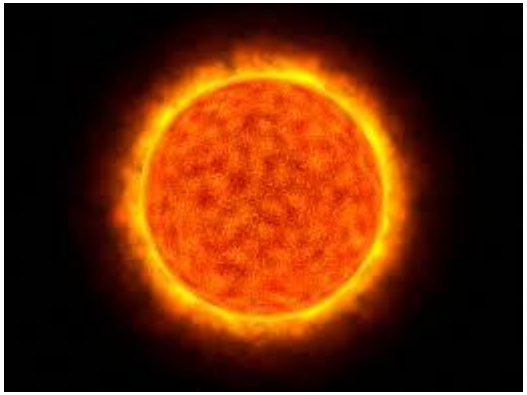
Light Sources

In the beginning God created the Heaven and the Earth. And then He said, “Let there be light”, and there was light. And the light came from the sun and for ten thousands of years the sun was the only light source known to man.

Light Sources

- Light source emits electromagnetic radiation in the visible spectrum.
- Two major sources are
  - Natural sources
  - Artificial sources



Natural Sources

- Astronomical objects
  - Sun
  - Stars
- Lightning
- Bioluminescence
- Volcanic

Natural Sources

- Direct chemical
  - Chemoluminescence - emission of light as the result of a chemical reaction
  - Fluorescence - emission of light by a substance that has absorbed light
  - Phosphorescence - absorbed radiation will be re-emitted at a lower intensity for up to several hours.

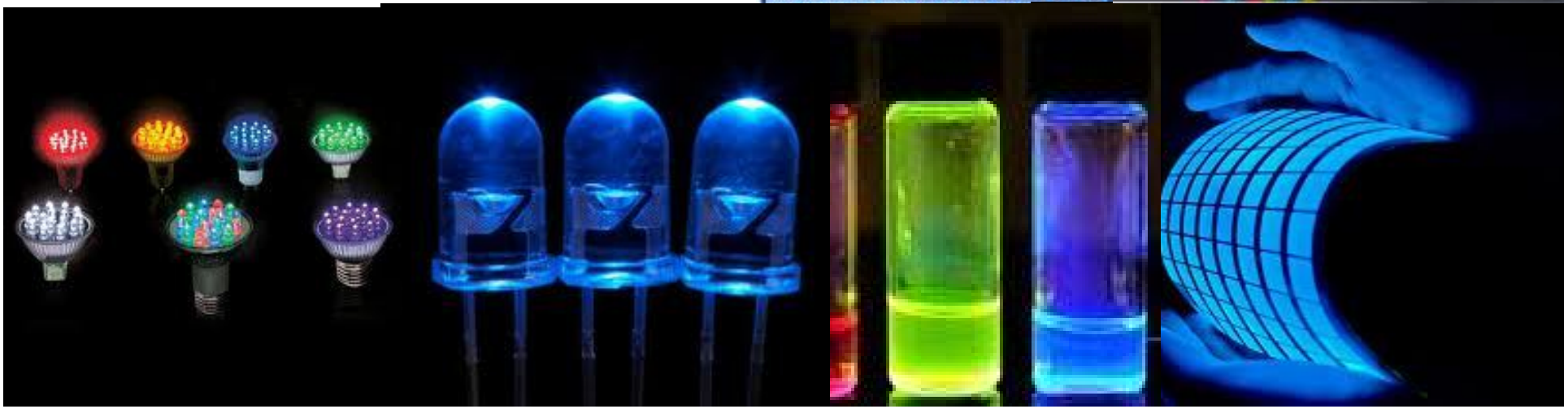
Artificial sources

- Non – electrically powered
  - Candles
  - Flash powder
  - Gas mantle
  - Lanterns
  - Kerosene lamps
  - Oil lamps

Electrically powered sources

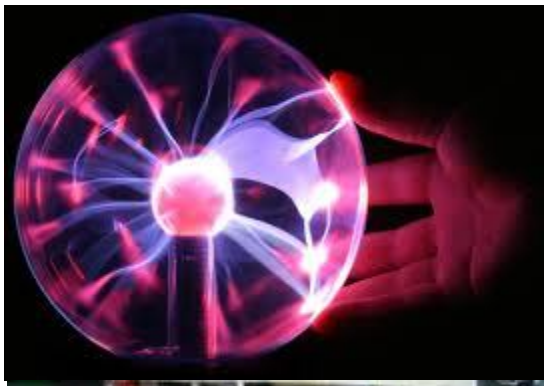
- Cathode ray tube (CRT monitor)
- Nixie tube
- Incandescent lamps
  - Incandescent light bulbs
  - Halogen lamps

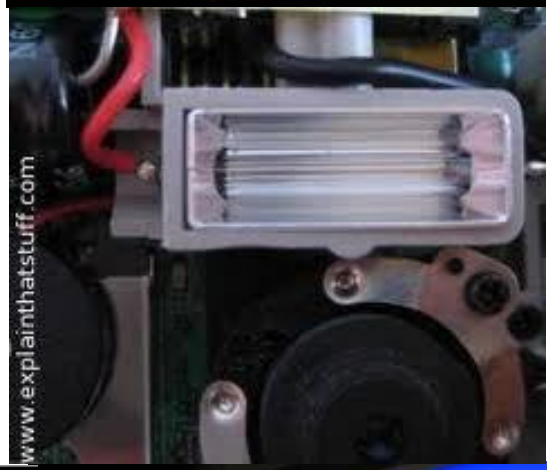
- Electroluminescent (EL) lamps
  - Light-emitting diodes
    - Organic light-emitting diodes
    - Polymer light-emitting diodes
    - Solid-state lighting
    - LED lamp
  - Liquid Crystal Display
  - Electroluminescent sheets
  - Electroluminescent wires

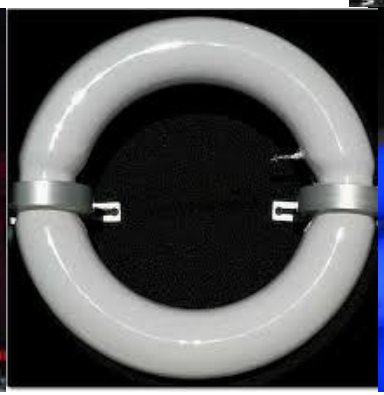


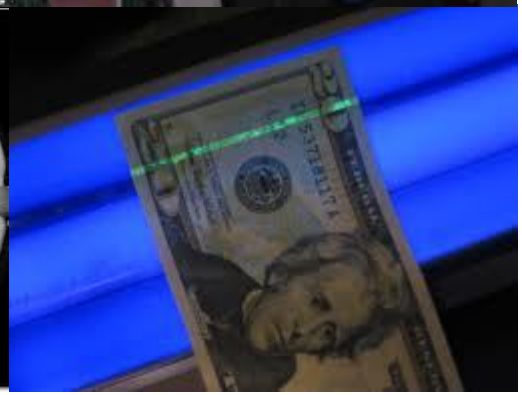
Electrically powered sources

- **Gas discharge lamps**
  - Fluorescent lamps
    - Compact fluorescent lamps
    - Black light
  - Induction lighting
  - Neon and argon lamps
  - Plasma lamps
  - Xenon flash lamps



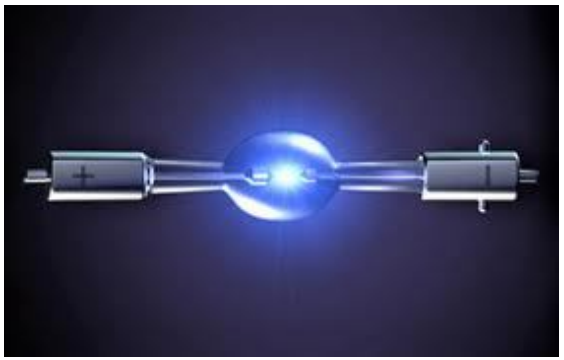






High-intensity discharge lamps

- Carbon arc lamps
- Mercury-vapor lamps
- Sodium vapor lamps
- Xenon arc lamps



Sources

- Day light
- Incandescent
- Electric discharge
- Fluorescent
- Arc lamps
- Lasers
- Neon signs
- LED-LCD displays

Daylight

- Energy of color temperature about 6,500 Kelvin is received from the sun at the outside of the earth's atmosphere at an average rate of about 0. 135 watt per square centimeter.
- About 75 per cent of this energy is transmitted to the earth's surface at sea level (equator) on a clear day.
- The apparent brightness of the sun is approximately 160,000 candles per square centimeter viewed from sea level.
- Illumination of the earth's surface by the sun may be as high as 10,000 footcandles and on cloudy days the illumination drops to less than 1,000 footcandles.

Sky light

- A considerable amount of light is scattered in all directions by the earth's atmosphere.
- The atmosphere is the mixture of gas molecules like nitrogen (78%), oxygen (21%), argon and water (in the form of vapor, droplets and ice crystals).
- There are also small amounts of other gases, plus many small solid particles, like dust, soot and ashes, pollen, and salt from the oceans.

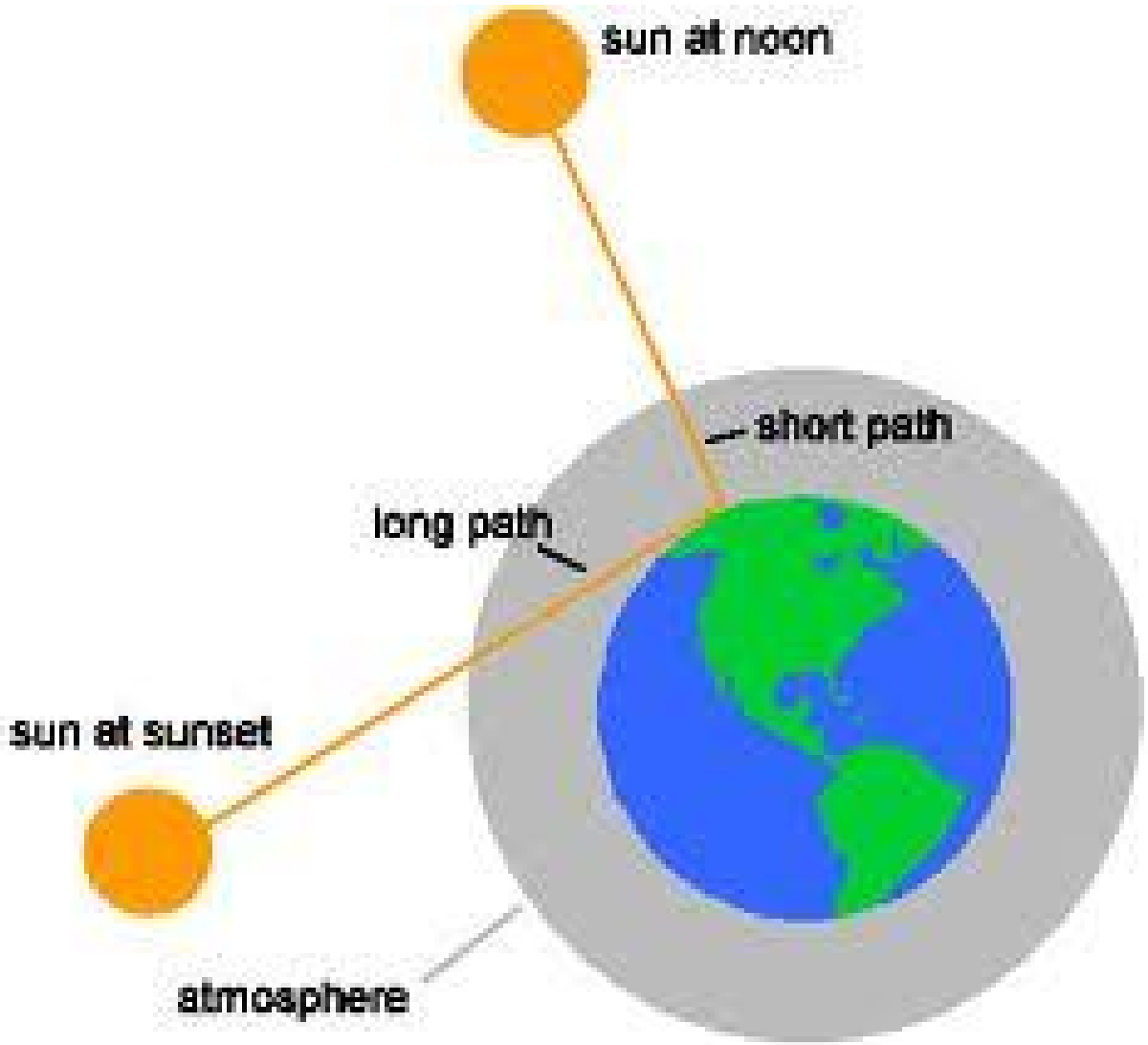
Why sky is blue colour in day time?

- Gas molecules are smaller than the wavelength of visible light.
- So if light bumps into them, some of it may get absorbed and after awhile, the molecule radiates (releases, or gives off) the light in a different direction.
- All of the colors can be absorbed. But the higher frequencies (blues) are absorbed more often than the lower frequencies (reds). This process is called Rayleigh scattering.


"White" light from the sun is composed of all the colors of the rainbow
Other colors continue more or less unimpeded to the surface
More than 20 miles above Earth the sky is black
Around 18 miles up light encounters air molecules that scatter blue light until it's coming from all parts of the sky

Why sky is in red colour during sunset?

- As the sun begins to set, the light must travel farther through the atmosphere before it gets to you.
- As more of the light is reflected and scattered, less reaches you directly. So the sun appears less bright.
- The color of the sun itself appears to change, first to orange and then to red.
- This is because even more of the short wavelength blues and greens are now scattered. Only the longer wavelengths are left in the direct beam that reaches your eyes.

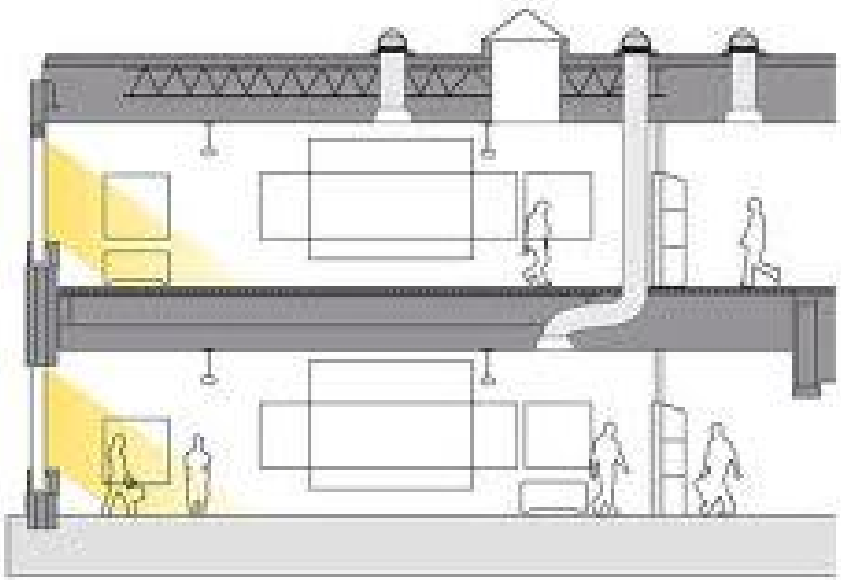

sun at noon
short path
long path
sun at sunset
atmosphere

Use of day light

- In 1879, Thomas Alva Edison discovered first electric light.
- Upto 1973, when industrialized nations were shaken by the oil price hike, electric lights were used.
- Usage of daylight gained importance after that as a supplement or replacement to electric lights.
- It provides us with vital boosts of vitamin D and serotonin, the levels of which affect our moods and general enjoyment of life.
- Two ways
  - Side lighting – through apertures in the walls
  - Top lighting – through apertures in ceiling

Use of day light

- External mirrors or Light shelves to reflect light deeper into the room.
- Fins and shading devices to prevent excessive glares.
- Fiber optics and hollow pipes with highly reflective interior surfaces for top lighting.



Disadvantages

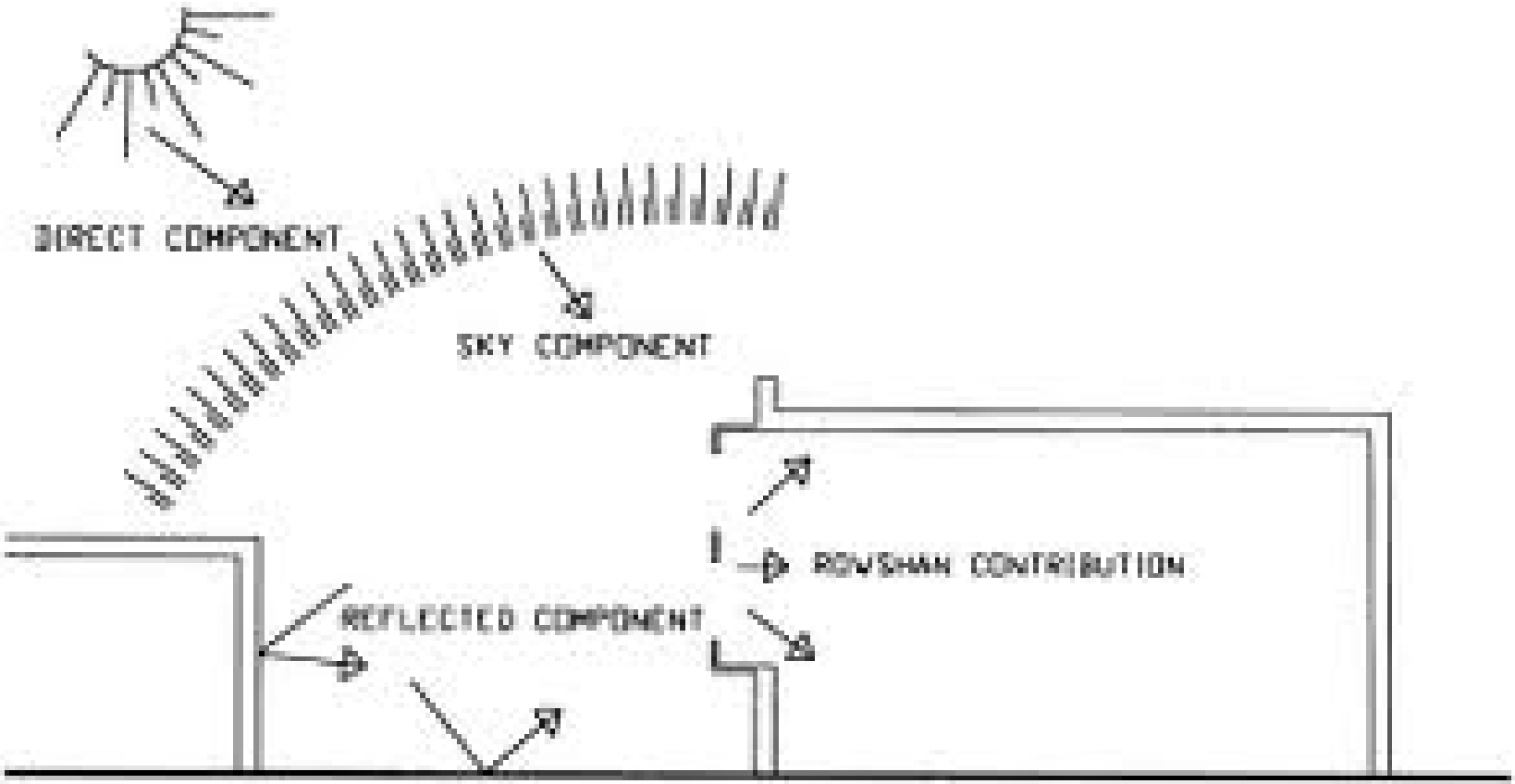
- High design and construction costs.
- Requires correct light distribution and glare control capabilities
- Sun being a dynamic light source changes its intensity, colour and direction.

- The solution to these problems is Skylighting.

Sky lights

- Skylights are horizontal windows or domes placed at the roof of buildings, often used for daylighting which acts as the fixture.
- Light sources in skylighting are the sun and the sky.
- The sun is considered a point source of light and it is highly directional.
- Light from the sky arrives from a large area and is more or less scattered and arriving from all directions.
- Beam light will cast a shadow; diffuse light will not cast a distinct shadow.
- Physical properties are the intensity, the color and the extent to which the light is scattered or diffused.

Three components of daylight



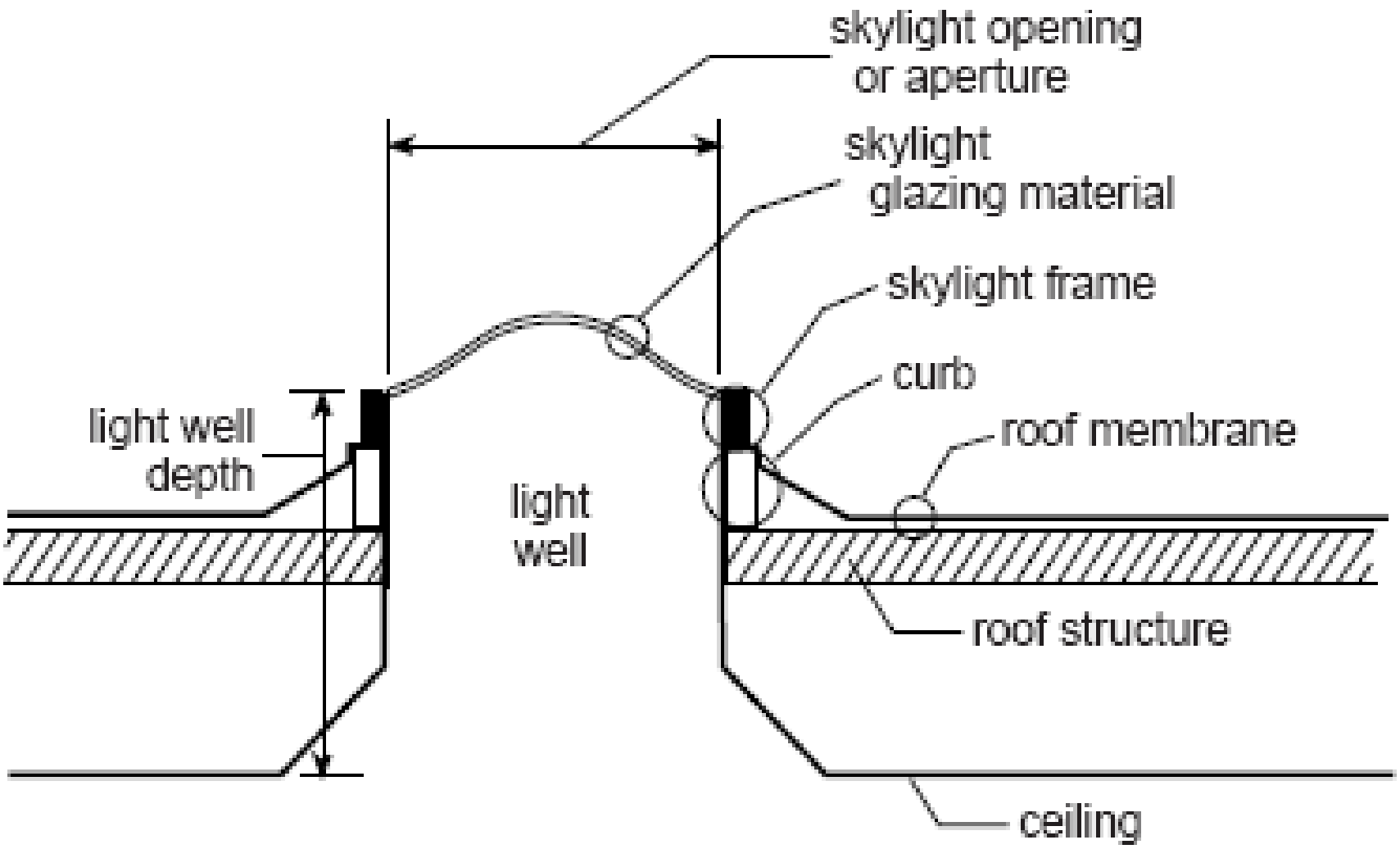
Availability of day light

- The intensity of sunlight varies with time of year and location on the planet.
- The brightness of cloudy skies depends largely on how thick the clouds are.
- The daylight on a day with complete cloud cover tends to create a very uniform lighting condition.
- Equations to predict the available daylight under varying weather conditions and for any point on earth's surface have been developed by IES.
- Illuminance calculated will be average and actual illuminance will be in the range of expected values on the clearest of clear days and the darkest of overcast days. (one half or twice)

Daylight Characteristics

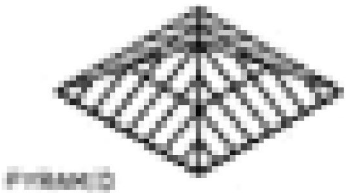
	Light Direction	Illumination fc	Brightness cd/m^2	Color Temp.	Color Description
Sun at midday	Beam	8,000 - 10,000	1,600,000,000	5500K	neutral
Sun at horizon	Beam	3,000 - 8,000	6,000,000	2000K	warm
Clear sky	Diffuse	1,000 - 2,000	8,000	10,000K	bluish
Cloudy sky	Diffuse & Beam	500 - 5,000	2,000	7,500K	cool

Skylight - construction

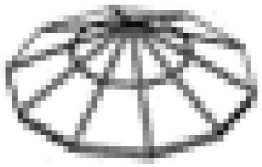


Skylight - construction

- Constructed of acrylic plastic sheets, fiber glass reinforced acrylic plastics, fiber glass and various forms of glass.
- These materials come in a number of colors—from clear and translucent white, to bronze and gray colors.
- They also come in a variety of thicknesses and number of layers.
- Either flat or domed.
- Advantages of domed skylight
  - Efficient in gathering light from all directions due to large surface area.
  - Stretches the skylight so it becomes thinner and increases transmittance factor.
- Lenses and louvers can be used to vary the transmittance factors.
- A single 4 X 8 skylight can introduce 2,80,000 lumens which is more than twice that is produced by a 1000 watts high pressure sodium lamp.

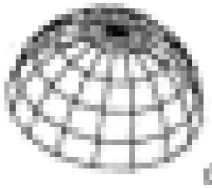


PYRAMID



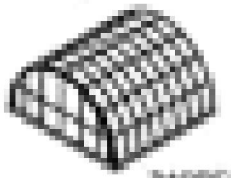
POLYGON

HIP-END

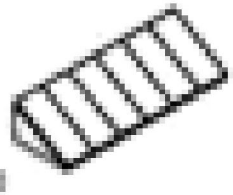


GLASS DOME

GABLE-END



BARREL VAULT

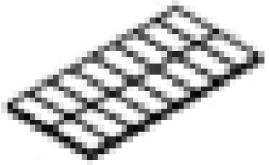


LEAN-TO

RETRACTABLE

RIDGE-MOUNT

SKYLIGHT VENT



FLAT GLASS

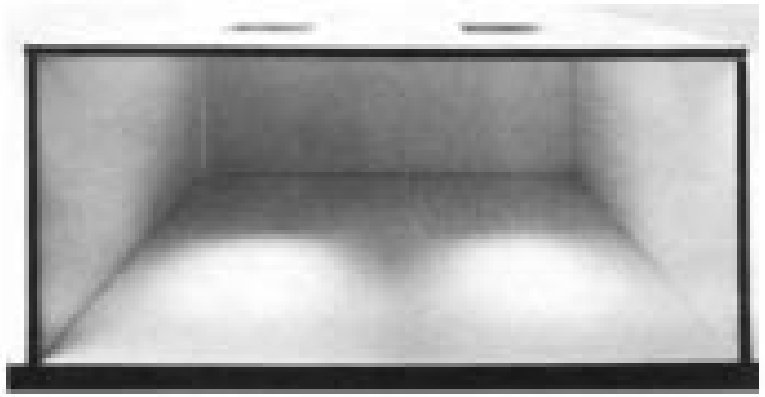
ACRYLIC DOME

Design considerations - Transmittance

- The selection of size, shape, number, and placement of skylights on the roof of the building is important.
- Two different transmittance factors
  - Domed transmittance – illuminance produced by direct light
  - Flat transmittance – Diffused sky component
- High transmittance above 70% will admit large concentrated radiant heat component.

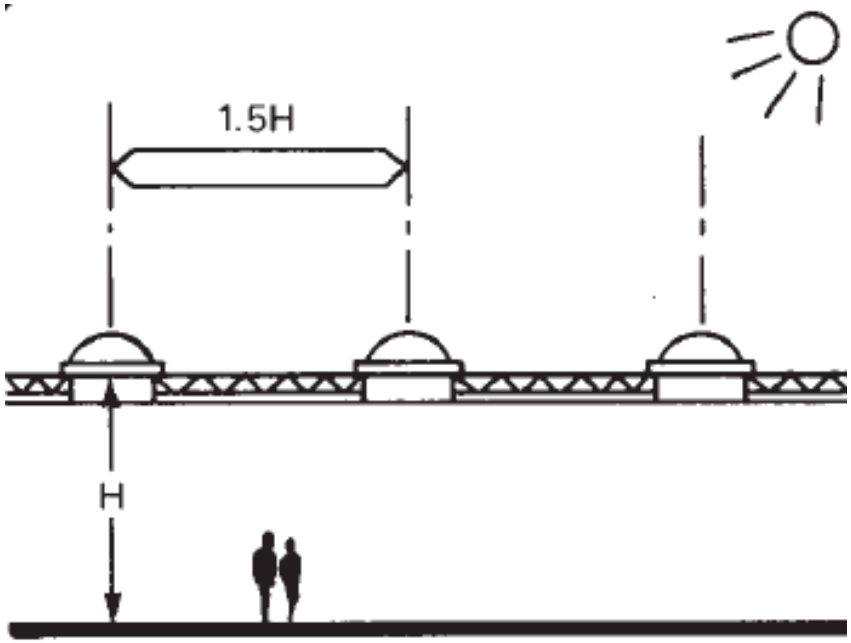
Design considerations – Size and spacing

- Large, widely spaced skylights are the most economical to install, but may produce bright conditions under the skylights and relatively dark conditions in between.
- Small, closely spaced skylights will provide more uniform lighting conditions and greater energy savings, but will be more costly to install.



Design considerations – Size and spacing

- The general rule of thumb is to space skylights at 1.0 to 1.5 times ceiling height.



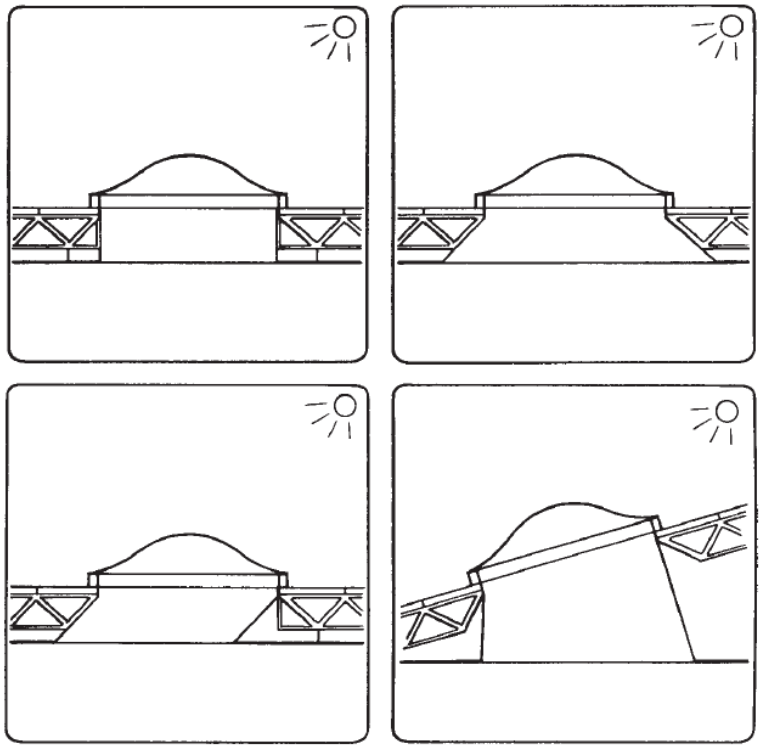
Cross Section

Design considerations - Daylight Distribution

- It can be controlled and diffused by the shape and reflective properties of light wells, shading devices, and the surfaces of the room itself.
- Well-balanced lighting conditions are essential to the visual comfort of the building occupants.

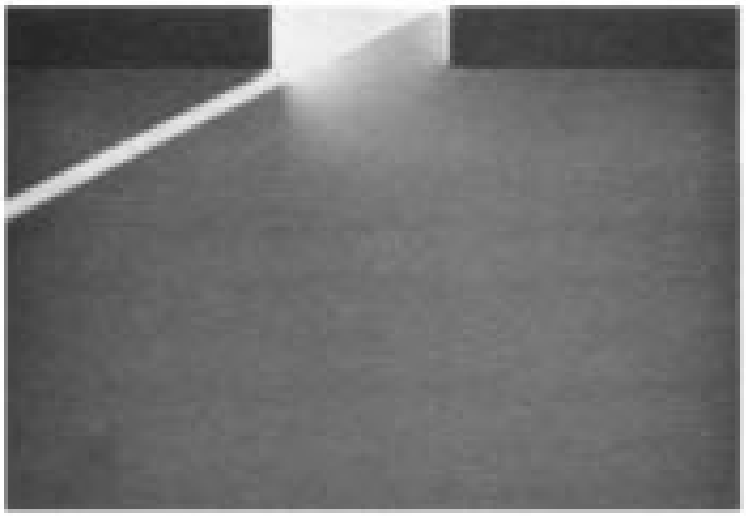
Light Wells

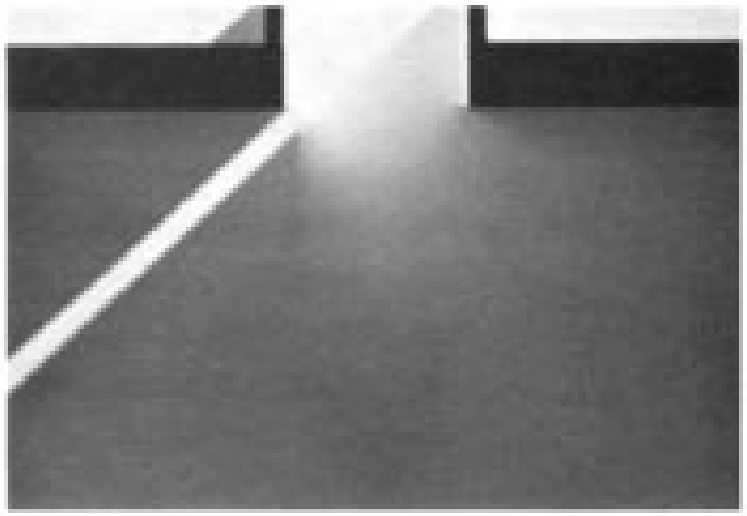
- They bring the light through the roof and ceiling structure, and they simultaneously provide a means for controlling the incoming daylight before it enters the main space.



Light Wells

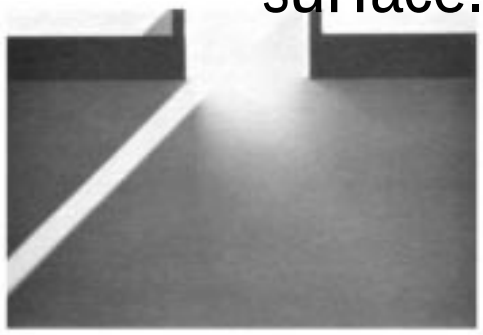
- In designing wells for skylights, a number of factors must be considered
- Solar geometry
  - The height and orientation of the sun change both daily and seasonally.

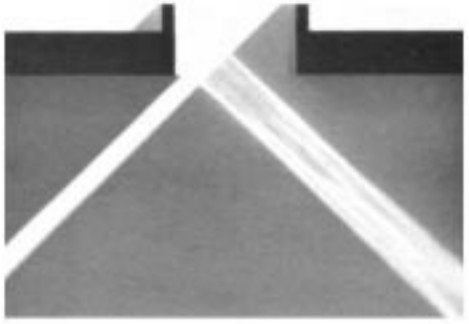


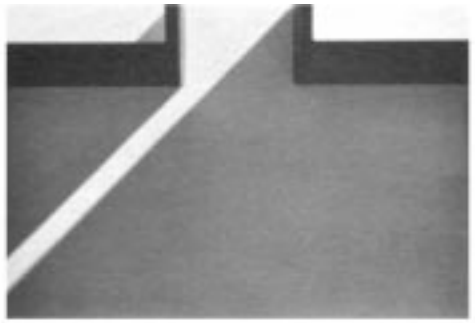


Light Wells

- Surface reflectance
  - Light wells reflect and diffuse sunlight as it bounces from the skylight to the task
  - Diffuse walls (e.g., flat or matte paints) reflect incident light in all directions, spreading the brightness
  - Specular walls (e.g., mirror surfaces) reflect a direct image of the sun or skylight to the space below
  - Semispecular walls (e.g., gloss paints) exhibit qualities of both diffuse and specular reflection.
  - Deeply colored well surfaces reduce nearly all light scattering, and tend to admit only direct sunlight surface.

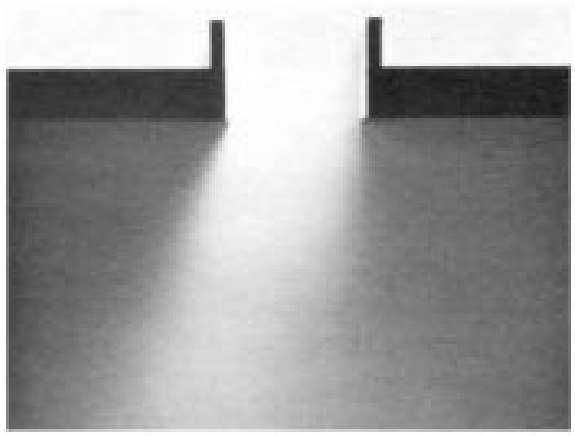


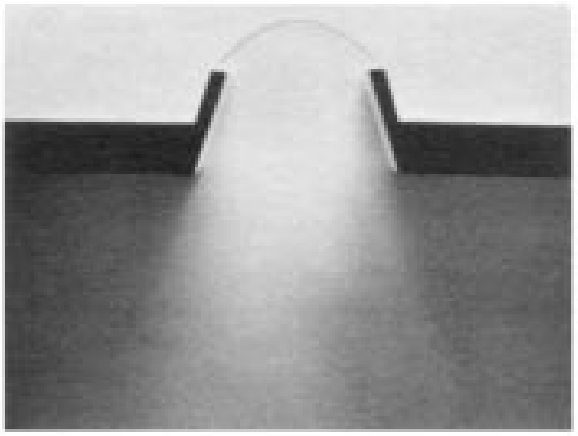




Light Wells

- Wall slope
  - The slope of light well walls helps to determine the distribution of light in the space.
  - The broader the base of the well, the larger the task area in the space having a direct view of the skylight.





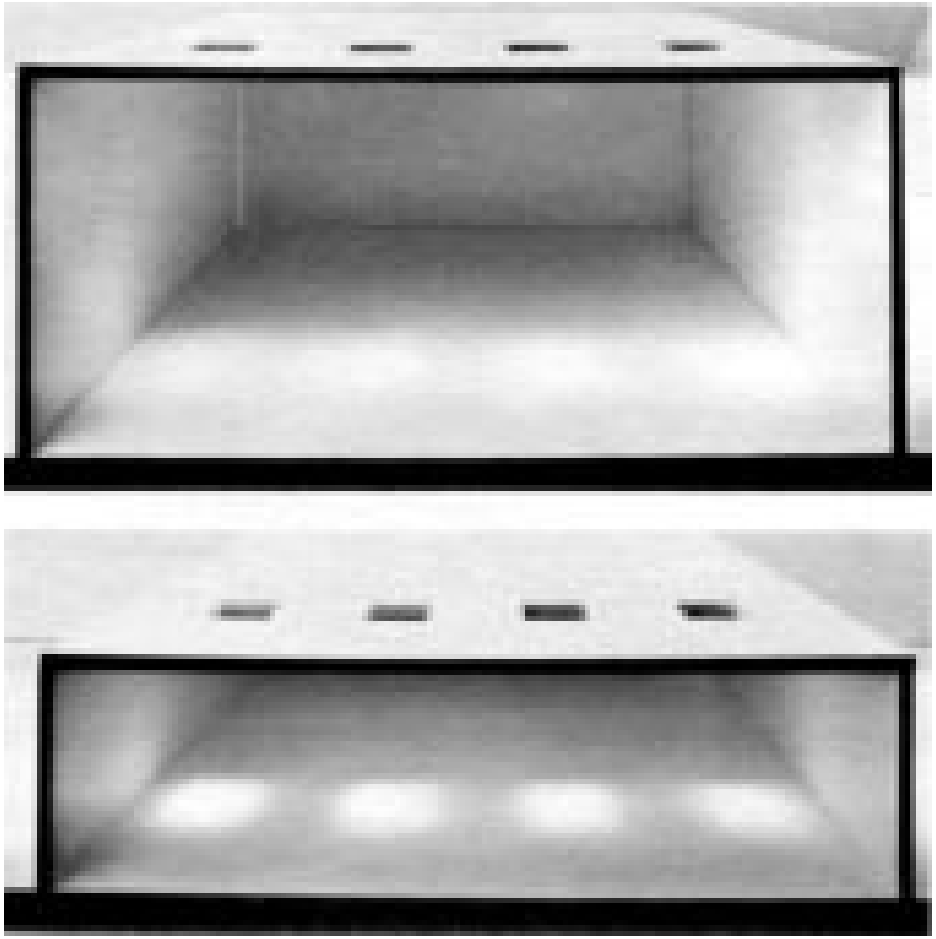
Shading devices

- Daylight can also be controlled and diffused with the use of additional vertical surfaces like banners, structural elements, or horizontal shading devices located under the skylight in the light well.
- Operable shading devices, whether manual or automatic, can also allow the amount of light reaching the room to be controlled, from full brightness to very dim.

Room Surfaces

- Daylight after passing through the glazing, the light well, and the shading devices, it interacts with the interior of the building.
- There it can be absorbed and contained, or bounced and blended, depending on the building design.
- Varying the ceiling height may increase or decrease the uniformity of the daylight distribution.

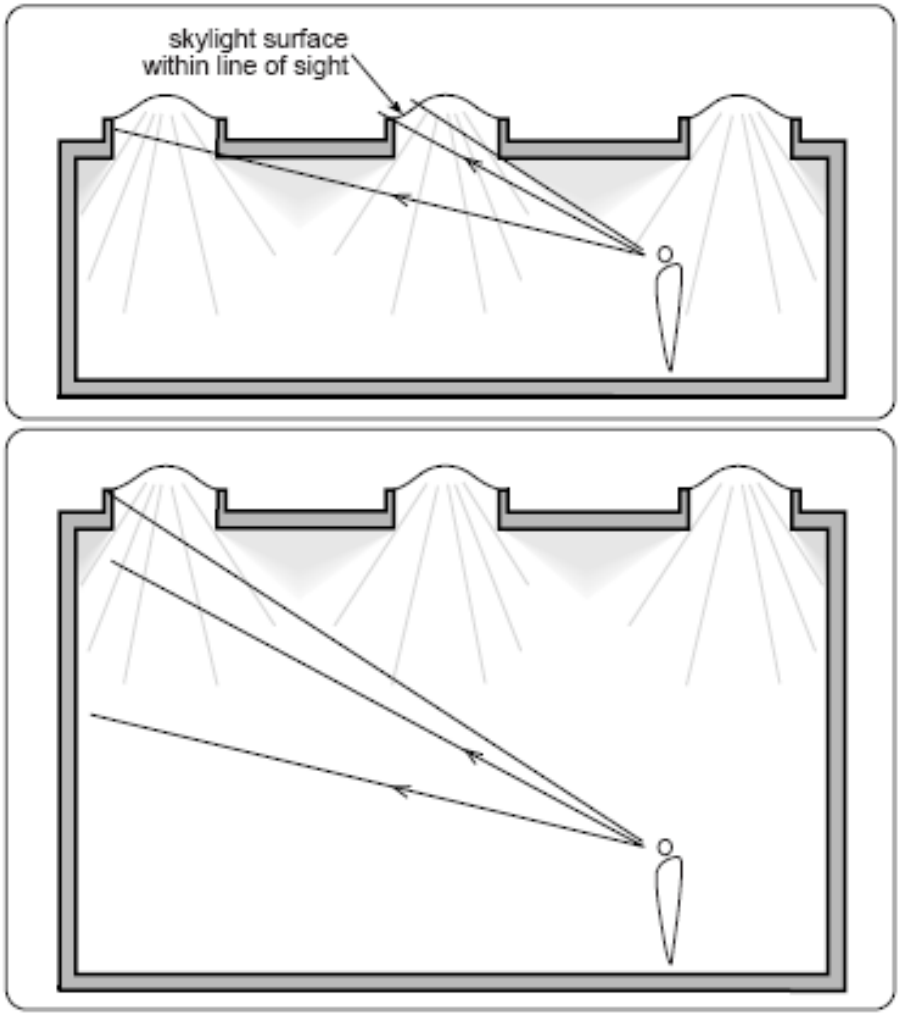
Ceiling height



Visual Comfort

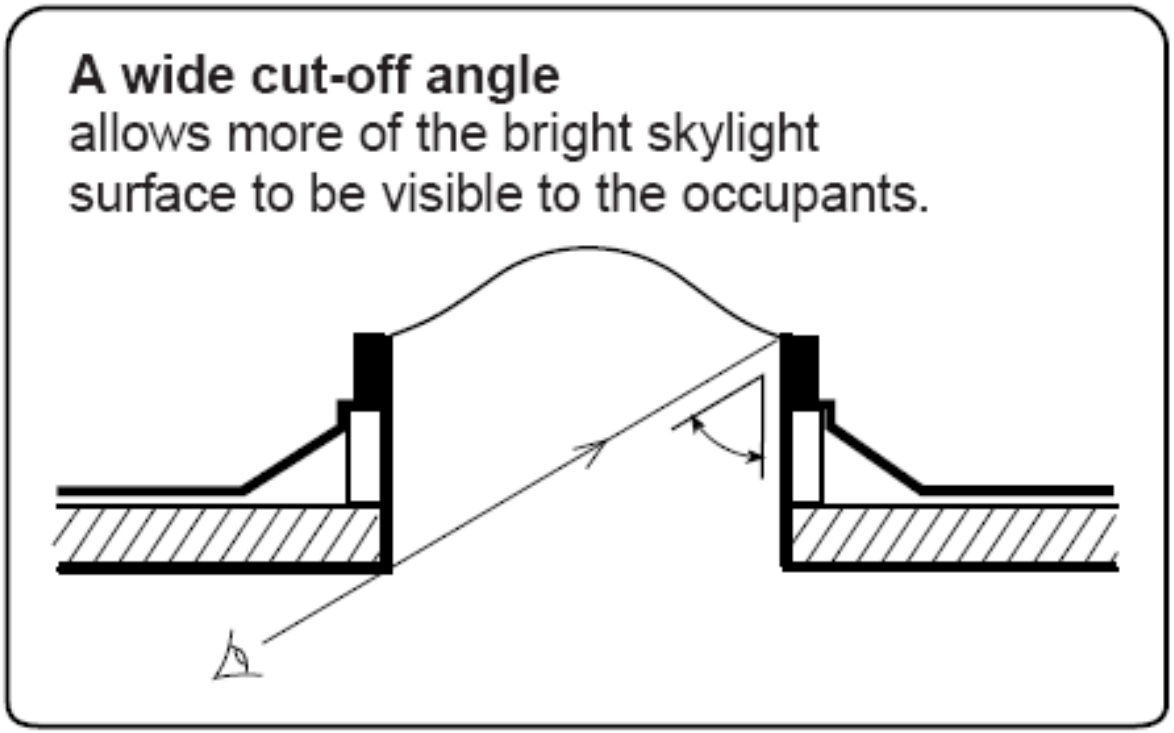
- There are two basic areas of concern:
  - Avoid excessively bright sources within the occupants' field of view
  - Avoid reflections from bright sources on the work surface
- The surface of diffusing skylights can become very bright in sunlight, and is a potential source of glare to people working in the space.

Height of ceiling

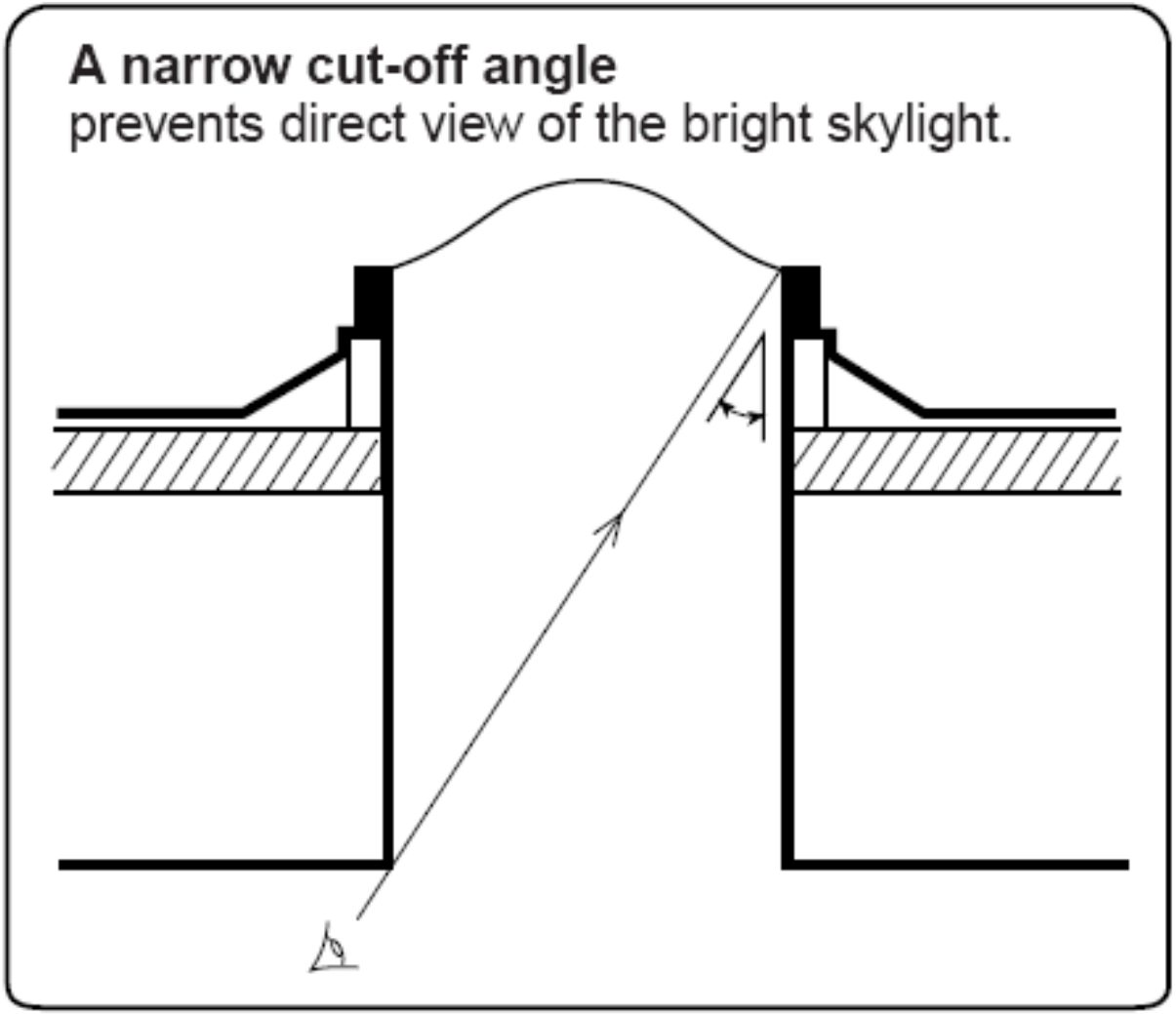


Cut-off angle

Cut-off angle is the angle of a line of sight, such that a viewer cannot directly see the bright light source in a lighting fixture.



Cut-off angle



Cut-off angle