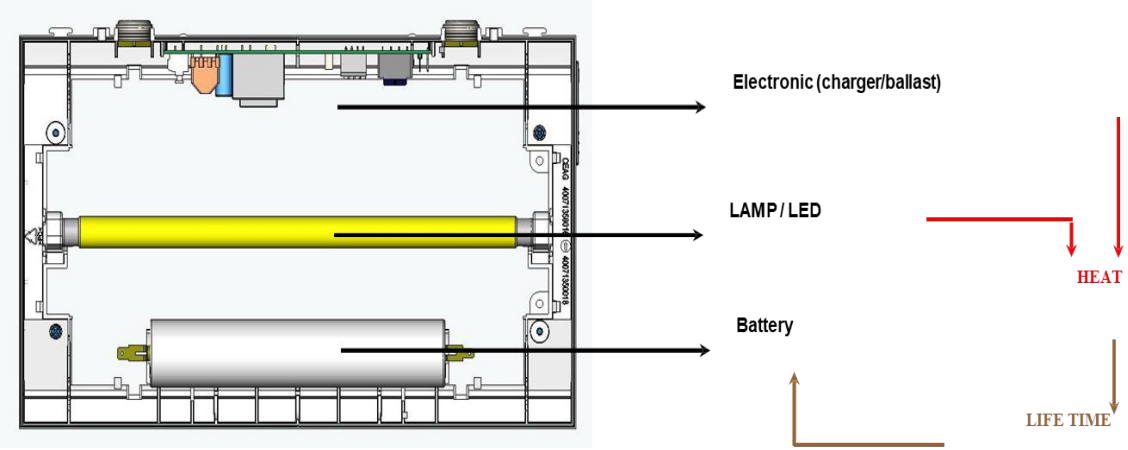
7.7. Emergency Lighting Options

Emergency Lighting **Options**

Self-Contained luminaires

Central Battery Systems

7.7.1. Self-Lighting Luminaires



- Advantages
  1. High availability
  2. Easy extension
  3. Low installation cost
  4. No fire protection necessary
  5. Low investment costs

- Disadvantages
  1. High follow-up costs caused by low battery life time (approx. 4 yrs. , often less), because the life time of 4 years refer to a surrounding temperature of 20 °C. Each advance of 10 degree reduce the life time of battery about 50 %.
  2. High test and maintenance costs due to weekly manual luminaire tests.
  3. Limited areas for use (Problem: areas with low temperature)
  4. Low Light Output……. More luminaires ….. Higher cost Individual luminaire monitoring only with additional wiring!!
  5. Start problems in areas with low temperatures, discreet battery placement in the luminaires barely possible

7.7.2. Central Battery System

- Advantages
  1. The batteries are designed for minimum 10 years as per EN 50171
  2. System is ordered for the project and will have full life from testing and commissioning of the system
  3. These Central batteries are centrally located in an air-conditioned room giving their full life which is minimum 10 years
  4. Longer durations possible
  5. No battery replacement in high ceilings.

- Disadvantages
  1. High installation cost
  2. More area is required for installation
  3. Complicated wiring

Thank you