

Lighting in Interiors

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ABSTRACT

This chapter explores the fundamental aspects of illumination, covering natural and artificial light sources and their applications in interior spaces. It introduces the significance of lighting in shaping ambiance and functionality, discussing light generation and essential units of measure for a comprehensive understanding.

The chapter emphasizes the importance of daylighting in architectural design, showcasing how natural light creates sustainable and visually appealing spaces. It delves into smart systems for managing daylight in buildings. Moving on to artificial light, the chapter traces the evolution of lighting technologies, analyzing various types like incandescent, fluorescent, LED, etc., and their applications.

Practical applications of artificial lighting in diverse interior spaces are examined, enhancing functionality and aesthetics. The chapter explores lighting strategies for bedrooms, offices, retail stores, and specialized environments. Additionally, it delves into futuristic trends, including smart lighting, human-centric concepts, and advanced materials like OLEDs and quantum dots, shaping the future of lighting design.

Keywords: Natural Lighting, Daylighting, Artificial lighting, Sources, Futuristic trends.

I. INTRODUCTION

Lighting is the purposeful and regulated use of light in diverse settings, indoors and outdoors, to achieve specific visual effects, improve visibility, and establish particular moods or atmospheres. It plays a crucial role in various fields, such as architecture, interior design, theater, photography, film, and visual arts. In architecture and interior design, lighting serves both practical and aesthetic functions, ensuring effective illumination for various activities, safety, and accentuating architectural or interior elements. Additionally, it can be employed to create desired moods, highlight focal points, and set a particular ambiance within a space. Lighting comprises both artificial light sources, like lamps and fixtures, and the capture of natural light, such as daylight. Visible light, which falls within the range of 400–700 nanometers in wavelength, is a form of electromagnetic radiation detected by the human eye. Natural light sources, such as sunlight, moonlight, and fire, occur naturally and are beyond human control, while man-made light sources, including electric lamps and flames, can be regulated according to desired timing and intensity.



Figure 1. Living room with natural and artificial lighting. [Source: <https://www.livspace.com/sg/magazine/lighting-living-room-lighting-ideas>]

II. LIGHTING TYPES IN INTERIORS:

Natural lighting:

Natural lighting refers to the illumination provided by the sun, and it is the most plentiful and eco-friendly source of light. Its presence can have positive effects on people, promoting a sense of well-being and enhancing productivity. However, natural lighting can sometimes be overly intense or harsh, leading to issues like excessive brightness and glare.



Figure 2. An interior space where the daylighting is incorporated through the window.[Source: <https://elemental.green/15-reasons-you-need-as-much-natural-lighting-in-your-home-as-possible/>]

Artificial lighting:

Artificial lighting is produced by man-made sources like lamps, light bulbs, and fixtures. It can be used to complement natural lighting or provide illumination in spaces without natural light. Artificial lighting is versatile and can be tailored to achieve different effects, such as ambient, task, accent, and mood lighting.



Figure 3. Pendant lights over a dining table.[Source: <https://www.decoist.com/2012-05-03/artificial-lighting-how-to-know-what-works-where/>]

III. HOW IS LIGHT GENERATED?

Natural light:

Natural light, which is produced by the Sun, originates from nuclear fusion reactions in the Sun's core, resulting in the emission of vast amounts of energy, including light. This light travels through space and reaches Earth, with some of it being absorbed by the atmosphere, but most of it passing through and illuminating the planet's surface. Natural light is crucial for visibility and plays a vital role in supporting plant growth. The intensity of natural light varies throughout the day and across different seasons, making it important to maximize its usage whenever possible.

Artificial light:

Artificial light, however, is generated through the movement of electrons in atoms. When electrons transition from higher to lower energy levels, they release particles of light called photons. The energy of these photons is determined by the difference in energy between the two levels involved in the transition. There are various methods of generating light, some of which include:

- **Incandescent light:** This is produced when an electric current flows through a metal filament, causing it to heat up and emit visible light.

- **Fluorescent light:** In this case, an electric current passes through a gas, leading to the emission of ultraviolet light. This ultraviolet light causes a coating on the inside of the lamp to fluoresce, producing visible light.
- **Light-emitting diodes (LEDs):** LEDs emit light when an electric current passes through them. They are highly efficient and capable of producing a wide range of colors.
- **Lasers:** Lasers produce an intense and coherent beam of light, meaning all photons in the beam travel in the same direction and have the same wavelength. Lasers have diverse applications, including in surgery, telecommunications, and manufacturing.

IV. UNITS OF LIGHT:

- **Luminous intensity** is a metric that gauges the amount of visible light emitted by a lamp in a specific direction. This measurement is expressed in candelas (cd). A higher candela value indicates a brighter lamp in that direction.
- **Luminous flux**, on the other hand, measures the total amount of visible light emitted from a lamp and is denoted in lumens (lm). The more lumens a lamp emits, the brighter it appears overall.
- **Illuminance** quantifies the amount of light that falls on a surface and is measured in lux (lx). One lux is equivalent to one lumen per square meter. The required illuminance in a given space depends on the activities conducted there. For instance, a workspace might need 500 lux, while a living room may only require 100 lux.
- **Power** signifies the amount of electrical energy consumed by a lamp and is measured in watts (W). Higher wattage corresponds to greater power consumption by the lamp.
- **Efficacy** assesses a lamp's efficiency in converting electrical energy into light and is measured in lumens per watt (lm/W). A higher lm/W value indicates a more efficient lamp in converting energy into light output.
- **Electric potential** refers to the difference in electrical potential energy between two points in an electric circuit. It is measured in volts (V). In the United States, the standard voltage in electric circuits is typically 120 V AC (alternating current).

V. COLOR EFFECTS:

Color temperature:

Color temperature is a measurement indicating the warmth or coolness of a light source, and it is expressed in Kelvin (K) on a scale ranging from 1,000 K to 10,000 K. The color temperature of a light source is determined by the temperature of the object emitting the light. For instance, a tungsten filament lamp emits light with a color temperature of around 2,700 K because the tungsten filament is heated to about 2,700 K when it's turned on. Different types of light bulbs can also affect the color temperature.

- Light can be categorized into warm, cool, and neutral based on its color temperature, measured in Kelvin (K). Warm light, with a color temperature of less than 3,300 K, is often referred to as "yellow" or "orange." It is commonly used in homes and businesses to establish a soothing and comfortable ambiance.
- On the other hand, cool light has a color temperature greater than 3,300 K and is often described as "white" or "blue." It is commonly employed in offices and work environments to promote a vibrant and productive atmosphere.
- Neutral light falls within the range of 3,300 K to 5,300 K and is also described as "white" or "daylight." This type of lighting is versatile and functional, making it suitable for both homes and businesses.

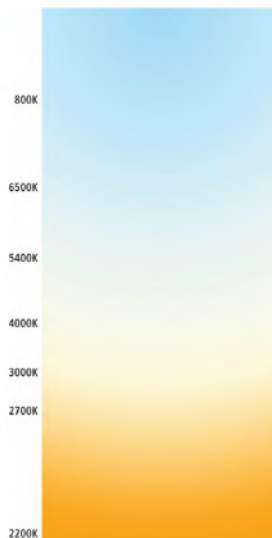


Figure 4. The range of color temperature of white. (Photo: Marcus Steffen)[Source: Residential Lighting Design]

Color rendering Index:

- The Color Rendering Index (CRI) is a metric used to assess how accurately a light source can reproduce the colors of objects in comparison to a reference light source, typically daylight. The CRI is represented on a scale from 0 to 100, with 100 being the highest possible score, indicating the best color reproduction. An incandescent lamp, for example, closely matches the black body radiator and has a perfect CRI score of 100.
- The CRI serves as a guide to determine how well a light source displays colors on a surface. For instance, low CRI lamps like sodium lamps used in some street lighting emit orange/yellow light, which severely impairs color perception, making it difficult to distinguish different colors under such lighting.
- A higher CRI rating indicates better color rendering. A CRI rating in the 90s is considered exceptionally good, while the 80s are still good but not outstanding. Light sources with a CRI below 80 are generally not suitable for residential use.
- To determine the CRI of a lamp, measurements are taken to assess how well it renders eight standard colors, including red, orange, yellow, green, blue, cyan, magenta, and white. These colors are used as a basis for evaluating the light source's ability to faithfully reproduce various colors.



Figure 5. A space showing different CRI scores. [Source: <https://www.uk.lumistrips.com/lumistrips-blog/cri-explained/>]

VI. NATURAL LIGHTING:

A. Introduction:

Natural lighting refers to the use of sunlight as the primary source of illumination within an interior space. It provides a connection to the outdoors, offers dynamic and changing light patterns throughout the day, and has various physical and psychological benefits. Natural lighting can be optimized through architectural features like windows, skylights, glass walls, or light tubes.

B. Sources of natural light:

- Natural sources of light in the world include fire, lightning, and bioluminescence from creatures like fireflies and deep-sea organisms. However, when we talk about natural light, we mainly refer to daylight, specifically sunlight. Sunlight is vital for life on Earth, and our evolution has made us best

suited to function under its illumination. Our visual system and responses to light and color are intrinsically linked to the qualities of sunlight.

- Sunlight takes various forms as it reaches Earth, encompassing direct light from the sun, light reflected and diffused by clouds, and scattering in the upper atmosphere, which results in the blue sky. The visible light from the sun has a cool white appearance, measuring around 6,000 Kelvin in color temperature. As sunlight approaches Earth, Rayleigh scattering in the upper atmosphere causes blue light to scatter more strongly, while other wavelengths are transmitted. This scattering phenomenon is responsible for the blue color of the sky.
- As a result of Rayleigh scattering, direct sunlight that reaches the Earth's surface appears warmer in color compared to what it would be without scattering. The interplay of a slightly yellower sun and the intense blue from the sky creates daylight on Earth with a color temperature similar to the natural white light of the sun.
- Sunlight is further scattered by water and ice in the atmosphere, and larger water droplets in clouds scatter all wavelengths of light, maintaining the light's white color. Even on completely overcast days without visible sunlight, illumination levels can remain relatively high. Nevertheless, overcast days can evoke a dull and occasionally depressive atmosphere, despite transmitting significant amounts of light.



Figure 6. A snowy hillside is the perfect place to see just how much of the light at ground level is contributed by the sky. The low angle of sunlight in this image throws much of the slope into shadow. The shadow is not black because it is still receiving direct light from the sky-hence the strong blue tint to the shadows. [Source: Lighting for Interior Design Book]

C. Range of Intensity:

Architectural design is deeply influenced by the strength of natural light, which profoundly impacts how individuals perceive and experience a space. Abundant natural light creates an inviting and stimulating ambiance, while limited light can lead to a more enclosed and somber atmosphere. The location of a building also plays a significant role in determining the intensity of natural light it receives, with urban areas often receiving less sunlight due to tall surrounding buildings blocking the sun.

The intensity of natural lighting varies greatly depending on various factors, including the time of day, season, weather conditions, and the building's location. On a clear day at midday, full sunlight can provide a high level of brightness, ranging from approximately 10,000 to 100,000 lux or even higher. When skies are partly cloudy, the intensity decreases to a few thousand to tens of thousands of lux, and overcast conditions lead to significantly lower illuminance levels, ranging from a few hundred to a few thousand lux.

Morning and evening natural lighting tends to be gentler and less intense compared to midday light, owing to the sun's lower angle and the atmospheric scattering, which contributes to a warmer and more diffused lighting quality.



Figure 7. The sky is seen in the images above at various times of the day. [Source: Lighting for Interior Design Book]

Several methods can be utilized to regulate the intensity of natural light in a building. For example, blinds or curtains can be employed to block sunlight, while skylights or sun tunnels can be installed to bring in natural light. Light-colored walls and furniture can also be used to reflect natural light, enhancing the brightness within the space. By comprehending the range of natural lighting intensity and implementing appropriate controls, architects can design a building that is both comfortable and functional.

Even when in the shade on a sunny day, a significant amount of ambient light is present, measuring 12,400 lux (1,152 fc) in the provided measurement. However, this is less than one-seventh of the 87,100 lux (8,092 fc) measured from direct sunlight on the right side. One unique characteristic of natural light is its ability to create a 7:1 variation in light levels over a short distance, something that is generally not achievable with artificial lighting in indoor spaces.



Figure 8. Even in the shade, on a sunny day there is a lot of ambient light around—12,400 lux (1,152 fc) in the measurement shown on the left. Nevertheless, this figure is less than one-seventh of the 87,100 lux (8,092 fc) measured from the direct sunlight on the right. A 7:1 variation in light levels over such a small distance would normally be designed out of the lighting of an interior space, yet this extreme contrast is exactly what natural light is all about. [Source: Lighting for Interior Design Book]

D. Direction of sunlight:

When designing a building or room, it is crucial to take into account the direction of natural light, as it significantly impacts the overall feel and utilization of the space. Several factors should be considered when determining the direction of natural light:

- **Time of day:** The direction of the sun's rays changes throughout the day, with morning light coming from the east and afternoon light coming from the west.
- **Season:** The sun's rays vary depending on the season, being more direct in summer and more indirect in winter.
- **Location of the building:** The position of the building in the northern hemisphere, for example, will influence the amount of sunlight it receives during different seasons.
- **Orientation of the building:** The building's orientation, or the direction it faces, plays a crucial role in determining the amount of sunlight it captures. South-facing buildings will receive more sunlight than those facing north.
- **Surrounding landscape:** The presence of tall trees or surrounding buildings can also affect the direction and quantity of natural light that reaches the building, with shaded areas receiving less sunlight compared to open areas.

Certain essential aspects are associated with the direction of natural light:

- **East:** In the morning, natural light emanates from the east as the sun rises. East-facing windows capture direct sunlight during the morning hours, providing a gentle and warm quality of light. This orientation is ideal for spaces where a soothing awakening or a welcoming atmosphere is desired.
- **South:** Throughout the day, the south direction receives the most consistent and abundant natural light, particularly in the northern hemisphere. South-facing windows receive direct sunlight in winter and indirect sunlight in summer, making them well-suited for maximizing natural lighting and achieving balanced illumination.
- **West:** During the late afternoon and evening, natural light comes from the west as the sun sets. West-facing windows allow for direct sunlight during these times, creating a warm and cozy ambiance. However, it is essential to consider potential issues with glare and overheating in spaces with excessive west-facing glazing.
- **North:** North-facing windows receive indirect or diffused light throughout the day, with minimal direct sunlight. This results in a soft and even illumination with minimal glare. North-facing spaces are particularly suitable for areas that require consistent, controlled lighting, such as art galleries or workspaces where glare needs to be minimized.

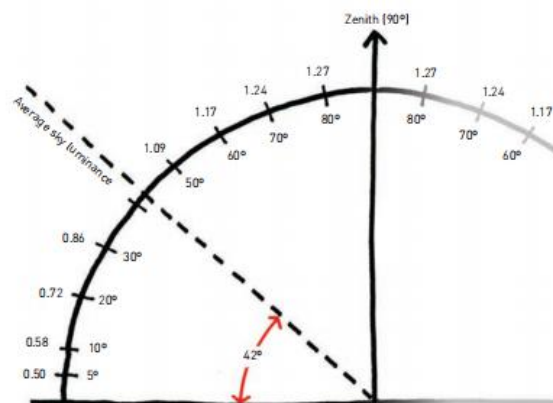


Figure 9. Even though a completely clouded-over sky may appear to have a constant thickness, there can nevertheless be large differences. A completely cloudy sky has an average brightness of 42 degrees above the horizon. Five degrees above the horizon, the sky is only half as bright as usual. It is possible for the zenith light from straight overhead to be 30% brighter than usual. When constructing glazing systems, taking into account the variations in sky luminance might be crucial. Roof glass that lets in zenith light may let in almost 212 times as much natural light per square yard of aperture than vertical glazing that only lets in near-horizontal light, even on cloudy days. [Source: Lighting for Interior Design Book]

E. Benefits of natural lighting:

- Exposure to natural light has a multitude of positive effects on health and well-being. It is associated with improved mood, increased productivity, and overall better well-being. Natural light plays a crucial role in regulating circadian rhythms, promoting better sleep patterns, and aiding in the synthesis of vitamin D, essential for bone health and immune function.
- In addition to its health benefits, natural light also contributes to visual comfort. It creates a balanced and visually appealing environment, enhancing the perception of colors, textures, and shapes. This, in turn, reduces eye strain and improves focus and concentration.
- Moreover, natural light fosters a sense of connection to nature, allowing occupants to experience the changing light patterns throughout the day and enjoy views of the outdoors. This connection to nature positively impacts mood and well-being.
- Studies have shown that exposure to natural light in workplaces leads to improved mood and productivity compared to spaces lacking natural light. It also helps in reducing stress and anxiety levels among individuals.
- Furthermore, natural light aids in regulating circadian rhythms, which improves the quality of sleep. Synchronized circadian rhythms with the natural light-dark cycle contribute to better sleep patterns.
- Not only does natural lighting benefit health and well-being, but it also results in energy savings. By utilizing natural light, there is a reduced reliance on artificial lighting, leading to cost savings on energy bills.

F. How to maximize natural light in interiors:

- **Orientation:** Arrange your home or office to face south or east if possible, as this maximizes exposure to morning and afternoon sunlight.
- **Light-colored surfaces:** Use light-colored walls and furniture to reflect natural light, creating a brighter and more open environment.
- **Skylights and sun tunnels:** Install skylights or sun tunnels to bring natural light into interior spaces that lack direct access to sunlight.
- **Open curtains and blinds:** During the day, open curtains and blinds to allow as much natural light as possible to enter the space, making it more inviting.
- **Mirrors:** Use mirrors strategically to reflect natural light into darker areas, brightening the space and creating a sense of openness.
- **Glare-free furnishings:** Choose furniture and accessories that don't reflect glare, ensuring a comfortable and unobstructed view in well-lit spaces.
- **Incorporate plants:** Plants not only brighten a space but also contribute to noise absorption and improved air quality.
- **Remove obstructions:** If there are obstacles like trees or buildings blocking natural light, consider removing or trimming them to maximize sunlight.
- **Clean windows regularly:** Keep windows clean to allow maximum natural light to pass through, preventing up to 70% blockage caused by dirty windows.
- **Dimmable lighting:** Use dimmers on artificial light fixtures to adjust brightness according to the available natural light.
- **Time of day consideration:** Consider the time of day when designing your space, placing windows strategically to achieve the desired lighting ambiance throughout the day.

G. Different windows for increasing natural light in interiors:

Various types of windows can be used to optimize natural light and enhance the aesthetics of a space. Each window type can be chosen based on the specific lighting and design needs of the space, promoting a well-lit and visually appealing environment.

- **Skylights:** Installed in the roof, skylights bring ample natural light and improve ventilation.
- **Fixed Windows:** These windows cannot be opened but allow maximum natural light entry.
- **Casement Windows:** Casement windows open outward, providing ventilation and a pleasant view.
- **Awning Windows:** These windows open upward and offer ventilation while providing shade.
- **Clerestory Windows:** Positioned high on the wall, these windows allow light in while maintaining privacy.
- **Corner Windows:** Wrapping around corners, corner windows offer extensive views and multi-directional natural light.
- **Floor-to-Ceiling Windows:** Extending from the floor to the ceiling, these windows flood the interior with daylight and create a seamless connection to the outdoors.
- **Bay or Bow Windows:** Projecting outward, bay or bow windows offer additional space and multiple glass panels to maximize natural light.

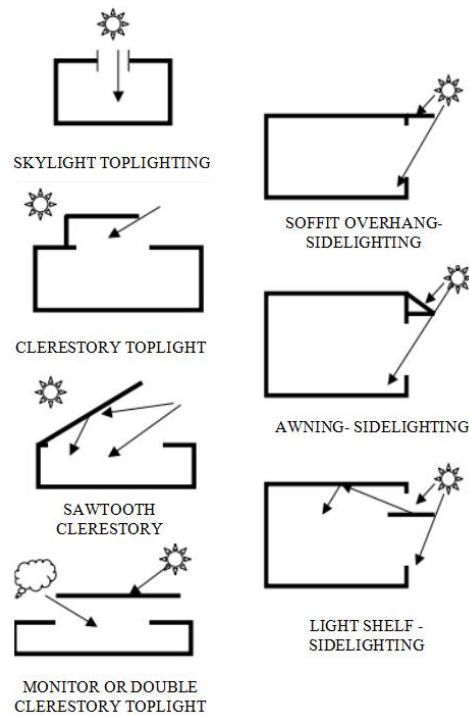


Figure 10. Lighting Concepts [Source: Lighting Design Basics]

H. Daylighting:

Daylighting is the intentional utilization of natural light to illuminate indoor areas. It involves carefully planning and incorporating windows, skylights, light tubes, or other openings in a building's design to optimize the entry of natural light while minimizing energy usage. The primary goal of daylighting is to create a harmonious and visually pleasing environment that promotes occupants' well-being while reducing the dependence on artificial lighting.

I. Key aspects of daylighting include:

- Daylighting design is centered on capturing and guiding natural light into indoor spaces effectively. This entails carefully considering window placement, size, orientation, and glazing properties to optimize the entry of daylight.
- Ensuring even distribution of natural light within the space is vital, achieved through techniques like light shelves, reflective surfaces, and interior layouts that minimize areas of shadow or glare.
- To control glare caused by direct sunlight, daylighting design incorporates window treatments like blinds, shades, or external shading devices to diffuse or block excessive sunlight while still allowing diffused natural light to enter.
- Daylighting aims to create visually comfortable environments that enhance the perception of colors, textures, and shapes, reducing eye strain and improving visual clarity.
- By utilizing natural light during daylight hours, daylighting design reduces the need for artificial lighting, leading to energy savings and enhancing the overall energy efficiency of the building.
- Creating a connection between the indoor environment and the natural outdoors is a key aspect of daylighting design, allowing occupants to experience the changing patterns of natural light and positively impact their well-being.
- Exposure to natural light through daylighting design has been linked to improved mood, productivity, and overall well-being, as it helps regulate circadian rhythms and promotes a healthier indoor environment.

J. Integration of daylighting with artificial lighting:

- Daylight-responsive controls like photosensors or dimming systems can be integrated to automatically adjust artificial lighting levels according to available natural light. This ensures consistent illumination, reduces energy consumption, and minimizes glare.
- Dividing the space into zones and using task lighting in specific areas allows for targeted illumination where needed, supplementing natural light effectively for various tasks or activities.

- To enhance daylight distribution, light shelves or reflective surfaces can be utilized to redirect and spread natural light deeper into the space, while daylight harvesting techniques capture and evenly distribute daylight through features like light shelves, light tubes, or light-diffusing materials, reducing the reliance on artificial lighting.
- Maintaining a balanced light color temperature between natural and artificial light sources creates a harmonious environment. Dynamic lighting systems can be employed to adjust artificial lighting's intensity and color temperature throughout the day, mirroring the changing qualities of natural light for enhanced visual comfort and connection to the outdoors.
- Glare control is crucial, achieved through well-designed window treatments like blinds or shades to manage direct sunlight during peak hours, ensuring visual comfort and optimal use of both natural and artificial lighting.
- By incorporating occupancy and daylight sensors, artificial lighting can be controlled based on occupancy levels and available natural light, optimizing energy usage by automatically adjusting or turning off lights when not required.

K. Basic principles of daylighting:

Ensure that all regularly occupied spaces have access to windows, skylights, or other natural light sources, with a focus on providing views. Keep in mind that the effective daylighted area extends about 2 times the window's width and 2 to 2.5 times its height into the building.

Minimize the size of the east and west sides of the building while maximizing the south and north sides. Designing east and west-facing windows can be challenging due to the sun's varying paths throughout the seasons, while north-facing windows in the northern hemisphere offer advantages in avoiding solar heating, and south-facing windows can be protected with passive elements like overhangs and light shelves.

For areas far from windows, consider using top-light skylights for one-story buildings or the top floor of multistory buildings. A recommended skylight area is around 3% to 5% of the total roof area to ensure sufficient interior lighting.

Control the amount of natural light entering the interior to prevent excessive brightness, typically 2.5 times or more than ordinary electric light levels. This can be achieved through appropriate window glass, exterior shading devices, interior shading devices, or a combination of these.

Provide an electric lighting system with automatic lighting controls to capitalize on energy savings. Dimming the electric lights rather than switching them on and off is preferred. Modern fluorescent dimming systems allow for daylighting controls and energy-efficient lighting options like fluorescent and compact fluorescent lighting.

VII. ARTIFICIAL LIGHTING:

A. Introduction:

Artificial lighting refers to light generated by man-made sources like lamps, light bulbs, and fixtures. It is used to illuminate indoor spaces when natural light is insufficient or unavailable, and it can complement natural light when needed. Artificial lighting offers the flexibility to create different ambiances and moods within a space, while also enhancing safety and visibility. Key points about artificial lighting are as follows:

- **Light Sources:** Various types of light bulbs or lamps, including incandescent, halogen, fluorescent, compact fluorescent lamps (CFLs), and light-emitting diodes (LEDs), constitute artificial lighting sources. Each type has distinct characteristics, such as energy efficiency, color rendering, lifespan, and color temperature.
- **Design Flexibility:** Artificial lighting allows precise control over light intensity, color, and distribution. Designers have the option to select from a wide array of fixtures, bulbs, and lighting systems to achieve desired effects, emphasize specific areas, or establish the desired ambiance in a space.
- **Color Temperature:** Artificial lighting can be adjusted to different color temperatures, ranging from warm (yellowish) to cool (bluish) tones. This adaptability enables customization and the creation of specific atmospheres or lighting effects.
- **Energy Efficiency:** Energy-efficient lighting options like CFLs and LEDs have gained popularity due to their longer lifespan and lower energy consumption compared to traditional incandescent bulbs. Utilizing energy-efficient lighting helps reduce electricity usage and lower energy costs.
- **Lighting Controls:** Various lighting control systems, such as dimmers, timers, motion sensors, and programmable lighting systems, offer flexibility in adjusting and automating lighting levels based on

occupancy, time of day, or specific requirements. These controls contribute to energy savings and enhance convenience.

- B. Evolution of artificial lighting:** The journey of artificial lighting has been marked by significant milestones and innovations throughout history. Here is a brief overview of its evolution:
- **Ancient Times:** Early humans relied on fire, using torches, campfires, and oil lamps for illumination. Ancient civilizations like the Egyptians, Greeks, and Romans used oil lamps and candles as their primary sources of artificial light.
 - **Medieval Period:** During this era, candles made from tallow or beeswax gained popularity, providing a more reliable and long-lasting lighting option due to advancements in candle making techniques.



- **Gas Lighting:** The 19th century saw the emergence of gas lighting, powered by coal gas or natural gas. Gas lamps illuminated streets, buildings, and homes, offering brighter and more efficient lighting compared to candles or oil lamps.
- **Incandescent Lighting:** Thomas Edison and Joseph Swan's invention of the incandescent light bulb in the late 19th century revolutionized artificial lighting. The incandescent bulb's heated filament inside a glass bulb emitted light when an electric current passed through it, becoming the dominant lighting technology for over a century.



Figure 12. Left: Gas Lighting; Right: Incandescent Lighting [Source: Google Images]

- **Fluorescent Lighting:** In the early 20th century, fluorescent lighting was developed as an energy-efficient alternative to incandescent bulbs. Fluorescent lamps used gas-filled tubes that emitted ultraviolet light, which then interacted with phosphor coatings to produce visible light, offering longer lifespan and greater energy efficiency.
- **LED Lighting:** A breakthrough in the late 20th century, LED technology uses semiconductor materials to produce light through the movement of electrons. LEDs brought highly energy-efficient, long-lasting, and versatile lighting solutions to the market. Rapid advancements in LED technology have led to its widespread adoption due to its numerous benefits.



Figure 13. Left: Fluorescent tube; Right: LED Bulb [Source: Google Images]

- **Present and Future:** Today, the evolution of artificial lighting continues with ongoing advancements in LED technology, smart lighting systems, and energy-efficient solutions. Innovations aim to enhance energy efficiency, control, customization, and integration with other technologies, leading to more sustainable and intelligent lighting systems. These developments focus on creating a more environmentally friendly and efficient lighting future.
- C. **Sources of artificial lighting:** In the field of architectural lighting, there are three primary lighting technologies commonly encountered. These technologies include:
- **Incandescent Sources:** Incandescent sources generate visible light by heating a material, typically a thin metal filament. This category comprises traditional incandescent lamps, as well as tungsten halogen, low-voltage tungsten halogen, and tungsten xenon lamps.
 - **Discharge Light Sources:** Discharge light sources produce light through an electrical discharge within a gas. This category includes fluorescent lamps, as well as metal halide and sodium lamps.
 - **Electroluminescent Light Sources:** Electroluminescent light sources encompass electroluminescent panels, light-emitting diodes (LEDs), and organic LEDs (OLEDs). These sources produce light through the movement of electrons in semiconductor materials.

| | |
|---|----------------|
| Standard 60-watt incandescent lamp | 890 lumens |
| Standard 18-watt compact fluorescent lamp | 1200 lumens |
| Standard 4-foot-long T-8 fluorescent lamp | 2850 lumens |
| Typical 100-watt high-pressure sodium streetlamp | 9500 lumens |
| Typical 1500-watt metal halide lamp used for lighting athletic stadiums | 165,000 lumens |

Figure 14. Lumens for common light sources. [Source: Lighting Design Basics]

Incandescent light sources:

Objects that are hot emit energy in the form of heat, and the higher their temperature, the more energy they radiate. When hot materials radiate heat, they emit infrared radiation, which is a part of the electromagnetic spectrum just below the visible light spectrum in terms of radiant power. If a hot object's temperature increases further, it will emit more electromagnetic energy and eventually start producing visible light along with heat. This state is known as incandescence. As the incandescent material gets hotter, the wavelengths of light it produces change. Initially, it emits mostly heat (infrared energy), but as its temperature rises, it starts producing red light, followed by the addition of each color of the spectrum as energy levels increase. Eventually, the incandescent material emits all colors of the spectrum and becomes white hot. Fire is a familiar example of incandescence, where combustible materials become so hot that they burst into flames, releasing energy in the form of both heat and light.



Figure 15. The color of the light produced by the filament is directly related to its temperature. [Source: Lighting for Interior Design]

Discharge light sources:

Passing an electric current through a gas can generate visible light, a process distinct from how incandescent sources produce light. In this process, the gas is excited by electricity, leading to collisions between atoms and the release of energy in the form of ultraviolet or visible light. Lightning is a familiar example of an electrical discharge through air, producing an intense flash of visible light.

Gas discharge lamps, which utilize this electrical discharge, offer several advantages over incandescent sources. They are more efficient in producing visible light as they do not rely on heating materials. This efficiency, combined with a longer lifespan, makes them an appealing alternative in various lighting applications.

Creating a gas discharge that produces visible light involves a more complex process than the straightforward heating of an incandescent filament. It requires significant energy to initiate the discharge and precise control to maintain a steady output. Consequently, sophisticated electrical control devices, commonly known as ballasts or control gear, are necessary to operate discharge lamps.

There are numerous types of discharge lamps, serving diverse purposes, from general lighting to producing colored light or being used in tanning booths. Each type contains specific combinations of gases and additives, such as metallic compounds. Different gases and combinations yield radiation in various parts of the spectrum, enabling the production of different colors of visible light. By mixing the gases, it becomes possible to achieve a whiter light source.

Discharge light sources are more efficient than incandescent sources because they produce more visible light for the energy consumed. However, they are most efficient at higher wattages, making it challenging to create very low-power discharge lamps with high efficiency.

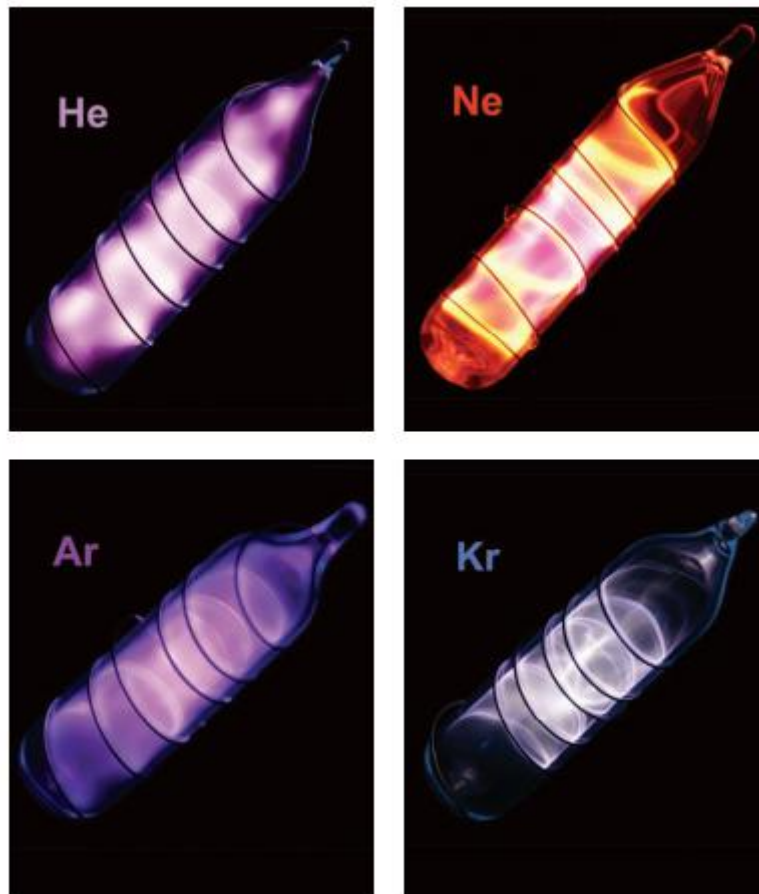


Figure 16. When an electrical discharge is passed through different gases they produce visible radiation in different parts of the spectrum. [Source: Lighting for Interior Design]

Electroluminescent light sources:

Electroluminescent (EL) materials emit electromagnetic radiation, typically visible light, when an electric current is applied. Unlike incandescent sources, this process doesn't involve heating and, as a result, electroluminescent light sources remain cool. Additionally, they do not require electric discharges through gases, allowing them to be much smaller than discharge light sources.

Electroluminescent light sources are often low-power, which affects their brightness. They are commonly used in cell phones, MP3 players, and vehicle instrument panels to backlit displays due to their thin and flat design. However, they are not sufficient for general lighting use.

Light-emitting diodes (LEDs):

Light-emitting diodes (LEDs) also operate on the electroluminescent principle but can be made as higher-power devices capable of producing more light. While LEDs have been around since the 1930s, it was only in the late 1990s that practical, high-brightness blue LEDs were developed, enabling full color mixing using red, green, and blue devices. RGB-based light sources can approximate white light, but modern white light LEDs function similarly to fluorescent lamps. The LED light source emits ultraviolet or near-ultraviolet light, which excites a phosphor coating, producing visible white light. This advancement has led to the creation of reliable and efficient white light LED sources suitable for general architectural lighting.

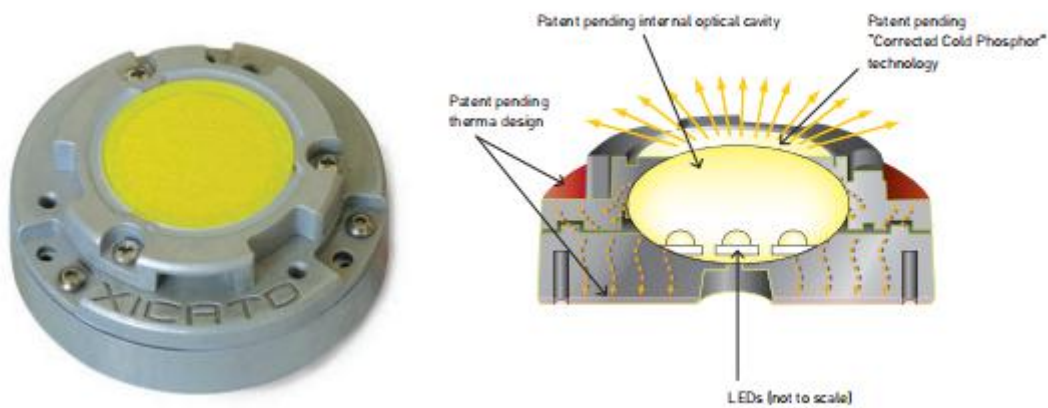


Figure 17. Left: An LED light; Right: This drawing, by the manufacturer, shows a section through an Xicato white LED module. [Source: Lighting for Interior Design]

Luminaires:

Various terms are used to refer to lighting equipment, depending on the context. In domestic settings, the word "lamp" is commonly used for items like "table lamp" or "floor lamp." However, in professional lighting, "lamp" specifically refers to the light source itself. Similarly, the term "light" is often used in phrases like "ceiling light" or "desk light," but in the professional context, it is not suitable as it describes the output rather than the equipment.

For non-technical individuals, the phrase "light fixture" is appropriate since it indicates the equipment's function as an assembly. This term is commonly used in theatrical situations to describe lighting equipment. However, the technically accurate term for lighting equipment is "luminaire." A luminaire is a complete package that includes the light source, lamp holder, reflector, lenses, housing, suspension, mounting, and other components necessary for a complete light fixture. In architectural lighting, "luminaire" is the widely accepted term.

In the art of storytelling, authors skillfully combine a limited set of letters, digits, and punctuation to create intricate narratives. Similarly, lighting design has a few fundamental components, and the expertise lies in their skillful arrangement and positioning to craft a beautiful lighting scheme.



Figure 18. The small size of LED light sources can allow the creation of luminaires that are physically tiny compared to traditional lamp and luminaire combinations. [Source: Lighting for Interior Design]

Nondirectional and directional luminaires:

The quality of light in a space is not solely determined by the luminaires used, but also by their positioning and design. For instance, a linear fluorescent lamp placed in a narrow ceiling slot can produce a

directional quality of light, while a narrow spotlight directed towards a white wall can create a soft and diffused quality of light. Non Directional luminaires spread light over a wide area without a specific direction, achieved through materials like frosted glass or fabric shades that diffuse the light. Alternatively, they may rely on the natural diffuse effect of certain light sources.

Dispersive or diffused light sources lack distinct shadows and create a soft, even illumination across surfaces. In a light-colored room, a bare lamp can often produce this quality of light as it reflects off various surfaces. On the other hand, directional luminaires are designed to control the spread of light and create a focused and directional effect. This can be achieved through shades, baffles, polished reflectors, or lenses. Some light sources, like dichroic spotlights or LED light sources with specially designed lenses, come prepackaged with a built-in reflector to control the light's direction.

When assessing the energy efficiency of a lighting scheme, it's not merely about the efficiency of the light source in producing visible light but also considers the quality and usage of the luminaire. The light output ratio (LOR) is a measure that takes into account how efficiently a luminaire converts the uncontrolled light from the light source into usable, directional light. While some luminaires might have a high LOR, others may focus the light output within a tightly controlled spread, making it more effective in illuminating specific surfaces. Thus, understanding the interaction between light sources and luminaires is crucial for achieving the desired lighting effect and energy efficiency.



Figure 19. A diffusing shade produces an almost equal quantity of light in all directions (top). This kind of luminaire is often referred to as dispersive, because there is no directional quality to the light. The same light source can be surrounded by a metal shade or reflector to create a directional luminaire (bottom). The distinction between nondirectional and directional light is not the light source, but how it is used in the luminaire. [Source: Lighting for Interior Design]

Concealed luminaires:

In the process of working with light, luminaires are just one aspect of the design. Selecting a luminaire is not equivalent to designing the lighting for a space. The lighting designer must consider not only the choice of light source and luminaire type but also how the luminaires will be used within the space. The physical presence of a luminaire often draws attention to its aesthetics, but the focus should be on how it enhances the overall lighting environment.

Even simple or less visually appealing luminaires can create stunning lighting effects when used appropriately. The priority should be on achieving the desired lit effect rather than solely on the appearance of the lighting equipment. Concealed luminaires, even if they may not be visually attractive, can serve their

purpose effectively if they produce the intended lighting effect. In some cases, the lit environment takes precedence over the visible aesthetics of the luminaires, making concealed or less aesthetically pleasing luminaires perfectly suitable for achieving the desired lighting outcome.



Figure 20. Concealed lighting is mounted within a linear display band. [Source: Lighting for Interior Design]

The use of basic luminaires can yield impressive results. In the case of a gallery, concealed lighting is cleverly integrated into a linear display band. This setup allows a single line of fluorescent strips to serve multiple purposes. It provides backlighting for transparent illustrations in the display band, washes light onto vertical banners situated behind the band, and also illuminates leaflet shelves positioned below each transparency. Furthermore, this illuminated feature contributes significantly to the ambient lighting in the exhibition space.

D. Direct and Indirect Light:

Direct light is emitted straight from the lamp into the room, while indirect light is reflected off a surface or architectural detail before entering the room. Direct light is brighter and more directional, providing better control over its direction. On the other hand, indirect light creates a softer, diffused wash of light on surfaces. One drawback of certain direct light fittings is the potential for glare, where the lamp's light shines directly into the eyes, causing discomfort and headaches. This is due to the constant dilation and contraction of the eye's pupil to adapt to the varying light levels. To address this issue, some fittings come with anti-glare baffles or louvres that reduce the angle at which the lamp can be seen, improving visual comfort without compromising the light output.

Indirect light does not produce glare, as it relies on reflecting light off surfaces to illuminate a space. It is used in various applications, from washing entire walls to lighting up specific areas like bookshelves and cupboards. Indirect light is an excellent choice for creating a relaxed atmosphere, as it reduces eye strain and provides even, soft lighting, making the room appear gentler. It is particularly suitable for bedrooms and living rooms where a calm ambiance is desired. However, caution is necessary when using indirect light, as excessive use can result in a flat and characterless space. It is advisable to light only a few surfaces, leaving some in shadow to create contrast and visual interest. For instance, ceilings with concealed uplighting elements in coffered designs create a contrast between the illuminated center and the shadowed lower parts. The surface that indirect light illuminates significantly impacts the overall lighting effect in the room. Dark surfaces reflect less light, necessitating the use of more powerful light sources or additional lighting to achieve adequate brightness. Brightly colored surfaces introduce their colors into the space, potentially overpowering the room with too many dominant colors and diminishing the effect of feature walls. Glossy surfaces act like mirrors, increasing the likelihood of direct glare and making light fittings visible rather than concealed. The ideal surface for reflecting indirect light is a matte, neutral-toned one, as it produces soft and bright lighting. While other approaches can be employed, using a matte, neutral surface generally ensures the most comfortable and effective lighting.

VIII. LIGHTING TYPES USED IN INTERIORS:

A. The Ambient Layer:

Ambient lighting serves the purpose of providing overall illumination in a room, allowing people to move around and have basic visual recognition without focusing on specific tasks. The level of ambient light plays a significant role in the room's atmosphere. If the ambient light is much lower than the task lighting, it creates a dramatic contrast, whereas nearly equal ambient and task light levels result in a brighter, cheerier, and more relaxed environment.

The choice of ambient lighting is crucial as it directly impacts the room's mood and ambiance. For example, in places like museums or boutique stores, low ambient lighting is often used to create contrast and enhance the sense of drama, achieved by downlights illuminating the floor while keeping the walls and ceiling dark. On the other hand, for a relaxed ambiance, increasing the brightness of room surfaces, particularly ceilings and upper walls, is essential. Uplighting is an effective method to achieve this effect, and the more even the uplighting, the more relaxed the room appears.

Various types of ambient lighting can be utilized, such as ceiling-mounted or recessed fixtures directing light downwards, wall sconces and floor lamps that wash the walls and ceiling with light, and cove lighting, floor lamps, and pendants that bounce light off ceilings and walls. Each of these options contributes to the overall illumination and ambiance of the space.



Figure 21. Ambient Lighting in Living room [Source: <https://www.hipcouch.com/magazine/getting-ambient-lighting-right>]

B. Accent Layer:

Accent lighting serves the purpose of illuminating and drawing attention to specific items, such as artwork or retail displays. Unlike other wall-lighting methods, accent lighting is specifically designed to highlight the object being showcased. To achieve effective accent lighting, a luminaire is positioned at an angle and directed towards the center of the attraction. It is typically mounted about 3 feet (or 1 meter) from the wall for every 2 feet (or 2 meters) that the center of the object is positioned below the light source. This arrangement results in a flattering light at approximately 30 degrees from vertical, which is considered ideal for showcasing art. Common types of accent lights include wall lights, recessed spot lighting, track lighting, and wall-mounted picture lights.



Figure 22. Accent Lighting in Living room [Source: <https://expertelectric.ca/residential-services/track-and-accent-lighting/>]

C. Task Layer:

Visual tasks in a space often involve work activities such as reading, which typically takes place on a table or desk. To address these tasks effectively, task lights are commonly provided at locations where such activities occur. Task luminaires encompass various types, including table lamps, floor lamps, desk lamps, drafting lamps, under-cabinet lights, and shelf lights. Additionally, overhead luminaires like pendants, troffers, and downlights can also be strategically placed to illuminate tasks.

Interestingly, the can downlight, a widely used light fixture in modern construction, was originally invented to illuminate tasks in churches, as traditional chandelier lighting did not provide adequate illumination for tasks like reading hymnals and prayer books. While the can downlight has found diverse applications, it remains an essential fixture for task lighting purposes.

Given that most rooms require more task lighting than ambient lighting, it is often energy-efficient to provide higher task lighting levels only where needed. This approach is known as the task-and-ambient or task/ambient design, where separate lighting layers are employed to minimize energy consumption, especially in offices, factories, and other workspaces.

Examples of task lighting include recessed and track lighting, pendants, under-cabinet lighting, floor, desk, and table lamps, as well as bathroom vanity lights.



Figure 23. Directional Spotlights and Floodlights [Source: Lighting for Interior Design]

D. Decorative Layer:

The Decorative Layer in lighting can be likened to the "jewelry of architecture." Similar to jewelry in fashion, its main purpose is to catch the eye and make statements about style or luxury. Decorative lighting plays a crucial role in interior design and themed environments, serving as ornaments to enhance the space's aesthetics. Examples of decorative lighting include chandeliers, sconces, lanterns, pendants, lamps, ceiling surface lights, and other traditional lighting types primarily used for their decorative value. Some utilitarian lighting fixtures have also become important decorative elements in themed designs. However, it is essential to note that many decorative lights may not provide sufficient illumination for functional tasks. As a result, accent lights or other functional lighting sources are often added to complement the decorative lighting and serve practical purposes. Decorative lights add visual interest and ambiance to a space, and there is a wide variety of decorative light types available to suit different interior styles and preferences.

- **Chandeliers:** Chandeliers are elaborate and decorative ceiling-mounted light fixtures with multiple arms or tiers adorned with crystals, glass shades, or decorative elements. They are popular in formal dining rooms, entryways, and spacious living areas.



Figure 24. Contemporary Chandelier over a dining table [Source: Google Images]

- **Crystal Chandeliers:** Crystal chandeliers are iconic and classic, featuring cut glass crystals that create a dazzling and glamorous effect, often seen in traditional and formal spaces.
 - **Candle Chandeliers:** These chandeliers mimic historical designs with real candle holders, though modern versions use electric candle-shaped bulbs to add a vintage and romantic ambiance to the room.
 - **Modern/Contemporary Chandeliers:** Contemporary chandeliers offer innovative designs with various materials like metal, glass, fabric, or unconventional items, featuring clean lines and artistic touches suitable for modern and minimalist interiors.
 - **Rustic Chandeliers:** Rustic chandeliers have a natural and rugged appearance with materials like wood, wrought iron, or distressed metal, perfect for creating a cozy atmosphere in farmhouse-style or lodge-inspired spaces.
 - **Transitional Chandeliers:** Transitional chandeliers blend classic and modern elements, making them versatile enough to complement a wide range of interior styles.
 - **Beaded Chandeliers:** Beaded chandeliers feature strings of beads or pearls, adding texture and visual interest, ranging from bohemian to glamorous designs.
 - **Drum Chandeliers:** Drum chandeliers have cylindrical or drum-shaped shades enclosing the light sources, providing a contemporary and sleek appearance.
 - **Tiered Chandeliers:** Tiered chandeliers have multiple levels of lights with arms extending outward, creating a majestic look suitable for larger spaces or high ceilings.
 - **Empire Chandeliers:** Empire chandeliers feature cascading designs with rows of crystal or glass beads, exuding elegance and opulence often found in luxury settings.
 - **Industrial Chandeliers:** Inspired by industrial design, these chandeliers have a rugged appearance with metal elements and exposed bulbs.
- **Pendant Lights:** Pendant lights, available in various styles, serve both functional and decorative purposes, becoming focal points or complementing room decor.



Figure 25. Drum Pendant Light [Source: <https://thepurpleturtles.com/products/mozukai-drum-pendant-lamp>]

- **Drum Pendant Lights:** Drum pendants have cylindrical or drum-shaped shades made of fabric or metal, providing soft, diffused lighting for different interior styles.
- **Mini Pendant Lights:** Smaller pendant lights for focused task or accent lighting, often arranged in clusters over specific areas like kitchen islands or dining tables.
- **Multi-Light Pendant Lights:** Consisting of two or more pendant lights on one fixture, multi-light pendants create a statement while offering functional lighting in linear or clustered configurations.
- **Glass Pendant Lights:** With glass shades, these pendants come in clear, frosted, colored, or textured glass, adding elegance and allowing the bulb to be a decorative element.
- **Industrial Pendant Lights:** Reflecting industrial aesthetics, these pendants have metal shades and exposed hardware, commonly used in contemporary and industrial-style interiors.
- **Crystal Pendant Lights:** Featuring sparkling crystal accents or entirely crystal shades, crystal pendants add glamour and elegance, perfect for formal spaces.

- **Wall Sconces:** Wall sconces are decorative lights mounted on walls, offering a variety of styles from traditional to modern, and providing accent lighting, artwork highlighting, or warm ambiance.



Figure 26. Traditional Wall Sconces [Source: <https://in.pinterest.com/pin/147352219028142567/>]

- **Traditional Wall Sconces:** These sconces have classic and ornate designs, inspired by historical or vintage aesthetics, featuring candle-style lights, intricate metalwork, and decorative details, perfect for traditional and formal interiors.
 - **Modern Wall Sconces:** With clean lines and minimalist designs, modern sconces use materials like brushed metal or glass to complement contemporary interiors with sleek shapes.
 - **Industrial Wall Sconces:** Embracing a raw and rugged look, industrial-style sconces feature exposed bulbs, metal shades, and utilitarian designs reminiscent of factory or warehouse lighting.
 - **Crystal Wall Sconces:** Adding elegance and luxury, crystal sconces have crystal accents or shades that refract light, creating a sparkling effect.
 - **Candle Wall Sconces:** Mimicking candleholders, these sconces have either real candles or electric candle-style bulbs, bringing a romantic and vintage touch.
 - **Up/Down Wall Sconces:** Upward-facing sconces create soft, indirect illumination bouncing back into the room, while downward-facing ones provide focused task or accent lighting.
 - **Art Deco Wall Sconces:** With geometric shapes and bold lines, Art Deco sconces evoke the early 20th-century Art Deco movement's style.
 - **Rustic Wall Sconces:** Incorporating natural materials like wood or distressed metal, rustic sconces bring a cozy and rustic charm.
- **Table Lamps:** Table lamps are versatile and decorative fixtures placed on side tables, nightstands, desks, or consoles. They come in various shapes, materials, and sizes, serving as statement pieces or complementing room decor.



Figure 27. Crystal Table Lamps[Source: Google Images]

- **Traditional Table Lamps:** Traditional table lamps have classic designs with intricate details, inspired by historical or antique aesthetics. They often feature ceramic or porcelain bases, brass or bronze accents, and fabric lampshades.
 - **Modern Table Lamps:** Modern table lamps have clean lines, minimalist designs, and use materials like metal, glass, or acrylic. They add sophistication to contemporary interiors.
 - **Industrial Table Lamps:** Embracing a rugged and utilitarian look, industrial-style table lamps feature metal components, exposed hardware, and vintage factory or workshop-inspired designs.
 - **Crystal Table Lamps:** Crystal table lamps exude elegance and luxury with bases or accents made of crystal that refract light, creating a sparkling effect.
 - **Art Deco Table Lamps:** Art Deco table lamps showcase geometric shapes, bold lines, and streamlined designs reminiscent of the early 20th-century Art Deco movement.
 - **Mid-Century Modern Table Lamps:** Drawing from the mid-20th-century design era, these lamps feature organic shapes, sculptural bases, and unique materials like teak or walnut.
 - **Rustic Table Lamps:** Rustic table lamps feature natural materials like wood, reclaimed materials, or distressed metal, creating a cozy and inviting atmosphere in farmhouse or cabin-style interiors.
 - **Task Table Lamps:** Task table lamps are designed for focused lighting during specific activities like reading or working, often with adjustable arms or heads.
 - **Candlestick Table Lamps:** Mimicking candlesticks, these lamps feature slender and elongated bases, bringing a vintage or formal touch to the room.
 - **Multi-Light Table Lamps:** Some table lamps have multiple light sources, allowing different brightness levels or light colors (e.g., warm and cool light) in a single fixture.
- **Floor Lamps:** Floor lamps are freestanding fixtures that offer both ambient and task lighting. They can come in decorative designs with unique lampshades, sculptural bases, or artistic elements.



Figure 28. Arc Floor Lamps[Source: Google Images]

- **Traditional Floor Lamps:** These floor lamps feature classic designs with intricate details, often inspired by historical or antique styles. They may have decorative bases, ornate metalwork, and fabric lampshades.
- **Modern Floor Lamps:** Modern floor lamps have minimalistic designs with clean lines and commonly use materials like metal, glass, or plastic. They are well-suited for contemporary interiors and can serve as focal points in a room.
- **Arc Floor Lamps:** Arc floor lamps have curved arms that extend over furniture, providing overhead lighting without ceiling fixtures. They create cozy reading nooks or add a dramatic touch to the space.
- **Reading Floor Lamps:** Designed specifically for reading or close-up tasks, these floor lamps often have adjustable heads, integrated magnifiers, or built-in task lighting features.
- **Industrial Floor Lamps:** Embracing a rugged and utilitarian look, industrial-style floor lamps feature metal elements, exposed hardware, and vintage-inspired designs.

- **Multi-Light Floor Lamps:** These lamps have several light sources, offering different brightness levels or the ability to create various lighting effects in a single fixture.
- **String Lights:** String lights, also called fairy lights or twinkle lights, consist of small bulbs strung together on a flexible wire. They are commonly used for decorative purposes, especially during festive events or to create a magical ambiance in outdoor areas.
- **Track Lighting:** Track lighting combines functionality and aesthetics, allowing you to direct spotlights to specific areas or objects in a room. Modern track lighting systems come in various sleek designs, adding a contemporary touch to the space.
- **Cove Lighting:** As previously mentioned, cove lighting is a type of indirect lighting that enhances the visual appeal of a room by creating a soft, concealed glow along the edges of walls or ceilings.
- **Lanterns:** Lantern-style light fixtures, whether used indoors or outdoors, can bring a rustic or vintage charm to a space. They are available in various materials like metal, wood, or glass to complement different decor styles.
- **Artistic or Sculptural Lights:** Some decorative lights are true art pieces, designed to be visually striking and unique. These lights can take various forms, such as sculptural fixtures, artistic pendants, or even light installations.

E. Lighting Effects:

- **Downlighting:** Downlighting aims to illuminate the horizontal surface beneath the luminaire. It can be achieved using various fixtures like can downlights, troffers, or industrial luminaires that emit directional light downward.
- **Uplighting:** Uplighting involves illuminating the ceiling, creating indirect lighting by bouncing light back into the space. Uplighting can be achieved with specific luminaires designed for this purpose or by using downlight fixtures installed upside down. Decorative lighting such as sconces and chandeliers can also be used for uplighting.



Figure 29. Left: Non- Directional Pendant; Center: Downlight Pendant; Right: Uplight Pendant[Source: Lighting for Interior Design]

- **Wall Washing:** Wall Washing is the even illumination of a wall from side to side and top to bottom. The goal is to provide uniform lighting, hiding imperfections in the wall but flattening textures. Wall Wash luminaires should be mounted about one-quarter of the wall's height away from it, with spacing between them varying depending on the luminaire used. High-performance luminaires are recommended for efficient and effective wallwashing, especially on gypsum wallboard walls.
- **Wall Grazing:** Wall grazing involves lighting a wall with luminaires placed close to it. This technique uses multiple narrow-beam, high-candlepower lamps closely spaced in a narrow trough near the wall's junction to achieve even illumination. Wall grazing is particularly suitable for highlighting the texture of surfaces like stone and brick. However, it may reveal imperfections in surfaces with a specular (shiny) finish, so caution should be exercised when using this technique on such walls.

IX. APPLICATIONS OF LIGHTS IN DIFFERENT INTERIOR SPACES:

A. Applications of lights in residential spaces:

- **Entryways:** Outdoor lighting at the entrance of the home should be well-lit to warmly welcome guests and identify visitors. Inside, ambient lighting should create an inviting atmosphere and ensure safe

passage to other areas of the house. Ceiling-mounted fixtures are perfect for providing a soft and welcoming light for guests entering the home.

- **Stairways and Hallways:** Proper lighting is essential for safety in stairways and hallways. Fixtures should be placed every few feet in the hallway, and wall washing can effectively define the space, highlight textures, and make the area seem more spacious and well-lit.
- **Utility Rooms:** Recessed lighting with well-diffused ambient light is usually sufficient for utility rooms. For specific task areas, like sorting and mending, consider using track lighting with pendant fixtures for increased illumination and a touch of elegance.
- **Bathrooms:** Lighting in bathrooms should prioritize safety, functionality, and aesthetics. Recessed lighting is ideal for providing comfortable and glare-free illumination. Wall sconces or pendant lights can be used around the sink and mirror for specific task lighting.
- **Bedrooms:** Focus on creating the right mood in bedrooms by using a combination of ambient and task lighting. Recessed lighting near the bed with dimmer switches can provide both accent and task lighting for reading or other activities.
- **Home Offices:** Home offices require comfortable lighting without harsh contrasts or glare, especially for computer use. Task lighting like track lighting over the desk area can help reduce eyestrain, while adjustable track fixtures can highlight pictures and certificates.
- **Emergency Lighting:** For added safety, emergency lights with rechargeable batteries can be used in different areas of the home, providing illumination during power outages.
- **Kitchens:** Kitchens need a blend of ambient and task lighting for efficiency and functionality. Recessed fixtures can be supplemented with under cabinet lighting for ideal task lighting on work surfaces.
- **Dining Rooms:** The lighting in dining rooms should be both beautiful and functional, with chandeliers or track systems providing an elegant focal point. Recessed or track lighting can provide ambient lighting and highlight prized possessions like artwork or sculptures.
- **Living and Family Rooms:** Various activities take place in these rooms, so lighting levels should suit each activity and mood. Accent lighting can be used on artwork and architectural details, while track lighting and recessed downlights can highlight bookshelves and large artwork. Sconces and recessed or track fixtures can create a focal point around the fireplace, and undercabinet lighting can expand the space and add visual interest to the room. Lower light levels should be used near TV and computer areas to avoid distracting glare.

| Color Temperature (Kelvins or K) | Applications |
|----------------------------------|--|
| 2500 | Bulk industrial and security High Pressure Sodium (HPS) lighting. |
| 2700-3000 | Low light levels in most spaces (10 foot candles (FC)). General residential lighting. Hotels, fine dining and family restaurants, theme parks. |
| 2950-3500 | Display lighting in retail and galleries; feature lighting. |
| 3500-4100 | General lighting in offices, schools, stores, industry, medicine; display lighting; sports lighting. |
| 4100-5000 | Special-application lighting where color discrimination is very important; uncommon for general lighting. |
| 5000-7500 | Special-application lighting where color discrimination is critical; uncommon for general lighting. |
| Minimum Lamp CRI | Applications |
| 50 | Noncritical industrial, storage, and security lighting. |
| 50-70 | Industrial and general illumination where color is not important. |
| 70-79 | Most office, retail, school, medical, and other work and recreational spaces. |
| 80-89 | Retail, work, and residential spaces where color quality is important. |
| 90-100 | Retail and work spaces where color rendering is critical. |

Figure 30. The image above shows how various lights are used in various interior settings. [Source: Lighting Design Basics]

B. Exterior Lights:

- Outdoor lighting serves a dual purpose of enhancing the aesthetics of our homes and ensuring safety and security. Well-designed outdoor lighting can significantly increase the value of a house by creating a beautifully illuminated landscape-like view.
- To achieve the perfect outdoor lighting, consider using external light fittings and outdoor LED light fixtures. Hanging lights, posts, and wall lights are excellent choices for providing ambient lighting to various areas outside the house. Pathway lights and security lights serve as task lighting, ensuring safety and convenience.

- Accent lighting can be achieved by using landscape kits and spotlights, adding an inviting and appealing touch to the house's exterior.
- Floodlights are highly powerful and capable of illuminating large areas. They are ideal for driveways and patios, usually installed from above as downlighting.
- Step lights, placed on or beside stairs in the form of uplighting, are essential for safety both indoors and outdoors, as they prevent accidents in dimly lit areas.
- Garden lights are both functional and visually attractive, used to highlight favorite spots or plants in the garden. These lights can cover large areas or focus on specific spots, depending on their setup.
- Bollard lights, lacking a shade or cover, emit light in all directions and resemble posts with lights on top.
- Fairy lights or string lights come in various shapes and sizes, serving as an interesting addition to both indoor and outdoor spaces. When hung through trees and hardscapes, they create a delightful festive ambiance.

C. Applications of lights in office spaces:

- **Panel Lights:** LED panel lights are highly efficient luminaires that offer uniform lighting in workspaces without the need for bulky fixtures that take up a lot of space. They seamlessly integrate with the ceiling, creating a clutter-free and aesthetically pleasing appearance for office environments. These lights can be arranged in various patterns, easily installed in false ceilings, and are well-suited for contemporary office needs. An example of a popular panel light is the Immaculate Trimless LED by Wipro Lighting, widely used in modern offices.
- **Architectural Lights:** Architectural lights are designed to enhance the sense of spaciousness, airiness, and openness in a given area. They are particularly suitable for waiting areas and reception spaces in offices, leaving a positive impression on visitors. Using LED architectural lights and chandeliers from reputable brands can give the office a modern and captivating look.
- **Reading Lights:** Flexible wall-mounted LED reading lights are a practical addition to office spaces, as they assist employees in working with documents and laptops by providing sufficient illumination. Having such luminaires beside chairs allows for easy access to light without the need to repeatedly get up and adjust the lighting. These fixtures not only add functionality but also contribute to a stylish and elegant ambiance. Mounting these reading lights at workstations and cabins can give the entire working environment a professional touch.

D. Applications of lights in retail spaces:

- **Accent Lights:** Accent lighting serves to draw attention to specific areas or merchandise, creating a dramatic effect and emphasizing focal points. It finds great use in retail stores with a luxury ambiance, such as jewelry stores or high-end fashion boutiques. Track spots and LED strip lights are common examples of accent lighting fixtures.
- **Decorative Retail Lighting:** To add charm and ambiance to a store, decorative lighting is employed. It sets the mood and creates a unique atmosphere, making it perfect for retail stores with a fun and playful vibe, like toy stores. Chandeliers, string lights, and paper lanterns are among the examples of decorative lighting used for this purpose.
- **Ambient Lighting:** Ambient lighting provides even illumination throughout a space, creating a relaxed atmosphere that highlights the merchandise. Ceiling lights, wall sconces, and track lights are all suitable options for ambient lighting. It is commonly applied in specialty stores like clothing boutiques.
- **Task Lighting:** Task lighting focuses on providing directed light to specific work or task areas, helping shoppers clearly see products and engage in detailed analysis. Under-cabinet lights and pendant lights are examples of task lighting fixtures. It is particularly beneficial in stores dealing with complex products like electronic devices, appliances, or beauty products.

X. FUTURISTIC TRENDS IN LIGHTING:

- **Smart Lighting and IoT Integration:** The combination of smart lighting systems with the Internet of Things (IoT) was becoming increasingly popular. Smart lighting enabled convenient control, automation, and customization of lighting settings using smartphones, voice commands, or other connected devices.
- **Human-Centric Lighting (HCL):** Human-centric lighting emphasized the design of lighting systems that mimic natural light patterns to support the human circadian rhythm and enhance well-being. HCL involved adjustable color temperatures and intensity levels throughout the day.

- **Li-Fi (Light Fidelity):** Li-Fi, a wireless communication technology, utilized light for data transmission. It had the potential to revolutionize data communication, offering faster and more secure data transfer compared to traditional Wi-Fi.
- **OLED (Organic Light-Emitting Diodes) Lighting:** OLEDs were thin, flexible, and lightweight lighting panels that could be integrated into various surfaces, providing new design possibilities. OLEDs also offered uniform and diffuse lighting with low energy consumption.
- **Advanced Energy-Efficient Lighting Solutions:** LED lighting technology was already energy-efficient, but further advancements in LED efficiency and controls were anticipated. Energy-efficient lighting solutions focused on reducing energy consumption and carbon footprint.
- **Sustainable Materials and Manufacturing:** Lighting manufacturers were exploring eco-friendly materials and more sustainable manufacturing processes in response to the growing emphasis on sustainability, aiming to reduce environmental impact.
- **3D Printing in Lighting Design:** The use of 3D printing technology was expanding to create intricate and customized lighting fixtures with unique shapes and designs, pushing the boundaries of lighting aesthetics.
- **Interactive and Reactive Lighting:** Lighting fixtures that responded to environmental changes, human presence, or user interactions garnered interest. These fixtures could adapt their lighting output based on sensor inputs or user preferences.
- **Artificial Intelligence in Lighting Control:** The integration of artificial intelligence (AI) in lighting control systems allowed for smarter and more dynamic lighting scenarios, optimizing energy consumption and enhancing user comfort.
- **Visible Light Communication (VLC):** VLC technology utilized visible light for communication purposes, enabling applications such as indoor positioning, data transmission, and information display.

XI. CONCLUSION:

In conclusion, this research paper provides a comprehensive understanding of lighting and its profound impact on our surroundings and human well-being. We explored the dynamics of natural and artificial lighting, delving into their generation, units of measurement, and color effects. The benefits of daylighting, including its connection to health and energy efficiency, were underscored, alongside insights on integrating natural and artificial light in interior spaces using diverse window types and placements. The evolution of artificial lighting, its sources, and the various types applied in interiors, as well as futuristic trends, were thoroughly examined. This study emphasizes the importance of a balanced and thoughtful lighting design to optimize human experiences, productivity, and sustainability. By embracing cutting-edge technologies and prioritizing human needs, we can create illuminating environments that brighten our lives and inspire a brighter future.

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