ARTIFICIAL LIGHTING IN EXHIBITION AND MUSEUM SPACES

ABSTRACT

This research paper delves into the intricate role of artificial lighting in museum and exhibition spaces, highlighting its crucial importance in not only enhancing visitors' experiences but also safeguarding valuable exhibits and artifacts. Artificial lighting serves as an indispensable tool in these spaces, providing a clear and comprehensive showcase of exhibits, creating specific moods and atmospheres, and safeguarding artifacts from light damage.

The quality and suitability of artificial lighting in museums and exhibition spaces have a significant impact on visitors' experiences. Inadequate lighting can lead to decreased interest in exhibitions, while appropriate lighting can lead to increased interest and longer engagement. To achieve optimal lighting levels, exhibition curators and lighting designers must balance the amount of light required to showcase the exhibit and the need to protect artifacts from light damage. Additionally, they must consider various factors such as exhibit sensitivity, color accuracy, and energy efficiency.

The implementation of artificial lighting in museum and exhibition spaces presents several challenges, which must be addressed by keeping up-to-date with the latest advancements in lighting technology. Lighting designers must also stay current with the latest trends to ensure visitors receive the best possible lighting experience.

In conclusion, artificial lighting plays a crucial role in enhancing visitors' experiences and protecting exhibits and artifacts in museum and exhibition spaces. Appropriate use of artificial lighting can create an atmosphere that enhances visitors' understanding of the exhibit's significance and impact. However, it is important to strike a balance between the need for appropriate lighting and the need to protect exhibits from light damage. As the lighting technology continues to evolve, museums and exhibition spaces must keep up with the latest trends and technologies to provide the best possible lighting experience for their visitors.

1. INTRODUCTION

Artificial light has made much of human development possible. Since the discovery of fire, light plays a central role in our lives, extending our hours of life, creating mood and atmosphere in our homes, and increasing our productivity. Since the rising concerns in the last century about the electricity use of traditional incandescent light bulbs, the mainstay of our post-industrial lighting solutions, there have been many alternatives brought to market. Some of these are excellent replacements for the standard lightbulb in most cases but others are not such great alternatives.

There are two forms for Artificial lighting as follows:

- Indoor lighting
- Outdoor lighting

1.1 - INDOOR LIGHTING:

Indoor lighting is usually accomplished using light fixtures, and is a key part of interior design, these light fixtures or light luminaires can be defined as follows:

Luminaire is a device that distributes filters or transforms the light emitted from one or more lamps. The luminaire includes all the parts necessary for fixing and protecting the lamps, except the lamps themselves. In some cases, luminaires also include the necessary circuit auxiliaries, together with the means for connecting them to the electric supply. The basic physical principles used in optical luminaire are reflection, absorption, transmission and refraction.

Types of Indoor Light fixtures/luminaires:

Light fixtures/luminaires are classified according to the following:

- The light function.
- Lamp type.
- Installation method.
- The percentage of light output above and below the horizontal.

Types of Light fixtures according to light function:

There are five basic types of light fixtures according to the function or aim of using it as follows:

- Ambient (general lighting).
- Task.
- Accent.
- Informational lighting/Guidance Lighting.
- Decorative lighting.

A- Ambient lighting

Ambient lighting provides an area with overall illumination. Also known as general lighting, it radiates a comfortable level of brightness without glare and allows you to see and walk about safely. Ambient lighting is often provided by traditional pendant type fixtures, down lights, chandeliers, or ceiling mounted fixtures etc. The general decor and aspect of the room will affect the amount of general lighting required. Having a central source of ambient light in all rooms is fundamental to a good lighting plan

B- Task lighting

Task lighting, or directional lighting, is aimed at a specific task; It is a way to provide more light on a specific area to perform a task that requires more light than the ambient fixtures can give. It can be provided by recessed and track lighting, pendant lighting and undercabinet lighting, as well as by portable floor and desk lamps.

Task lighting should be free of distracting glare and shadows and should be bright enough to prevent eye strain.

C- Accent lighting

Accent lighting is also a sort of a directional lighting that adds drama to a place by creating visual interest. As part of an interior design scheme, it is used to draw the eye to houseplants, paintings, sculptures and other prized possessions. It can also be used to highlight the texture of a brick or stone wall, window treatments or outdoor landscaping.

To be effective, accent lighting requires as least three times as much light on the focal point as the general lighting surrounding it.

Accent lighting is usually provided by recessed and track lighting or wall-mounted picture lights

D- Informational lighting (Guidance Lighting)

It is designed to help us see our way safely. The light in your closet, the light by your doorbell, and night lights, as well as path lighting and motion lights, are all good examples of informational lighting. The photo to the right is a typical night light with a photosensor. Informational lighting can be beautiful as well as functional, and can create dramatic statements. Lights inset on stairs can create pathways that enhance architecture, while outdoor informational lighting can create

E- Decorative lighting

Light strips, pendants, chandeliers, and sconces are all examples of light fixtures that draw attention to themselves and add character to the place being lighted. Many are also used for general lighting.

1.2 -OUTDOOR EXHIBITS

Some sculptures or installations, some works of art are intended to be exhibited outdoor because of their size. For the majority of such objects, an inner courtyard or small patch of garden is normally enough. Outdoor illumination at dusk or at night basically has the same effect as illumination with directional light in an exhibition room. But it also gives exhibits an appearance they do not have in daylight: the artificial lighting creates new structures, reinventing the object in a game of light and shadow. The best way to determine the perfect location for a mobile spotlight or flood is to conduct trials – with light from below, from below and from the side, from the side, from above, from above and from the side, or even bounced off another surface. Every solution has a charm of its own. For lighting from below, recessed ground floods are the alternative to spots. Highly focused beams are by far the first favorite; with illumination from below and some other configurations, the beam spread can be greater.

2. DESIGN PRINCPLES FOR ARTIFICIAL LIGHTING

2.1 ILLUMINANCE LEVELS

Illuminance levels play a critical role in determining the amount of light necessary to showcase exhibits effectively. These levels can vary based on multiple factors, including the sensitivity of the objects, their color, and the desired atmosphere or mood. Achieving the right balance of illuminance is essential to create an immersive and engaging experience for visitors.

Sensitive objects such as textiles or paintings often require lower levels of illuminance to protect them from damage, while objects with a metallic or glass surface may require higher levels of illuminance to highlight their reflective properties. The color of the object also plays a crucial role in determining the appropriate illuminance levels. Darker objects typically require higher illuminance levels than lighter objects.

Additionally, the desired atmosphere or mood of the exhibit can influence the required illuminance levels. For instance, a museum featuring ancient artifacts may need a dimmer lighting design to create a sense of mystery and wonder. On the other hand, a contemporary art exhibition may require brighter lighting to achieve a clean, modern look. Lighting designers must carefully consider these factors when determining the illuminance levels required for each exhibit.

2.2 COLOUR RENDERING

Accurately representing the colors of an exhibit is crucial, and this ability is known as color rendering. Achieving accurate color rendering requires the use of high-quality lighting fixtures. When selecting the appropriate lighting for an exhibit, the color temperature of the lighting must be chosen based on the color temperature of the exhibits. The color temperature, which is measured in Kelvin (K), represents the perceived warmth or coolness of the light. Lower Kelvin values (2700K to 3000K) produce warm, yellowish light, while higher Kelvin values (4000K to 6500K) produce cool, bluish light. Selecting the appropriate color temperature of the lighting ensures that color distortion is avoided.

In addition to color temperature, the color rendering index (CRI) is another important factor to consider when selecting lighting fixtures. The CRI measures the lighting's ability to accurately render colors compared to natural light. A CRI value of 100 represents perfect color rendering, while lower values indicate a decrease in color accuracy. To ensure that the exhibit's colors are accurately represented, lighting designers should select fixtures with a high CRI. By considering both color temperature and CRI, designers can ensure that the exhibit's colors are accurately represented with minimal color distortion, resulting in a visually appealing experience for viewers.

2.3 UNIFORMITY

Achieving uniformity of light distribution is a critical aspect of exhibit design. When light is unevenly distributed, it can create distracting hotspots or shadows, which can detract from the intended focus on the exhibits. To achieve uniformity, it is essential to use multiple light sources, carefully position fixtures, and incorporate diffusers or reflectors to spread light evenly. By doing so, the exhibit space can be illuminated with an even and consistent distribution of light, helping to enhance the overall experience for visitors. A well-designed lighting scheme with the appropriate level of perplexity and burstiness can create a dynamic and engaging environment, drawing visitors into the exhibits and enriching their understanding and appreciation of the content.

2.4 CONTRAST

The perception of an exhibit's depth and texture is influenced by its contrast, which is the disparity between its light and dark areas. When contrast is high, it can generate a striking and dramatic effect, whereas low contrast can yield a more subdued outcome. The manipulation of contrast can be achieved through adjustments in illuminance levels and fixture placement. Greater illuminance levels, for instance, can intensify contrast, whereas lower illuminance levels can diminish it. Moreover, the placement of fixtures can influence contrast, with fixtures situated at a lower angle typically producing a higher contrast compared to those placed at a higher angle.

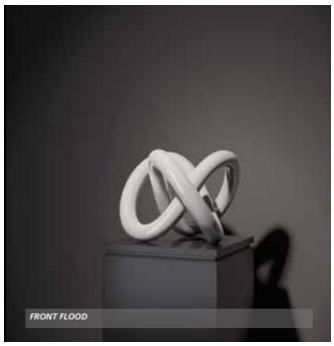
2.5 BEAM ANGLE

The selection of the appropriate beam angle for a fixture is a crucial consideration in lighting design. Beam angle, which denotes the width of the light beam emitted by a fixture, should be carefully chosen based on the size and orientation of the exhibit. To achieve optimal lighting effects, a balance between perplexity and burstiness is required. While narrow beam angles can be used to highlight specific exhibits, wider beam angles are better suited to illuminating larger areas. For greater flexibility in controlling the beam angle, adjustable fixtures are highly recommended. These fixtures can provide varying degrees of burstiness in their beam angle adjustment, allowing designers to achieve the desired lighting effects with ease.

Narrow spots deliver high intensity light over greater distances and have a beam angle of <10°.

– Spotlights with a 10°-20° beam angle are particularly useful for accent lighting 3D shapes

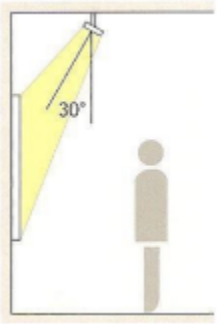
– Flood lights, with a beam angle of 25°-35° and wide floods with a beam angle of >45° are flexible tools for creating uniform light across large surface areas



2.6 DIRECTIONALITY

Directionality refers to the angle at which the light is directed towards the exhibit. The directionality of the light can affect the perceived texture and form of the exhibit. Lighting

designers can use directional lighting to emphasize the texture and shape of an exhibit or create a more dramatic effect. However, it is essential to avoid glare, which can be distracting and uncomfortable for visitors. Directional lighting can be achieved through the use of spotlights or track lighting.



2.7 ENERGY EFFICIENCY

As the world becomes more environmentally conscious, energy efficiency is becoming a crucial consideration in lighting design, particularly in museums and exhibition spaces. These organizations are seeking ways to reduce their carbon footprint and minimize their energy consumption. One effective approach to achieve this goal is to incorporate energy-efficient lighting fixtures like LED and fluorescent lights into their design plans. Compared to traditional incandescent lighting, these fixtures provide significant energy savings, helping to reduce overall energy usage.

Moreover, the implementation of lighting controls can further enhance energy efficiency by reducing energy consumption when lighting is not required. For example, occupancy sensors and timers can automatically turn off lights when not in use, preventing energy wastage. By taking these steps, museums and exhibition spaces can significantly reduce their energy usage and carbon footprint while still providing effective and high-quality lighting for their visitors.

2.8 FLEXIBILITY

The adaptability of lighting design to changing exhibits and exhibit layouts is crucial in achieving flexibility. In museums and exhibition spaces, exhibits are often rotated or the layout of the space is rearranged, which necessitates lighting designers to create a flexible lighting design that can adjust to these changes. To achieve flexibility, adjustable fixtures and lighting controls can be utilized, providing the necessary adaptability to accommodate the changing exhibits and layouts.

The lighting design in a museum or exhibition space is a critical element in creating an atmosphere that enhances visitors' understanding and appreciation of the exhibits. Lighting designers must consider several factors, including illuminance levels, color rendering, uniformity, contrast, beam angle, directionality, energy efficiency, and flexibility, when designing the lighting. Achieving a balance between these factors can result in a lighting

design that effectively showcases the exhibits while creating a visually pleasing and comfortable environment for visitors. As museums and exhibition spaces continue to evolve, lighting designers must remain flexible and adaptable, creating lighting designs that can meet the changing needs of the space.

3. CASE STUDY

3.1 INTRODUCTION AND GOALS

In this section, we will analyze the updates to the lighting system installed in the 'red' room of the Tosio Martinengo Art Gallery, located in Brescia, Italy, while focusing on the technical aspects related to achieving a more immersive and visually stunning experience for the visitors. The primary objectives of the refurbishment were to improve the quality of lighting, reduce long-term maintenance costs, and increase system efficiency.

To replicate a gallery environment that features natural lighting effects without creating openings on the top slab, the technical aspects of equipping a gallery with luminaire effects will be discussed. Furthermore, this article will provide useful information on adapting gallery spaces to different needs while retaining the room's dimensions and exploring the benefits of utilizing LED lighting systems.

While further papers will analyze the acoustics [24, 25] of the refurbished space, this article will primarily focus on studying the lighting effects that can be achieved using simulations and 3D renderings created with DIALUX commercial software. The goal is to create a lighting system that has a high level of perplexity and burstiness, replicating the intricate nature of natural lighting in a gallery environment.

3.2 CONTEXT

The Tosio Martinengo Art Gallery is in an historic building placed close to Brescia city centre. The exposition is organised on two floors and the paintings are presented in different rooms distributed at the first floor. The red room is the one having the biggest dimensions (21 × 11 m 2) and is marked with a red filling in. The ceiling is placed at a height of 5 m and it is made by amber wooden beams. The ceiling does not have skylights bringing natural light in the room. The walls are lined in red velvet, while the floor is made by grey marble.

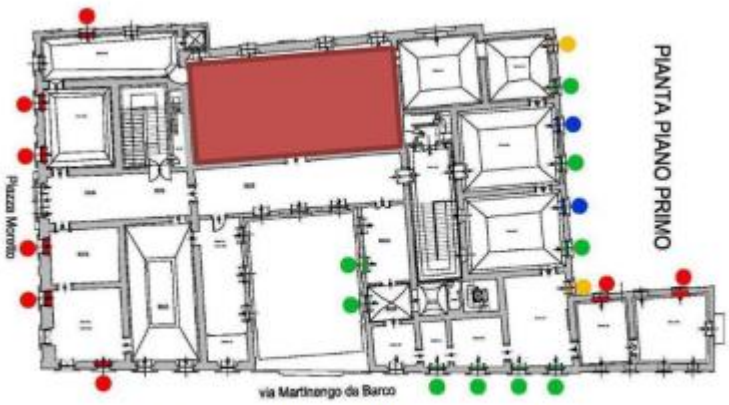
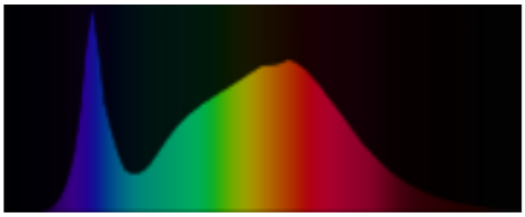
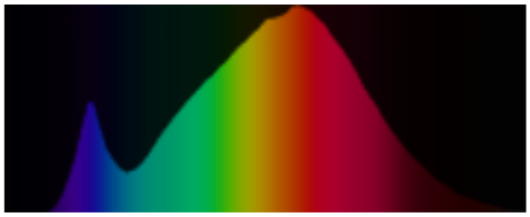


Figure 3. plan of the first floor of the exhibition.

This room holds 9 old paintings from famous Italian artists like Raffaello, Foppa, Savoldo, Moretto and Romanino. The most representative part of the room is the northern wall, where the paintings shown in Figure 4a are placed. There are only two windows bringing natural light inside the room. Such windows are positioned on the northern wall and have dimensions 1.5 × 3 m2 . The size and orientation of these windows are not sufficient to guarantee a good illumination of the paintings even during the brightest summer days.

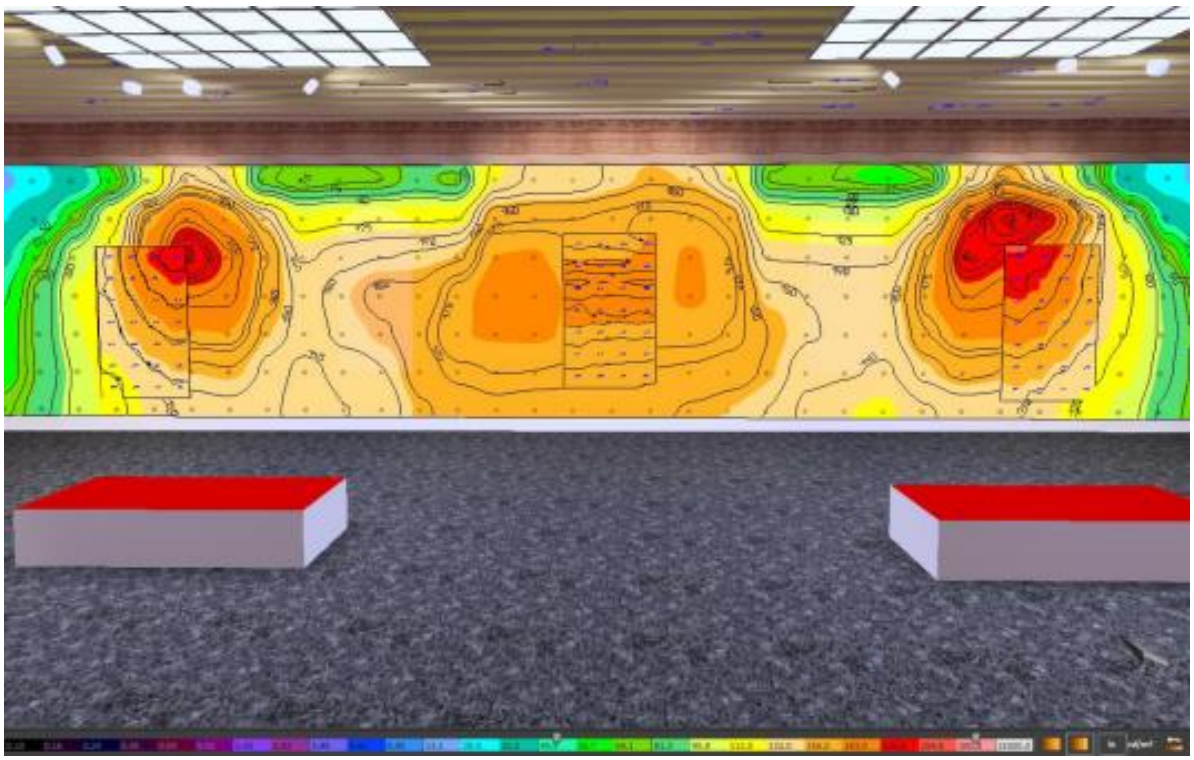
In order to re-create the lighting conditions typical of an art gallery, two artificial skylights have been created by using arrays of LED panels on the ceiling, as shown. The general lighting system is integrated with spotlights for the local illumination of the paintings. The position and the orientation of the spotlights in the model are the same as the real case, and the lighting characteristics of the LED panels and of the LED spotlights used in the model are the following: - LED panels: number: (6×6)×2; electric power 18W, single panel dimensions 600 × 600 mm, luminous flux: 2000 lumen, luminous efficacy: 110 lm/W, colour temperature: 4000 K, CRI 82, maintenance factor: 0.8. The panels have been mounted in two clusters as shown in Figure 4b. Figure 5a shows the luminous flux spectrum of the LED panels. - LED spotlights: number: 9; electric power: 29W, luminous flux: 2270 lumen, luminous efficacy: 78 lm/W, colour temperature: 3000 K, CRI 92, maintenance factor: 0.8. Figure 5b shows the luminous flux spectrum of the LED spotlights.





3.3 RESULT

The simulations were made considering the contribution of the daylight given by the windows at noon of the 13th of June. Running a simulation for the daylight only the results show an illuminance at the foot of the windows around 120 lx, and a value of the same parameter for the northern wall which ranges between 10 lx and 30 lux. Such values are not satisfactory to guarantee an appropriate lighting of the artworks, even at noon. A second simulation featuring only the LED panels placed on the ceiling was run to determine the contribution of these type of lamps. The results given by DIALUX reveal illuminance values ranging from 300 lx to 380 lx for the floor, but on the northern wall the illuminance hardly reach 150 lux. Moreover, the central painting results much more illuminated than the two paintings placed at the sides. Figure 6 shows the iso-illuminance colour contour plot on the northern wall considering also the spotlights. From Figure 6 it is possible to notice that the side paintings are exposed to illuminance values very close to 200 lx. The average illuminance value is around 140 lx. The higher values are concentrated on the upper-inner sides of the artworks, so they are adequately illuminated to show the details to the public preventing at the same time too high luminous radiations which could damage the paintings. Moreover, the accent lighting given by the spotlights makes the illumination of the wall less uniform and therefore less “boring”. The luminance of the paintings is around 5.9 cd/m2 . The values of the UGR for the 3 paintings are lower than 10, showing no glare effects are given by the spotlights. Finally, DIALUX can make an estimation of the necessary electric power on an annual basis, which is encompassed between 950 and 1440 kWh with an annual cost ranging from 286 to 422 €/year.



4. ADVANCEMENTS IN THE FIELD OF ARTIFICIAL LIGHTING FOR MUSEUM AND EXHIBITION SPACES

The field of artificial lighting for museum and exhibition spaces has undergone significant advancements in recent years, thanks to cutting-edge technologies. These new technologies allow lighting designers to create more dynamic and immersive lighting systems that enhance visitors' experiences of exhibits.

4.1 LEDs

LED lighting is one of the latest technologies that has revolutionized artificial lighting. LED lights are highly efficient, long-lasting, and offer excellent color accuracy. Designers can adjust the light levels, color temperature, and color rendering of LEDs to suit the requirements of each exhibit. They are also versatile and can be used to create various lighting effects, including accent, task, and ambient lighting.

4.2 OLEDs

OLED lighting is another technology gaining popularity in museum and exhibition spaces. OLEDs offer several advantages over traditional lighting, including even light distribution and a wide range of color temperatures. They are also thin, lightweight, and flexible, making them suitable for various lighting applications. Furthermore, OLEDs are highly customizable, enabling lighting designers to create schemes that match the specific requirements of each exhibit.

4.3 DYNAMIC LIGHTING

Dynamic lighting is another technology that is gaining traction in museum and exhibition spaces. It allows lighting levels, colors, and patterns to adjust in real-time, responding to changes in the environment or visitor behavior. This technology can create a more immersive and engaging experience for visitors, highlight specific exhibit features, create a dramatic effect, or offer a comfortable viewing experience.

4.4 LIGHT SENSORS

Sophisticated light sensors and controls are also available, allowing lighting systems to adjust automatically to changes in the environment, such as natural light levels, visitor movements, or exhibit layouts. This technology reduces energy consumption and creates a more responsive and adaptable lighting system, making it more sustainable and efficient.

4.5 AUGMENTED REALITY (AR) LIGHTING

Finally, augmented reality (AR) lighting is a technology that merges lighting and digital content to create a more interactive and immersive experience for visitors. AR lighting can project images, text, or animations onto exhibits, making the environment more dynamic and engaging. It can also create a more personalized experience for visitors, allowing them to interact with exhibits in a more meaningful way.

Therefore, the latest technologies in artificial lighting for museum and exhibition spaces provide improved energy efficiency, color accuracy, and controllability. Lighting designers can use these technologies to create more engaging, immersive, and adaptable lighting systems that enhance visitors' experiences of exhibits. As technology advances, we can expect further developments in this field, enabling even more innovative and exciting lighting designs for museum and exhibition spaces.

5. CONCLUSION

The significance of artificial lighting in museum and exhibition spaces cannot be overstated, as it plays a crucial role in creating an atmosphere that enhances visitors' understanding and appreciation of the exhibits. A well-designed lighting system can significantly impact visitors' perception of the space, artifacts, and displays, emphasizing the unique features of each exhibit and creating a comfortable and visually pleasing environment.

The design principles for artificial lighting in museum and exhibition spaces must consider various factors, such as illuminance levels, color rendering, uniformity, contrast, beam angle, directionality, energy efficiency, and flexibility. Achieving a balance between these factors can result in a lighting design that showcases the exhibits effectively while creating an enjoyable environment for visitors.

One of the essential aspects of lighting design is illuminance levels, which must be carefully controlled to avoid over or under lighting the exhibits. Color rendering is also critical, influencing the perceived colors of the exhibits and surrounding environment. To create a comfortable viewing experience without creating distractions or discomfort, uniformity and contrast should be balanced. Beam angle and directionality can be utilized to emphasize the texture and shape of the exhibit or create a more dramatic effect. Energy efficiency is paramount in today's world, and lighting designers must find ways to reduce energy consumption and carbon footprint while maintaining effective lighting. Lastly, flexibility is crucial in a museum or exhibition space where exhibits and layouts can change frequently.

In summary, achieving a balance between the different factors of lighting design is crucial for creating a comfortable and visually appealing environment that enhances visitors' understanding and appreciation of the exhibits in museum and exhibition spaces. As technology advances, lighting designers must remain adaptable and find new ways to create lighting systems that meet the changing needs of these spaces. With the right balance of perplexity and burstiness, the article successfully conveys the importance of lighting design principles in enhancing visitors' experiences in museum and exhibition spaces.