Introduction to Lighting
(Artificial And Daylight)

Lec 8+9

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BSc Architecture Engineering

LIGHTING

- Principles
- Visual Comfort
- Design Consideration
- Sky Conditions
- Daylight Factor

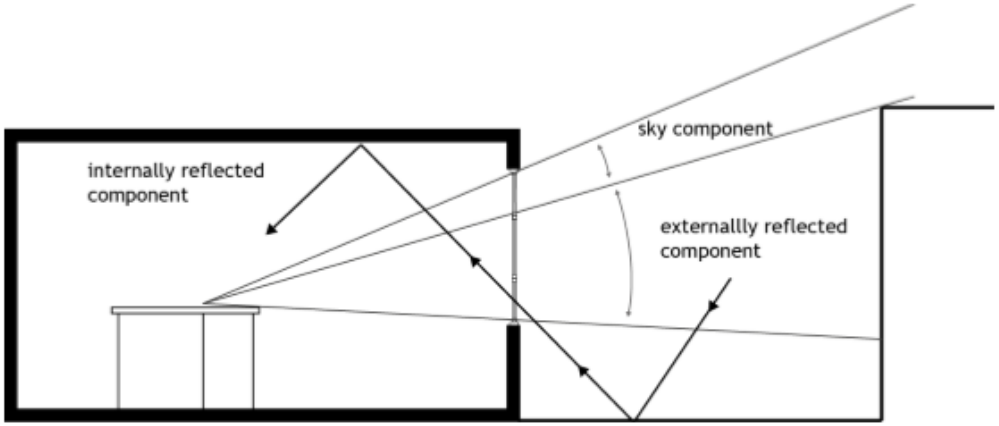
Principle

Daylight is diffuse natural light from the sky.

- It is the desirable natural light in a space.
- Daylight varies depending on sky conditions.

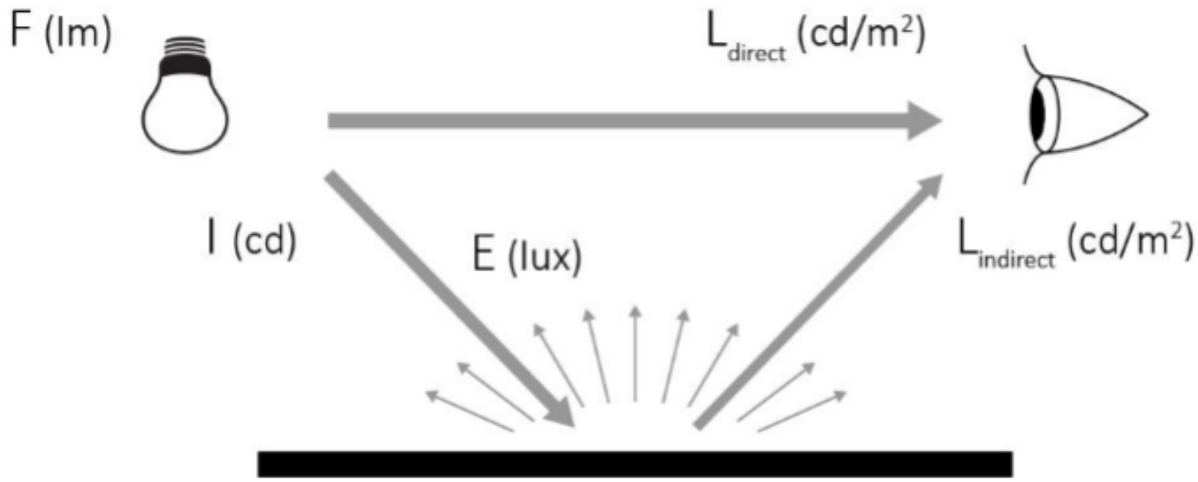
Sunlight is direct light from the sun.

- Direct sunlight can produce glare and excessive heat gain.



Principle

Measuring the light
Photometric metrics



Light flux (F): This is the rate of flow of luminous energy and is measured in **lumens (lm).**

Illuminance (E): this is the amount of light reaching a surface and is measured in lumens/m^2 or **lux**. **Or foot candle**

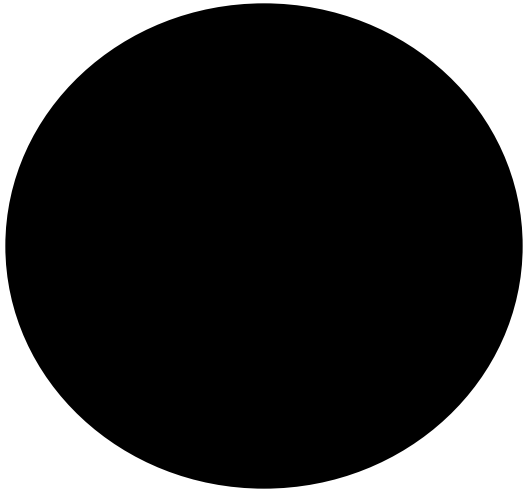
Luminance (L): this is a measure of what the eye actually sees and is related to the amount of light reflected from the surface, depending on both the surface reflectivity and the illuminance i.e. the incident light level on the surface. The unit is the **candela/m^2**.

Principle

Black body :An idealized physical body that absorbs all incident electromagnetic radiation

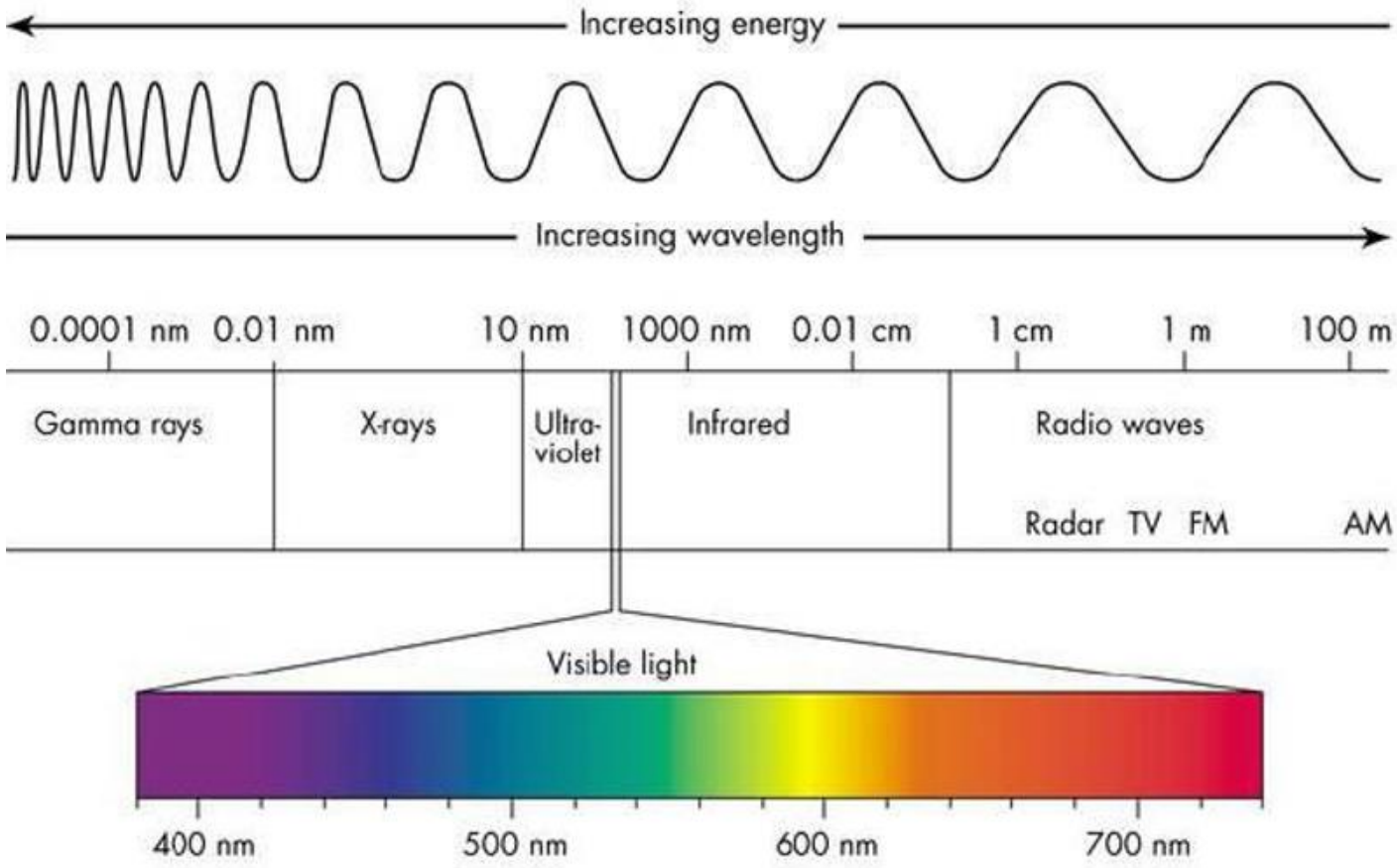
A black body in thermal equilibrium (constant temperature) emits electromagnetic radiation called black body radiation

The spectrum of emitter radiation is determined by the temperature alone



Principle

With increase in temperature, radiation with increasingly smaller wavelengths are emitted



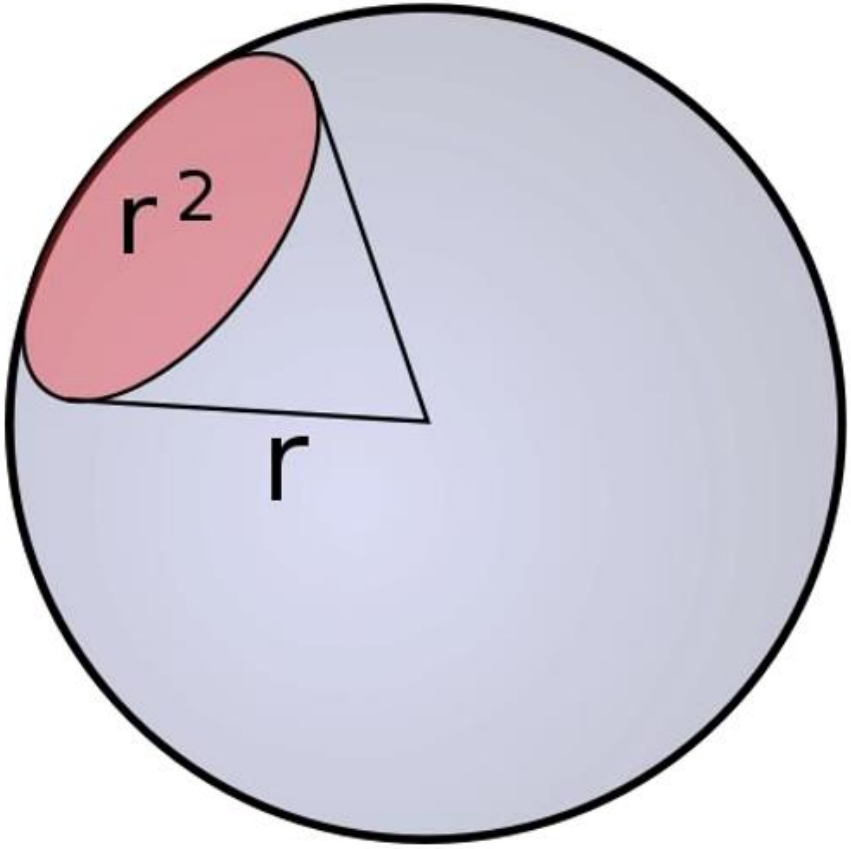
Principle

The color of a light source is the temperature of an ideal black body radiator that radiates the light of comparable hue to that of the light

Principle

Steradian:

Steradian is defined as the angle subtended at the center of a sphere by a part of its surface having an area equal to (radius)^2



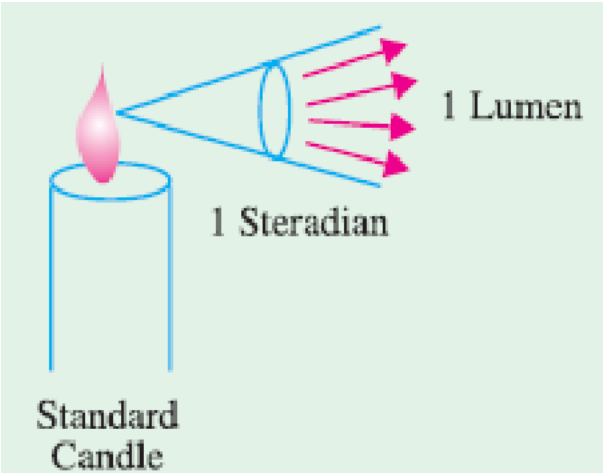
Principle

Candela:
The unit of luminous intensity of a light source. A source of one candela (cd) emits one lumen per steradian.

Luminous Flux: It is the light energy radiated out per second from the body in the form of luminous light waves.

Defined as flux contained per unit solid angle of the source of one candela or standard candle.

Unit of luminous flux is Lumen (lm)



Principle

The most common measure of light output (or luminous flux) is the lumen

Light sources are labeled with an output rating in lumens

As lamps and fixtures age and become dirty , their lumen output decreases. (Lumen depreciation)

Most lamps ratings are based on initial lumens

(i-e when the lamp has been operated for 100 hours)

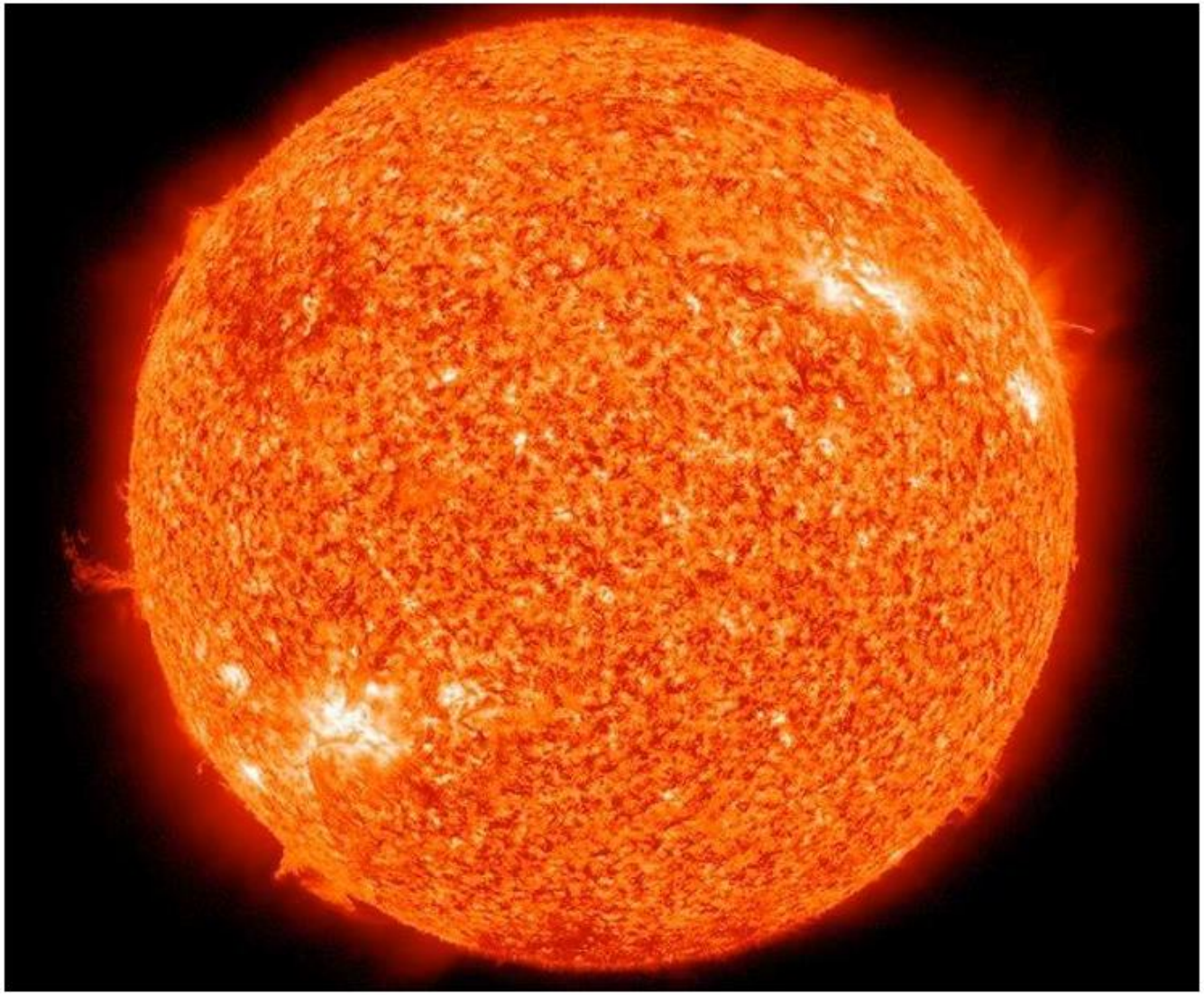
- The color rendering index (CRI), sometimes called color rendition index, is a quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source

0 to 100

CRI=90 CRI=70 CRI=50

Principle

Light Source

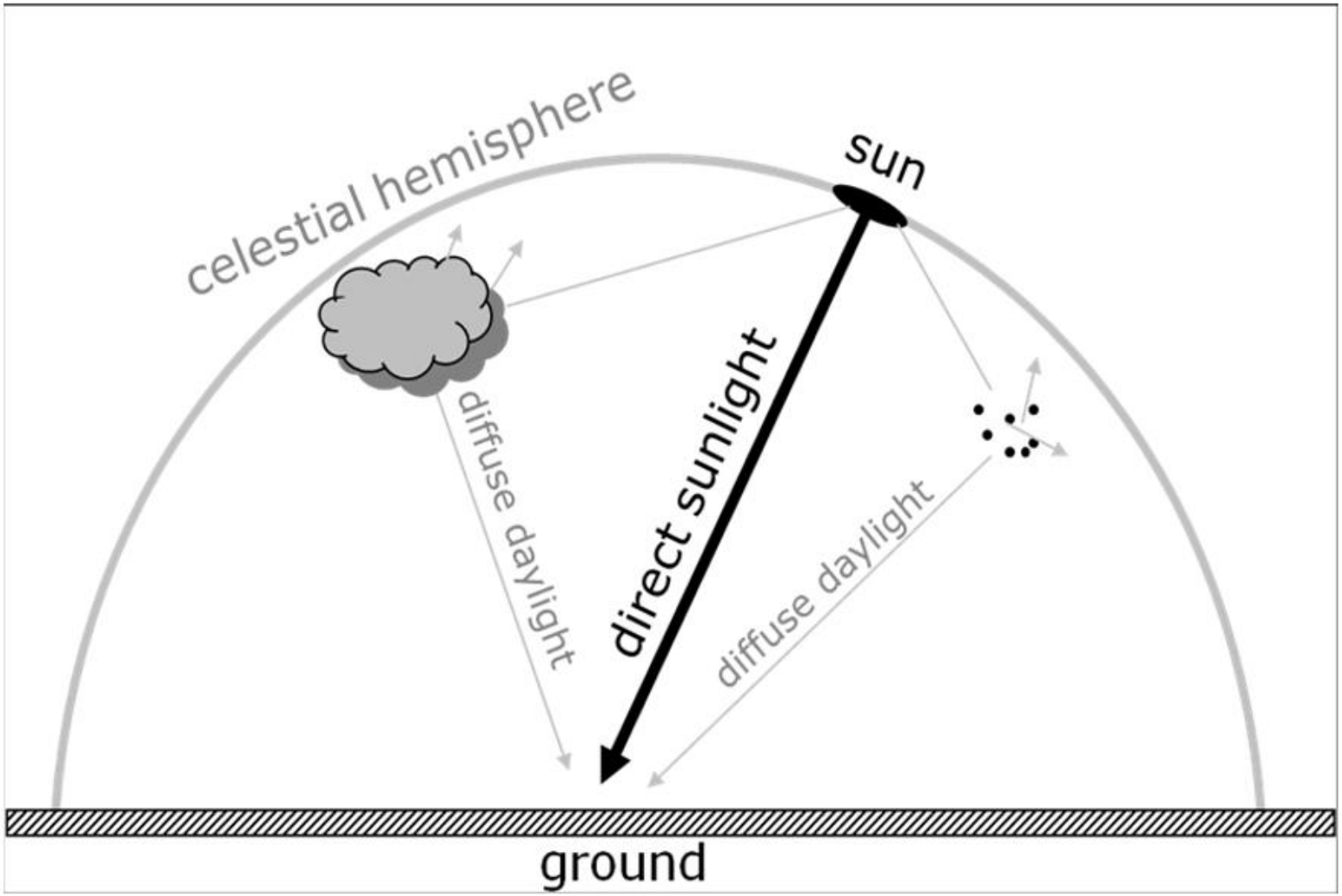


The Sun

150 million km away; diameter of 1.4 million km; surface temperature of 5800 K

Principle

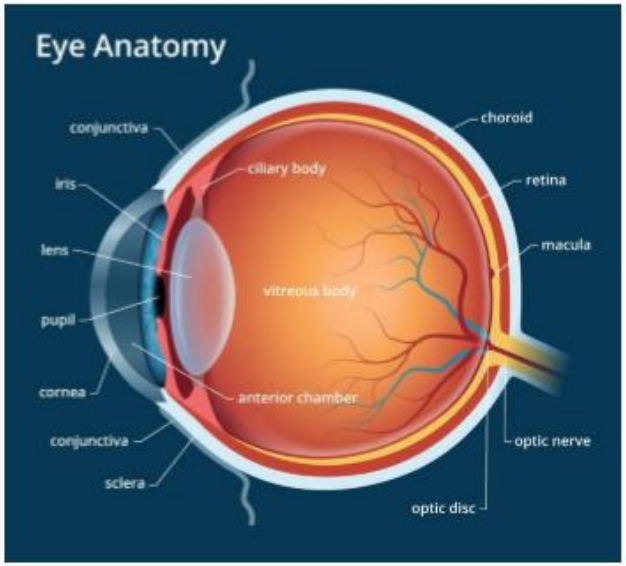
Light Source

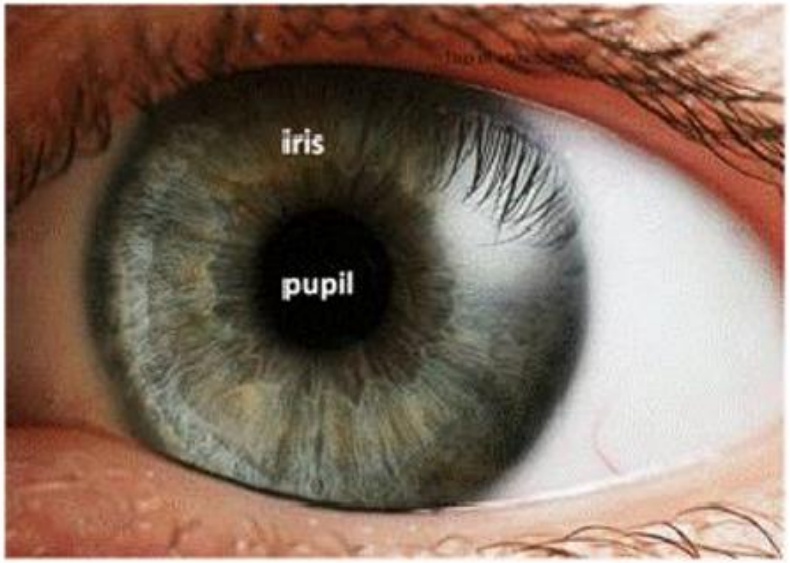


Source: https://ocw.mit.edu/courses/architecture/4-430-daylighting-spring-2012/lecture-notes/MIT4_430S12_lec02.pdf

Principle

Our receptor





Retina has three types of photoreceptors: Cones, Rodsand and Ganglion Cells

Source: Google

Principle

Our receptor

Day and Night Vision

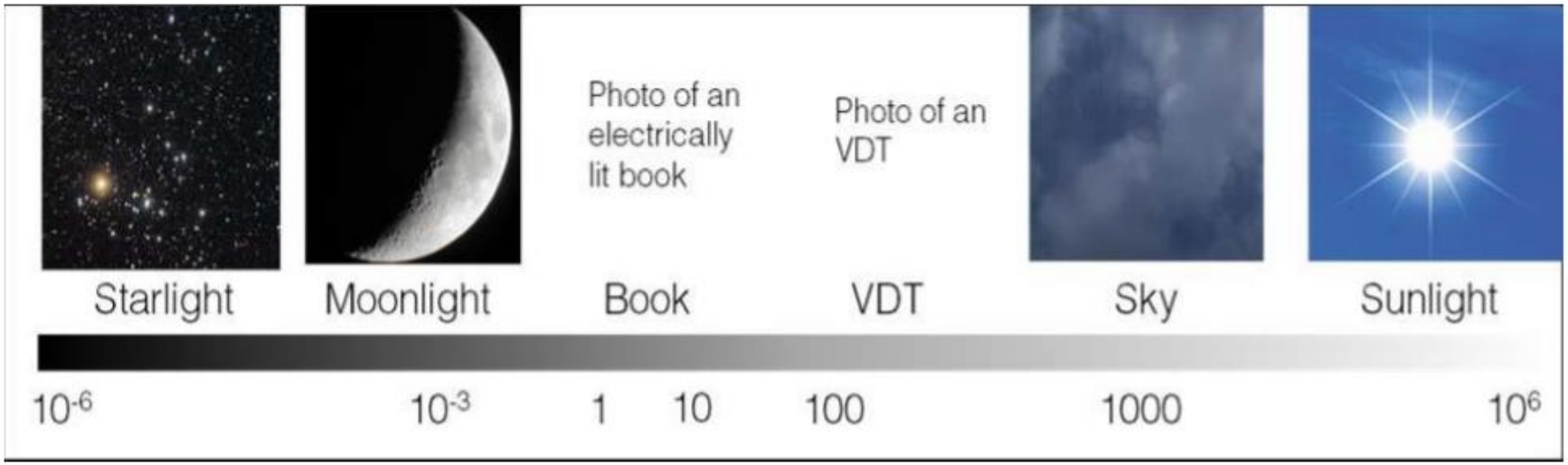
Photopic(Day time Vision): The cones of the eye are of three different types representing the three primary colors, red, green and blue (>3 cd/m2).

Scotopic(Night Vision): The rods are responsible for night and peripheral vision (< 0.001 cd/m2).

Mesopic(Dim Light Vision): occurs when the light levels are low but one can still see color (between 0.001 and 3 cd/m2.

Principle

Eye Adaptability



- The human eye can see across twelve orders of magnitude.
- We can adapt to about 10 orders of magnitude at a time via the iris.
- Larger ranges take time and require 'neural adaptation'.

Visual Comfort

Why is visual comfort essential in any environment?

- enables the occupant to work and move about in safety.
- enables tasks to be performed correctly and at an appropriate pace.
- creates a pleasing appearance.

What do designers need to consider to provide good daylight?

quantity

- **Illuminance** or the amount of light reaching a surface.
- Distribution of light.
- control sunlight penetration, in order to prevent unwanted solar gains

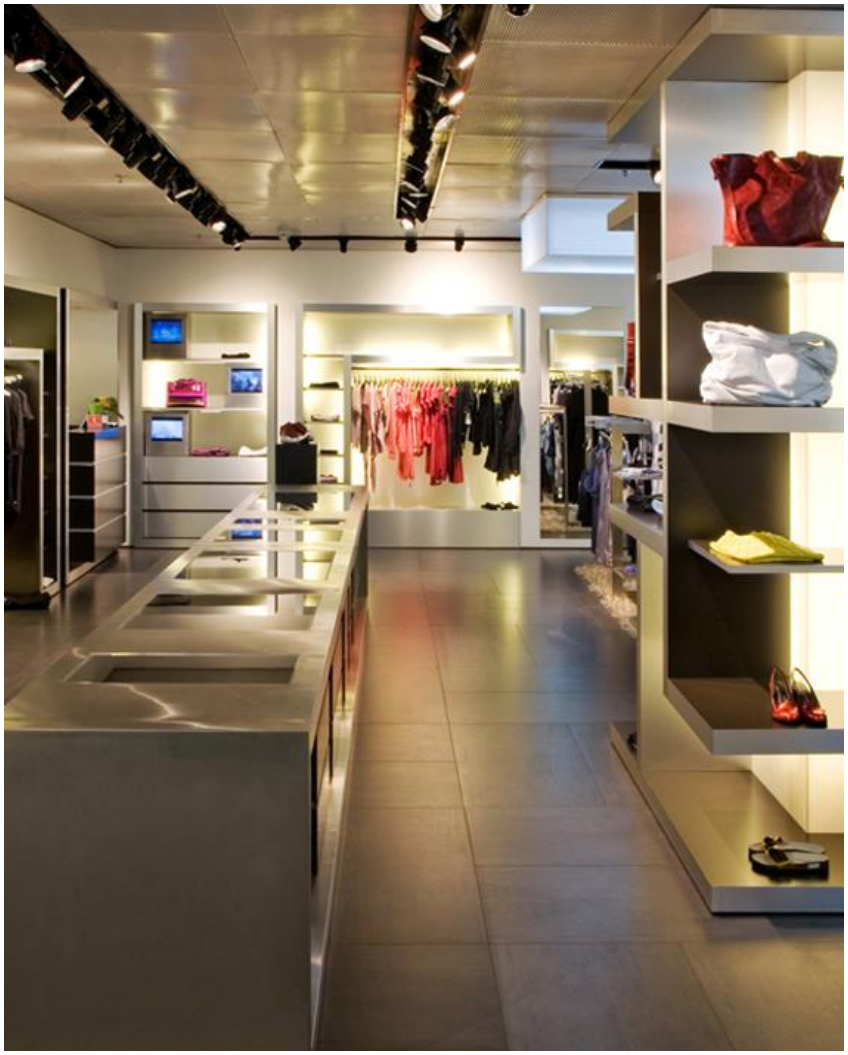
quality

- Colour
- Contrast
- **Glare**

Visual Comfort

CONTRAST

Visual Comfort



GLARE

Assignment

- Since you all are home bound, so take some time and roam around in your house. Take images of the areas which depict the following
- Contrast
- Glare

Note: This must be uploaded on Google classroom by Thursday 26th , 2020 (8:00 Pm)

Design Considerations

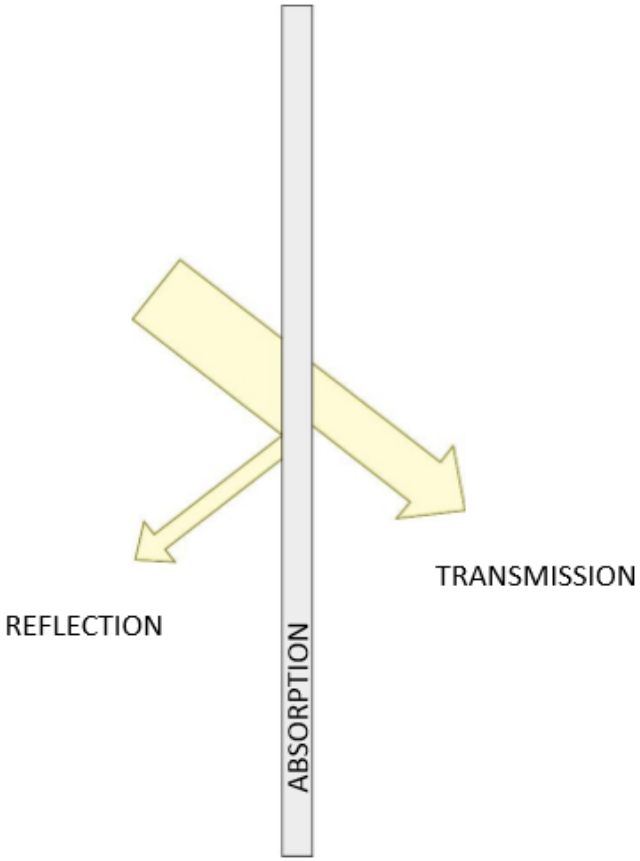
Recommended lighting design criteria:

Building/room type	Maintained Illuminance (lux) at the appropriate working plane or height	Notes
Dwellings		
— bathrooms	150	
— bedrooms	100	Study bedrooms require 150 lux at desk
— halls, stairs	100	
— kitchen	150–300	
— living rooms	50–300	
Offices		
— conference/boardrooms	300–500	
— computer rooms	500	
— corridors	100	
— drawing office	750	
— entrance halls/lobbies	200	
— general office space	300–500	
— open plan	300–500	
— toilets	200	
Retail		
— department stores	300 for circulation areas	Note: higher lighting levels will be required at checkouts and tills and for display lighting
— small shops	300 for circulation areas	
— supermarkets	400 for circulation areas	
— shopping malls	50–300	
Schools		
— teaching spaces	300	

For design purposes please refer to the full table given in CIBSE Guide A.

Design Consideration

Glazing - light transmittance

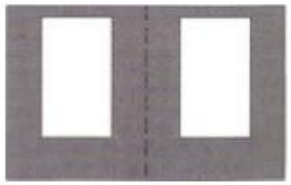


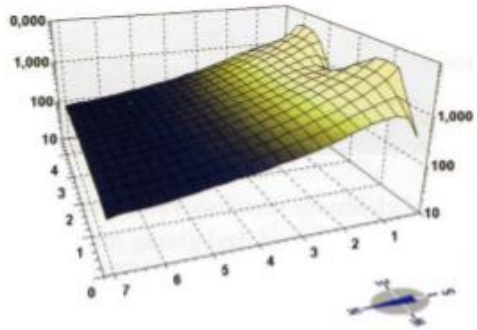
Typical values for clear 6 mm glass:

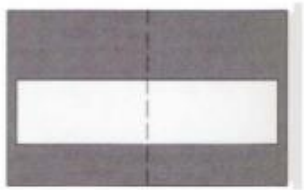
- Reflectance: 0. 1
- Absorptance: 0.05
- Transmittance: **0.85**

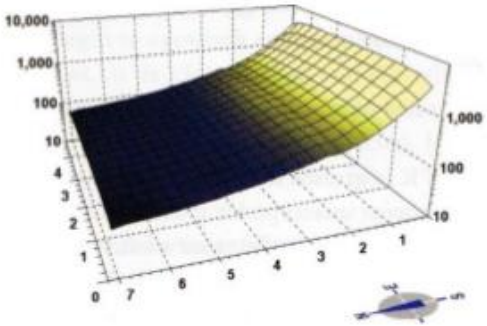
Design Consideration

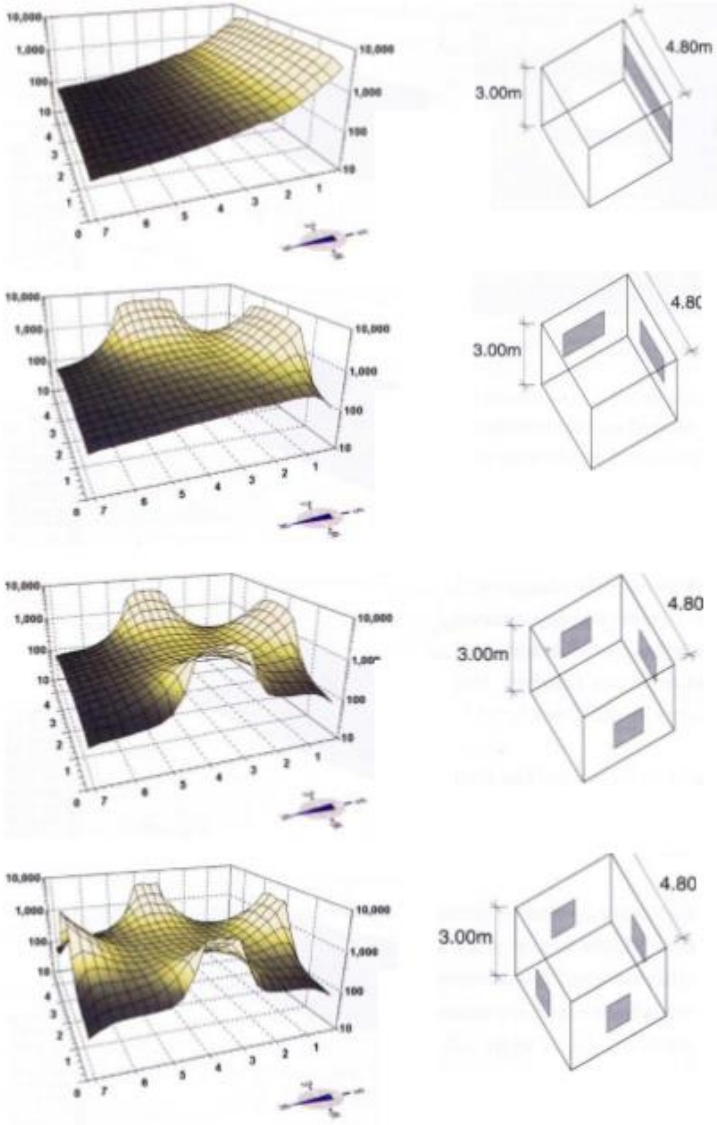
Window design











Baker, N. and K. Steemers (2002). ***Daylight Design of Buildings.*** *James & James Science Publishers.*

Design Consideration

What is **daylight factor**?

Ratio of the illuminance at a point on a given plane due to the light received directly or indirectly from a sky of assumed or known luminance distribution, to the illuminance on a horizontal plane due to an unobstructed hemisphere of this sky. The contribution of direct sunlight to both illuminances is excluded.

Baker, N. and K. Steemers (2002). ***Daylight Design of Buildings.*** *James & James Science Publishers.*

- In simple terms: the percentage of outside light that reaches the given point inside.
- Expressed in **%**.
- **Was created to be applied ONLY with a CIE overcast sky.**
- **Requires complimentary information regarding the (diffuse) sky illuminance.**

LIGHTING CALCULATIONS

Lighting Calculation

1. **The following have to be considered:**

- Task(s) being performed (contrast, size, etc.)
- Ages of the occupants
- Importance of speed and accuracy

2. No of Luminaires May be selected considering

- Fixture efficiency
- Lamp lumen output
- Reflectance of surrounding surfaces
- Effects of light losses from lamp lumen depreciation and dirt accumulation
- Room size and shape
- Availability of natural light *(daylight)*


the figurative point of view

Highlighting

- In an art gallery, the illuminance (light intensity) on a painting needs to be 480 lux more than its surroundings.
- The size of the painting is 100 x 50 cm.
- LED spot lights, having efficacy of 60 lm/W are used.
- Calculate the electric power required for the lights.

Luminous efficacy is a measurement commonly used in the lighting industry that indicates the ability of a light source to emit visible light using a given amount of power. It is a ratio of the visible energy emitted to the power that goes into the bulb from the electrical line (visible energy emitted is also known as luminous flux, and the units are measured in lumens). Note: in some countries, luminous efficiency is substituted for luminous efficacy. Luminous efficiency, however, is a unit less measure (watts out / watts in) where luminous efficacy is not (lumens out / watts in).

Solution

- Lumins = Illuminated Area x Lux

  1 x 0.5 x 480 = 240 lm

- Power = Lumins / Efficacy

  240 / 60 = 4 W

Working Areas

- Uniform lighting, no dark spots
- Comfortable light conditions
- Light must be reflected from work pieces, not directly towards people.
- No shadows, light sources spread out in size, number

Lighting in Work Area

- In a factory floor, 250 lux light intensity is required.
- The floor area is 20 x 35 m and only half the light from the ceiling gets to the work benches.
- Calculate the number of tube lights required, if each has efficacy 70 and power 50 W.

Solution

- Lumins = Illuminated Area x Lux

  20 x 35 x 250 = 175,000 lm
- Power = Lumins / Efficacy

  75,000 / 70 = 2,500 W
- We need twice this power, 5,000 W
- 5,000 / 50 = 100 tubelights