Building Electrical Installation

Level - V

Based on December, 2024, Curriculum Version 2

MODULE TITLE: Providing Advice on Effective and Energy Efficient Lighting Products

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Acronym

OHS	Occupational Health and Safety
CFL	Compact Fluorescent Lamp
LED	Light Emitting Diode
CAD	Computer Aided Design
LD	Light Design
CCT	Correlated Color Temperature
OPR	Owner's Project Requirements
BOD	Basis of Design
ROI	Return on Investment
LEED	Leadership in Energy and Environmental Design
CxA	Commissioning Authority
IECC	International Energy Conservation Code
CRI	Color Rendering Index
IES	Illuminating Engineering Society
NEMA	National Electrical Management Agency
WHS	Work Health and Safety
LPW	Lumens Per Watt

Introduction to Module

In Building electrical installation field, Providing Advice on Effective and Energy Efficient Lighting Products is very important for the overall designing and using light service. It helps to know basic efficient of light concepts, methods of light designing effectively in the industrial, commercial and residential buildings.

This module is designed to meet the industry requirement under the Building electrical installation occupational standard, particularly for the unit of competency: Provide Advice on Effective and Energy Efficient Lighting Products.

This module covers the units:

- Providing advice of lighting products
- Basic knowledge of lighting product data

Learning Objective of the Module

- Apply Procedure of OHS
- Explain light drawing.
- Explain basic Terms and definitions of lighting products
- Identify Electromagnetic spectrum and illumination standards
- Obtain lighting document

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units

Unit one: Providing Advice of Lighting Products

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Basic terms of lighting products
- Purpose and types of lights
- Lighting Design
- Light and Identification Codes
- OHS requirements

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify basic terms of lighting products
- Explain Purpose and types of lighting products
- Demonstrate Operating principles of lighting products
- Identify Automotive Battery Rating and Identification Code
- Apply OHS requirements and personal protection needs

1.1. Procedure of OHS

Safety Guide for Electrical Engineers on Site Inspections

Common Hazards on Site

Electrical engineers face numerous hazards on-site, but one of the most significant is exposed, energized wiring. This hazard is particularly dangerous because it can be easily overlooked. If an engineer unknowingly comes into contact with live equipment, it can lead to severe injury or even death.

Preparing for Safety

Preparation is the cornerstone of staying safe. Before heading to a site, it's essential to gather as much information as possible:

- Identify who will be on the site, including owners, contractors, other engineers, and architects.
- Understand which parts of the site are currently active and being worked on. This helps in identifying high-risk areas and planning your inspection route to avoid exposure to hazards.
- Review the building's electrical distribution system thoroughly. Familiarize yourself with the layout, the location of key electrical components, and any areas that might pose a risk.

On-Site Safety Protocols

Once on site, adhering to strict safety protocols is crucial. Here are some key practices to follow:

- Avoid touching anything that might be live. This includes wires, panels, and other electrical components. If there's any doubt about the status of equipment, assume it's live and dangerous until proven otherwise.
- For any close inspections of potentially hazardous always call in a qualified electrician to assist.
- Essential Personal Protective Equipment (PPE) for electrical engineers includes:
- Steel toe boots: These protect your feet from heavy objects and provide insulation against electrical hazards.
- High visibility vests: make you easily identifiable on a busy site, reducing the risk of accidents.
- Safety glasses: These protect your eyes from dust, debris, and potential electrical arcs.

Checking Equipment

Double-checking is a crucial step that can prevent accidents and ensure a secure inspection environment. It's a simple practice that significantly reduces the risk of injury. Always follow the mantra: "Test before you touch." This not only protects you but also sets a good example for others on the site.

Handling Safety Protocol Violations

If you encounter situations where safety protocols are not being followed, it's important to act promptly and responsibly:

- Inform the general contractor about the hazard immediately. They have the authority and responsibility to address safety issues on site.
- Allow the contractor to address the issue with their team. It's important to respect the chain of command and ensure that the right people are informed.
- Document any incidents in your site visit report. Note what the hazard was, how it was identified, and how it was corrected. This documentation is crucial for accountability and for improving future safety protocols.

Reporting safety violations not only helps in addressing immediate hazards but also contributes to a culture of safety on the site.

Importance of Communication

Effective communication on-site is vital for maintaining safety. Engineers and contractors need to stay informed about ongoing activities, potential hazards, and any changes in the inspection plan:

- Regular safety briefings and meetings can help keep everyone on the same page.
- Use clear, concise language to communicate safety instructions and updates.
- Ensure that all communication channels are open and accessible, whether it's through radios, phones, or face-to-face meetings.

Good communication ensures that everyone understands the safety protocols and knows what to do in case of an emergency. It helps in coordinating efforts and ensuring that safety measures are consistently applied.

Staying Updated with Safety Standards

Keeping up with the latest safety standards and regulations is crucial for any electrical engineer. This involves:

- Regularly talking with colleagues and industry professionals to share knowledge and experiences. These conversations can provide valuable insights into new safety practices and emerging hazards.
- Consulting resources like NFPA 70e, which offers guidelines on best practices for electrical safety. This standard covers everything from personal protective equipment to procedures for safe work practices.

OSHA Workplace Lighting Requirements

OSHA workplace lighting standards cover everything from the recommended lighting level of offices to light cover requirements and many other topics in between.

Will get to these in a minute, but first a few lighting and OSHA terms must be explained:

The Recommended Lighting Level of Offices

Since appropriate illumination enhances (or diminishes) your workers' ability to see computer monitors, the recommended lighting level of offices is different from other workplaces. Straining to see text and images on a screen makes it difficult to work, and it can lead to mistakes and eye fatigue.

To combat this problem, OSHA has made the following lighting recommendations for offices:

- Place well-distributed rows of diffuse lights parallel to the line of sight.
- Provide supplemental task and desk lighting.
- Use blinds on windows to eliminate bright light (vertical blinds for windows that face east and west and horizontal blinds for windows that face north and south.
- Orient the computer so window lighting is at a right angle to the screen.
- Use light colors and matte finishes on walls and ceilings to reduce contrast and soften lighting reflections.

General construction areas require a minimum of 5 foot-candles of illumination, and plants and shops require at least 10 foot-candles.

For other types of workplaces, the minimum illumination standards are as follows:

- First-aid stations and infirmaries: 30 f-c
- Warehouses, walkways, and exits: 10 ft-c
- Underground shafts and tunnels: 5 ft-c
- Waste areas, loading platforms, refueling areas, active storage areas: 3 ft-c

And here are the typical lux levels required in common commercial installations:

- Offices, laboratories, and show rooms: 500 lux
- Factories and workshops: 750 lux
- Warehouse loading bays: 300–400 lux
- Lobbies, corridors, and stairwells: 200 lux
- Warehouse aisles: 100–200 lux

OSHA Light Cover Requirements

OSHA light cover requirements state that all light fixtures must have protective plates. If light fixtures are in an area where they could be damaged, they must be guarded by strong barriers to prevent shattering. This is also the requirement for covers of pull boxes, junction boxes, and fittings.

Additionally, light fixtures:

- Should be at least 7 feet above work surfaces or must have an OSHA-compliant shatterproof shield
- May not have any exposed live parts
- Cannot have an opening large enough that a finger can fit through
- Must be firmly mounted to the wall

1.2. Basic Knowledge of Light Design

1.2.1. Basic Terms and Definitions of Lighting Products

Lighting Efficacy

Light efficacy is a follow-up lighting term of wattage and lumens. It measures how well the light source produces visible light and it is calculated by lumens per watt.

Figure 1.1: Light efficiency

Most products typically have this measurement provided due to the increasing importance of efficacy nowadays. Nonetheless, it is still very simple to figure out light efficacy of a given product based on other measurements

Fluorescent lights: including compact fluorescent lamps (CFL) are *more energy efficient* than incandescent and halogen light bulbs – so they *cost less to run*.

CFLs are quite popular in homes as they have the convenience of being direct replacements for many traditional and halogen incandescent bulbs – as are more efficient LED lights. Fluorescent tubes have a different fitting (the ballast) and are often used in garages, offices and other workspaces.

Halogen light: In other words, a halogen bulb can have the same light output (lumens) as a traditional (standard) incandescent lamp using less energy (Watts). This means it's more energy efficient – though nowhere near as efficient as a CFL or LED.

Ornamental light: Decorative Luminaries installed indoor that are chandeliers, sconces, lanterns, neon and cold cathode, light emitting diodes, theatrical projectors, moving lights, and light color panels.

Incandescent lamp: The traditional or standard incandescent lamp was the most common type of light bulb type for more than 100 years.

However traditional light bulbs use lots of electricity and don't last very long compare to other lighting types such as CFL and LED.

Sodium vapour lamp: A lamp in which an electric discharge takes place throughout a metallic vapor is known as a vapor lamp.

Sodium vapor lamps are widely used for **lighting in outdoor areas like roadways, parking, security areas, airports, etc**.

LED Bulbs: A quality LED produces the *most* light with the *least* electricity. Fortunately, their purchase price is also continuing to go down.

Smart LED bulbs are usually controlled by a smart phone app. They can be remotely switched on and off and adjusted to change their brightness (lumens) or color temperature.

Security Lighting: A functional solution to illuminate a landscape, driveway or parking area for convenience and as a deterrent to any criminal activities for homeowners' safety. Most Security Lighting is switched on by a sensor when it is dark or when it senses motion (or both).

Sconce: Wall mounted fixture with a incorporated diffuser design or derived from the form of chandelier, often with exposed or decorative light sources.

Shade: A component that covers the light bulb on a light fixture to diffuse the light it emits.

Shop Lighting: Usually refers to garage lighting. Ceiling-mounted fluorescent light fixtures to provide ambient lighting or installed above your workbench to provide task lighting.

Cabinet Lighting: Lighting fixtures installed under a cabinet, shelf, or similar surface in order to produce localized lighting. Cabinet Lights can be installed inside cabinets to illumniate decorative

Luminous efficacy is a measure of how well a light source produces visible light. It is the ratio of luminous flux to power, measured in lumens per watt in the International System of Units (SI). Depending on context, the power can be either the radiant flux of the source's output, or it can be the total power (electric power, chemical energy, or others) consumed by the source

Table 1.1: luminous efficacy

Type	Luminous efficacy of radiation (lm/W)	Luminous efficiency
Tungsten light bulb, typical, 2800 K	15	2%
Class M star (Antares, Betelgeuse), 3300 K	30	4%
Black body, 4000 K, ideal	54.7	8%
Class G star (Sun, Capella), 5800 K	93	13.6%
Black-body, 7000 K, ideal	95	14%
Black-body, 5800 K, truncated to 400–700 nm (ideal "white" source)	251	37%
Black-body, 5800 K, truncated to ≥ 2% photo pic sensitivity range	292	43%
Black-body, 2800 K, truncated to ≥ 2% photo pic sensitivity range	299	44%
Black-body, 2800 K, truncated to ≥ 5% photo pic sensitivity range	343	50%
Black-body, 5800 K, truncated to ≥ 5% photo pic sensitivity range	348	51%
Monochromatic source at 540 THz	683 (exact)	99.9997
Ideal monochromatic source: 555 nm (in air)	683.002	100%

1.2.2. Lighting Design

Concept of Lighting design

Although many think that lighting design is simply finding the right lighting fixtures for a space, and this is broadly true, it is a complex process led by the lighting designer.

This lighting design process requires the combination of technical, aesthetic and experiential knowledge and aims to achieve the transformation of all types of spaces based on the experience of the users and their needs. It also aims to highlight the architecture or the main design elements to achieve an attractive and original result.

Throughout the process we study the characteristics of each space, the objectives to be achieved and the variables that affect the lighting to achieve several things:

- Avoid that the result is different from the expected one.
- Achieve the objectives set.
- To give rise to functional and attractive spaces.

Lighting design in architecture and design

The process of lighting design in architecture and interior design, is understood as a study on the light of each space, its application and its interaction with other elements.

Lighting design in architecture and design is based on adapting the lighting to the needs and well-being of the users, and precisely for this reason it must generate an emotional response. it is necessary not only a previous study of the project, but also a detailed planning to achieve the perfect result.

In this sense, knowing the needs of the people who will inhabit the facilities is key to achieving lighting that combines wellbeing, luminosity and harmony.

Functions of the lighting designer

A lighting designer is a lighting specialist profile.

The lighting designer works together with interior designers and architects to achieve, with light, the objectives of the project, making recommendations based on their knowledge and experience in lighting design.

In addition, a lighting designer must be constantly updated on news, lighting trends, quality standards and regulations, as these are aspects that largely condition the choices that are made throughout the lighting design process.

Generally, the work process of a lighting designer goes through the following stages:

Preliminary analysis of the lighting project: the characteristics and requirements of the project and the space are studied.
Technical project: it is the development of the lighting design project itself, the lighting calculations, the choice and arrangement of luminaires, etc.

Associate lighting designer

The associate lighting designer (associate LD) will assist the lighting designer in creating and executing the lighting design. While the duties that an LD may expect the associate LD to perform may differ from person to person, usually the assist, LD will do the following:

- Attend design and production meetings with or in place of the LD
- Attend rehearsals with or in place of LD and take notes of specific design ideas and tasks that the lighting department needs to accomplish
- Assist the LD in generating the light plot, channel hookup and sketches
- If needed, the Associate may need to take the set drawings and put them into a CAD program to be manipulated by the LD this job is usually given to the assistant LD if there is one).
- The assistant LD may be in charge of running focus, and may even direct where the lights are to be focused.
- The associate is generally authorized to speak on behalf of the LD and can make creative and design decisions when needed (and when authorized by the LD). This is one of the biggest differences between the Associate and the Assistant.

General Design Considerations

a. **Load Calculations:**
   - Verify total connected load and demand load calculations.
   - Confirm that the service entrance and feeder sizing are adequate.

b. **Service Entrance:**
   - Ensure proper sizing and placement of the service panel.

- Confirm that the service entrance conductors are adequately rated and protected.
- Verify proper grounding and bonding of the service.

c. **Panel boards:**

- Ensure proper placement of panel boards, including accessibility and clearance.
- Verify that the panel boards are adequately rated for the connected loads.
- Confirm proper circuit breaker sizing and type.

d. Single Line Diagram (SLD) and Key Notes

- Review the SLD and corresponding key notes.
- Ensure compliance with utility standards.
- Consider wall-mounted or freestanding configurations, solar taps, and meters for ADUs.
- Utilize Siemens electrical equipment.
- Ask Michael from Siemens for switchgear selection.
- Ensure sufficient space for electrical equipment.
- Typically, utility companies that are part of California Public Utilities Commission (CPUC) do not allow 3rd party metering.

e. **Electrical Room Coordination:**

- Collaborate with the architect to ensure adequate space for the electrical room.
- Verify sufficient room for solar disconnects.
- Coordinate with the architect for the solar equipment room.

f. Feeder Schedules:

- Review feeder schedules.
- Specify conductor and conduit types (SER, PVC, EMT).

g. Voltage Drop and Fault Current:

- Check voltage drop and fault current calculations.
- Provide worst-case voltage drop calculations.
- Add an autotransformer if the elevator control panel fault current exceeds 10K.
- Feeder voltage drop should not exceed 3%, Branch voltage drop should not exceed 3%, and overall feeder and branch should not exceed 5%.

h. **Electric Vehicle (EV) Load Calculation:**

- Perform EV load calculations.
- Collaborate with the architect on EV location planning.
- Adhere to CAL Green standards for EV after July 1, 2024

i. **Site Lighting:**

- Coordinate with the architect and client for pole lights and bollards.
- Work with the landscape architect to avoid tree conflicts.
- Collaborate with the civil engineer to avoid water and sewer pipes and fire hydrants.
- Implement motion sensors for pole lights over 40W and less than 24 feet height.
- Verify photometric calculations and lumens.
- Coordinate with the architect and client for emergency lighting and battery backups.
- Check light spill past the property lines and any light spill that will go into a residential unit's window. Provide house-side shield on pole light as needed.
- For outdoor lighting, if the light fixture is 6200 lumens or greater, then check that the BUG ratings (Backlight, Up light, Glare) meet the requirements per Cal Green section 5.106.8.

j. . Units

- Check lighting and receptacle layout.
- Avoid conflicts with mechanical equipment.
- Verify GFCI and AFCI compliance.
- Ensure subpanel locations are not in shear walls.
- Check receptacle layout for islands and peninsulas in kitchens.
- Ensure the counter top receptacle comply with ADA.
- Smoke detectors shall not be within 10 feet of a cooking appliance unless listed for installation near cooking appliance.
- Provide smoke detectors inside each bedroom, and directly outside the bedroom.
- Avoid conflicts with smoke detectors and mechanical registers/grilles (should be at least 3 feet away)
- For safety, add GFCI in addition to AFCI for the circuit breaker that serves the bathroom lighting.

k. . Title 24

- Review Title 24 calculations.
- If the **general lighting** (does not include decorative lighting) in the primary daylight zone is more than 120W, daylight sensors are required and need to be indicated in Title 24 LTI forms.

l. Special Systems

- Smoke and Carbon Monoxide Detectors.
- Low-Voltage **System**

LIGHTING DESIGN REQUIREMENTS

- **Energy conservation**

The following strategies shall be evaluated for use:

- Design shall include task lighting that allows occupants to achieve task illumination for specific visual tasks such as reading, writing, medical examination, and surgery procedures etc.
- Design shall include daylight harvesting where practical.
- Design shall use vacancy sensor instead of occupancy sensor where practical.
- Design shall use occupancy sensors in public rest rooms and large multi- occupant spaces.
- Design shall select luminaires with maximum efficiency.
- Design shall avoid lighting above or in front of illuminated vending machines.
- Design shall limit façade lighting to public entrances.
- Design s**hall include automatic lighting control system in conjunction with by- pass switches for lighting circuits in non-patient care areas and where practical**

- **Lighting design strategies**

In order to achieve design objectives stated in this manual, A/E should employ design strategies with focus on the applications and tasks of the space/room and the occupants /users.

- **Lighting design objectives**

Lighting design shall meet the following primary objectives:

- **Interior**

✓ Design for Safety and Security: Lighting systems shall effectively support patient care and safety, life/fire safety and security for patients, staff, and visitors

✓ Design for Function: Lighting systems shall provide sufficient level of lighting for patients, staff and visitors to effectively perform designated applications and tasks.

✓ Design for Visual Comfort: Lighting systems shall contribute to the visual comfort for patients, staff, and visitors. Glare should be mitigated using practical design methods and correct specification of luminaires.

✓ Design for Maintenance and Operation: Lighting systems shall be easily maintained and operated. Similar components of luminaires from different manufacturers should be compatible and interchangeable

- **Exterior**

✓ Design for Safety and Security: Lighting systems shall contribute to maintain effective safety and security for patients, staff, visitors, and property.

- ✓ Design for Function: Lighting systems shall provide sufficient level of lighting for patients, staff, and visitors to effectively perform applications and tasks such as driving, parking and walking, as well as way finding.
- ✓ Design for Maintenance and Operation: Lighting systems shall be easily maintained and operated. Similar components of luminaires from different manufacturers should be compatible and interchangeable

- **Lighting control design strategies and objectives**

Light control design strategies with focus on effective patient care and safety, life/fire safety and security, and energy conservation.

- **Lighting control design methodologies**
  - ➢ **INTERIOR**

- ✓ Light Control. Exceptions to each category of control requirements shall be taken into consideration for the design.
- ✓ Do not use time-scheduled lighting controls such as time clocks, astronomical clocks and timers for patient care space, and utility closet/rooms/vaults.
- ✓ Provide automated lighting controls only after careful consideration that safety and security is not compromised
- ✓ Maximize daylight harvesting, where applicable.
- ✓ Provide override devices where automated lighting controls are installed. Local override devices shall be readily accessible and labeled
- ✓ Provide a Lighting Control Zone Schedule on the drawings.
- ✓ Integrate automated lighting controls with BAS controls, where possible

  - ➢ **EXTERIOR**

- ✓ Lighting control requirements and exceptions shall comply with the latest
- ✓ Utilize automated control
- ✓ Use photo-electric sensors to control all outdoor luminaires
- ✓ Use infrared motion sensors to reduce illumination in non-essential areas that require illumination but are not commonly occupied after operating hours.
- ✓ Use programmable time clock controls or BAS time control in non-patient care areas that are unoccupied after operating hours

- **Luminaire selection guidelines**
  - **interior**

✓ project requirements, preexisting conditions (if any), and latest applicable codes.

✓ Review product installation data to assure compliance with specifications

✓ If LED is specified, review LED luminaires to evaluate glare control, flicker rates, and color rendering capabilities.

✓ Confirm luminaire construction shall be able to withstand surface wipe down disinfection.

✓ Lenses shall not deflect on contact

✓ Sterile environments shall utilize sealed and gasketed luminaires

✓ Luminaires in patient-care areas shall be provided with lens

✓ In a VA project, ceiling mounted surgery light – single or multiple light heads – provides task illumination for delicate surgical tasks.

  - **exterior**

✓ standard details to meet project's scope, specific project requirements, pre-existing conditions (if any), and latest applicable codes.

✓ Review product data to assure compliance with specifications.

✓ Luminaires shall be UL listed for wet locations.

✓ Recessed in-grade luminaires shall have a non-wicking conduit entrance.

✓ Luminaires shall be rated for operation at temperatures anticipated for local area.

✓ Pole height for site lighting shall comply with local codes or ordinances, and specific project scope and requirements.

- **Light source selection guidelines**

Selection must be determined in conjunction with luminaire, ballast/driver, and light controls.

  - fluorescent
  - high intensity discharge (hid)
  - light emitting diodes (led)

- **Emergency power pack selection guidelines**
- **Lighting control selection guidelines**
- **Lighting calculations**
- **Lighting system commissioning**
- **Lighting maintenance considerations**

1.2.3. Electromagnetic Spectrum and Visible Light

Without light, it would be impossible for the world as we know it to exist. Light allows to see and recognize objects and people around us. Natural light causes plants to grow – plants which we use as a food source or more importantly create the biosphere full of oxygen that we breathe. Artificial light allows us to continue working and living when natural light disappears at night.

- Light is energy in the form of electromagnetic radiation. The electromagnetic spectrum includes everything from radio waves to gamma rays. The visible part of the spectrum covers energy in the range of 380nm (violet) to 780nm (red). Visible light consists of energy within the wavelengths covered by this range, which when mixed together appears as white light.
- Colored objects only appear colored if their colors are present in the spectrum of the light source and are reflected to the eye. A broad spectrum will make colors look natural, whilst a narrow spectrum will make colors look dull, or even grey and muddy.

  The eye has 3 sets of light receptors:
  - Cones – to determine colors (red, green and blue)
  - Rods – for monochromatic vision at low light level
  - Melanopsin containing ganglion – detect light/dark to regulate body rhythms
- The detection of light by Melanopsin containing ganglions helps to regulate the body's natural rhythm. This is known as the Circadian Rhythm. Darkness stimulates the release of the sleep hormone melatonin, whilst bright light (>1000 lux) particularly in the blue end of the spectrum, stimulates the release of cortisol increasing alertness.
- Further research has identified that the color of artificial light and how it mimics natural daylight can promote wellbeing.

The Units of Light

- **Luminous Flux** (Light Output) – The total amount of light emitted by a light source.
  Unit: lumen (lm) {cd/steradian}
- **Luminous Intensity** (Intensity) – Luminous flux emitted in a specified direction.
  Unit: candela (cd) {lm/steradian} This is the SI Base Unit of light.
- **Illuminance** (Light Level) – The amount of luminous flux falling onto a surface area.
  Unit: lux {lm/m^2}

- **Luminance** (Brightness) – Luminous intensity per projected area of the source.
  Unit: candela per square metre (cd) {cd/m²}

Below are the terms, definitions, and abbreviations that are commonly used on Good Earth Lighting website. Many definitions are based on information from the American Lighting Association.

Accent Lighting: Localized and directional lighting used to highlight, focus attention and dramatize. Accent Lighting fixtures include Spot Lights, Rope Light, and specialty products.

Ballast – Electronic: Ballast utilizes electronic components to transform current at high frequency to operate fluorescent or discharge lamps. As a rule, Electronic Ballasts are more energy efficient than Magnetic Ballasts.

Ballast – Magnetic: A Ballast that uses core and coil assembly to transform electrical current to start and operate fluorescent or HID lamps.

Ballast Factor: The measured ability of particular ballast to produce light from the lamps it powers. Ballast Factor is derived by dividing the lumen output of a particular lamp/ballast combination by the rated lumen output of the same lamp on a reference ballast. A Ballast Factor of 1.0 equals 100% of the lamps rated lumen output.

Chandeliers: Typically used in dining rooms and in the foyer. Providing general lighting, a chandelier can be a focal point of style and beauty for a room. Chandeliers are jewelry to the home decorator.

Compact Fluorescent: Compact Fluorescent lamps “CFL” are energy efficient, long lasting light bulbs that are useful for replacing incandescent lamps in small fixtures. The lamp life is about ten times longer and use about one-fifth of the energy of regular light bulbs.

Circle E Ballast: Indicates special EPACT compliant version of ballast. Check the laws and codes for specific applications.

1.2.4. Vision and Illumination Standards

Illumination

The quantity of a light emitted by a lighting source is known as illumination. Heating effect of electric current is used in producing illumination. When a solid or vapour is heated it begins to radiate energy in the surrounding media. Lux is the unit for illumination.

General illumination defines the environment and clarifies room situations. The light is soft and uniform. There are no hard shadows or contrasts. Outdoors, this type of illumination can be found in car parks, pathways and streets. According to the standard, a certain degree of illuminance must be reached here. Indoors, general illumination represents the background light, to be able to grasp the dimensions of a room.

Accent Lighting: Lighting that focuses its output in a narrow beam, drawing attention to specific decorative features or objects, making them stand out from their surroundings. Accent lighting is also useful in gallery or high-end retail applications, where it can be used to draw attention to specific pieces, or products to provide visual hierarchy.

Ambient Light: Light which emanates in all directions to provide a blanket illumination without emphasis on any one object. This can be provided by a glowing light source such as a large lamp shade, daylight or other large flat light sources.

Amp (ampere): Measurement unit for the flow of electric current. In lighting installations, wiring and protections are calculated based on the amperes drawn by the lighting circuits, as well as their rated voltage.

Angle of Light: Angle between the orientation of a light source and the viewing direction. For example, the angle of light is 0° when looking at a down light directly from below and increases progressively as the viewer steps away from it.

The term is commonly used in theatrical lighting, to describe the angle between the stage lighting direction and the viewer's line of sight.

Architectural Lighting: Architectural lighting is the essential lighting which illuminates a building structure and is integral to the design and construction of the building. Typically, this is simple in both form and function.

Beam Angle: Also known as beam spread, the beam angle is a value that describes the downward light cone emitted by a lighting fixture with a reflector. The beam angle is measured between the downward direction, where the lamp provides maximum lighting intensity, and the direction in which intensity drops to 50%. In other words, a lamp with a large beam angle spreads light into a wider cone.

Candela (cd): The measure of directional light. Unit of luminous intensity of a light source in a specific direction. Also called candle. Technically, the radiation intensity in a perpendicular direction of a surface of 1/600000 square meter of a black body at the temperature of solidification platinum under a pressure of 101,325 npm(newton per square meter).

Color rendering and color distortion.

Designer uses all of the tools in their toolkit to control the qualities of the lights to alter their function for their intended use.

There are four controllable qualities of light.

- Intensity: Relative brightness of lights.
- Color: The color created by filters or combination of filtered lights.
- Movement: Physical movement of lighting sources created by cued changes in lighting states.
- Direction: Angle of lighting source to its target.

Color Rendering Index

CRI-indicates how true to color lighted objects appear. CRI measures light sources on a scale of 0 to 100. A higher number means more accurate color rendering. Sunlight is the benchmark for CRI at 100. Most residential applications use lamps with a CRI of at least 80.

Color Temperature or Chromaticity

The appearance of white light, in terms of warm or coolness. The color temperature is measured in Kelvin or "k." The higher the color temperature, the visually cooler or bluer the light appears. Typical indoor residential lighting requires light in the 2700K – 3500K range. Commercial, utility, and outdoor lighting is generally specified in a range between 3500K – 5000K range.

A standard of measuring the characteristics of light, measured in degrees Kelvin. Lower numbers indicate a warmer color temperature (more red) Higher number indicate a cooler color temperature (more blue)

Cool White: White light that is characterized by a cooler or blue color tone. The term is generally used for lighting with a correlated color temperature (CCT) of around 4000-6500K.

CRI – Color rendering Index: The measurement from 0 to 100 percent indicating how accurate a light source is at rendering color when compared to a reference light source. The higher the CRI, the better the colour rendering ability. Light sources with a CRI of 95+ are considered good at colour rendering

Essential of Good lighting design

There are several levels of lighting – for example general, task or decorative. Good lighting design will harmonize all of them across the workspace to suits every user, regardless of what activity they're doing, their ages or their preferences.

Principles of lighting design.

Light intensity: A lux is equal to the lighting level of a one meter square surface that's one meter away from a single candle. European standards suggest a desk should, be 500 lux. But for some this is too bright, for others too dim. That's why it helps to have the flexibility of dimmable lights across your office, and lamps on each desk.

Uniformity (Brightness): The lighting levels on your desk should be relatively close to the lighting levels around your work area. Large variations can lead to visual stress and discomfort. Fluctuating light levels can be distracting too, and could lead to a high level of visual discomfort – reducing both productivity and wellbeing.

Colour of the light: The colours we see in natural and artificial lights affect our mood. Warmer red, orange and yellow hues are great in breakout spaces and kitchens, because they make us feel comfortable and relaxed. Welcoming whites and light blues encourage alertness, so are great for conference rooms. And mid and deep blues improve productivity – so are useful in brainstorming and meeting rooms.

Glare: Glare is defined as an excessive brightness, contrast or quantity of light – and can cause everything from visual discomfort and eye fatigue to headaches and migraines. There are several sources of glare, so use a mix of solutions. Ensure windows can be covered to block the sun. Encourage everyone to work at angles that reduces the chance of glare. And use products (desks, dividers etc.) with matt finishes.

Flicker: Electric lighting has low frequencies of flicker that are not present in daylight, and have been associated with eye strain, headaches, migraines and epileptic seizures. EU standards means it's unlikely a new lamp will flicker. But it can degrade over time, so it's important to regularly maintain them with new bulbs, and to check for faults.

Brightness contrasts: While slight differences in brightness can help to create visual hierarchies – too much can cause glare or eyestrain. Your monitor's a good example. A balanced contrast ratio between the backlit screen and the area behind it makes it easy to focus on work. Too much of a difference in light will make it difficult to read and see details, and could hurt your eyes.

Maintenance: An often-overlooked principal. Materials and products are key to any lighting design – and degrade over time. So make sure bulbs are properly replaced in every couple of years.

Tune able and customizable lighting: To really boost productivity, it's worth looking at tune able lighting. Tune able light is usually set to mimic the colour and intensity of daylight conditions – which is great for focus rooms or spaces without windows. It's usually very flexible too, giving you the option to change the mood of a space with warmer or colder light.

Circadian lighting design: Light is vital to our circadian rhythm – the internal clocks that keep our physiological functions (from sleeping to digestion) on a rough 24-hour cycle. Since poor lighting design can interrupt our circadian rhythm, pick lighting designs that combine natural and artificial light sources and ensure we get the periods of brightness and darkness we need.

Blue light: Exposure to blue light suppresses your melatonin and can shift your circadian rhythm too. Try to limit the amount of TV you watch, or time spent looking at your mobile – especially late at night. Several apps and programs can help, warning you when you've been 'attached to a screen' for too long.

1.3. Light Document

Basic Important considerations for lighting design

- **Room Size.** The size of the room is one of the most important considerations for lighting design in meeting spaces.
- **Energy Conservation.** The more bulbs you have in the space, the more energy you'll use. Consider using LED bulbs or other energy-saving lighting methods.
- **Use of Technology.** Test your light levels based on what you plan on using the room for and the technology it will need to accommodate.
- **Proper Brightness.** If light levels are too low, it can make people drowsy during the meeting. Do some testing of your light levels to make sure you have the ideal brightness for the room.
- **Lighting Control.** There are all different ways of controlling a room's lighting levels. You can have a dimmer switch that lets you adjust the levels of all the lights at once.
- **Safety.** Many organizations arrange it so no one can enter an entirely dark room.

Lighting Design Considerations

Here are a few lighting design tips and concepts to consider aspects that go into making a workspace when choosing application or position of lighting designing:

A. Light Distribution and Brightness

Windows are definitely a worthwhile design choice, but you also have to account for the adverse effects of natural light. These include:

- Varying amounts of cloud cover
- Unwanted heat output
- Glare on computer screens or workspaces,

B. Conservation of Energy

Efficacy: The ratio of light produced to energy consumed. It's measured as the number of lumens produced divided by the rate of electricity consumption (lumens per watt).

C. Color temperature

LED bulbs have several benefits that make them the ideal choice for an office environment. They are:

- **More efficient:** LEDs can use anywhere from 25 to 80% less energy than their incandescent counterparts.
- **Longer lasting:** LED lights also **save** money through **replacements**.

- **Cooler:** With a lower heat output, these lights are safer and help you
- **Dimmable:** Colors are varied and flexible, allowing for lighting fixtures

D. The Appearance of the Space and Luminaires

Lighting design types should be aesthetically pleasing and match the feel of the office space.

Luminaires refer to different light fixtures and include recessed fixtures, direct and indirect pendants, under-cabinet lighting, wall wash lights, sconces, and task lighting, among others.

Effective luminaire combinations can create expertly lit areas.

Glare: Direct glare refers to the view of a light source, typically in high contrast to its surroundings.

Lamps and sunlight can cause it.

E. The Appearance of Color

If you ask people what color a light bulb emits, many of them will say “white,” but there is actually much more to the color of light than that. White light has a color temperature measured in Kelvins.

- **Warm/Deep:** 2700K to 3500K. This range would include the color of a sunset.
- **Neutral/middle:** Around 4000K.
- **Cool:** Above 4700K. This color resembles a bright, sunny day.

F. Lighting Control and Flexibility

With a comprehensive lighting system, you may need a little more than a light switch to control them all, especially if you are using smart options with sensors or automatic responses.

G. Lighting of Faces

Lights influence more than just the bright parts of an office — they also affect the dark parts. Some styles of lighting options increase the presence of shadows and offer themselves to dramatic lighting. In museums, points of interest may receive **up to 10 times** the ambient light level to highlight the item.

H. Cost of Implementation

While you consider overhauling an entire lighting system, the associated costs surely haven’t escaped your mind. Some of the costs involved include:

- Equipment
- Installation

- Design
- Maintenance
- Energy
- Environment

I. Installation

The installation process can vary widely, but one thing is for sure — if you opt to organize your lighting system yourself, you'll need an electrician and maybe a contractor too.

J. Maintenance

To get the most out of your light system, you'll need to maintain it properly.

You can cut down on maintenance costs by purchasing equipment that requires less work to keep up with, like LED bulbs, which have longer life spans.

Self-check #1

Part: I True or false

1. **Dimmable** Colors are varied and flexible, allowing for lighting fixtures
2. Quantity of a light emitted by a lighting source is known as illumination
3. Luminous efficacy is a measure of how well a light source produces visible light.
4. Light efficacy is a follow-up lighting term of wattage and lumens
5. OSHA light cover requirements state that all light fixtures must have protective plates

Part II: Choose the best answer from the give alterative

1. The more bulbs you have in the space, the more energy you'll use. Consider using LED bulbs or other energy-saving lighting methods.
   A. Energy Conservation B. Room Size C. Use of Technology D. Lighting Control
2. Test your light levels based on what you plan on using the room for and the technology it will need to accommodate
   A. Energy Conservation B. Room Size C. Use of Technology D. Lighting Control
3. If light levels are too low, it can make people drowsy during the meeting. Do some testing of your light levels to make sure you have the ideal brightness for the room.
   A. Proper Brightness B. Energy Conservation C. Room Size D. Use of Technology
4. There are all different ways of controlling a room's lighting levels. You can have a dimmer switch that lets you adjust the levels of all the lights at once
   A. Energy Conservation B. Room Size C. Use of Technology D. Lighting Control
5. The measure of directional light. Unit of luminous intensity of a light source in a specific direction.
   A. Candle B. Beam Angle C. Ambient Light D. Accent Lighting
6. Also known as beam spread, the beam angle is a value that describes the downward light cone emitted by a lighting fixture with a reflector
   A. Candle B. Beam Angle C. Ambient Light D. Accent Lighting
7. Angle between the orientation of a light source and the viewing direction.
   A. Candle B. Beam Angle C. Ambient D. Amp (ampere).

8. Lighting that focuses its output in a narrow beam, drawing attention to specific decorative features or objects, making them stand out from their surroundings

   A. Candle B. Beam Angle C. Ambient Light D. Accent Lighting

9. The lighting levels on your desk should be relatively close to the lighting levels around your work area.

A Proper Brightness B. Energy Conservation C. Light Efficiency D. Use of Technology

Part III: Write Short answer

1. Write at least ten Lighting Design Considerations criteria's
2. What are the Principles of lighting design
3. What are the safety required in common commercial installations

Unit Two: Effective Lighting Product Data

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- OHS and risk control measures
- Lighting and manufactures' data
- Nature of Lighting advice requirement
- Types and features of outdoor luminaries
- Light distribution and beam spread types
- Referring technical and costing inquiries
- Documenting inquiries and responses

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Apply OHS and risk control measures
- Explain lighting and manufactures' data
- Advice requirement for Nature of Lighting
- Identify Types and features of outdoor luminaries
- Select Light distribution and beam spread types
- Refer technical and costing inquiries
- Document inquiries and responses

2.1 OHS and Risk Control Measures

Evidence required to demonstrate competence in this unit must be relevant to and satisfy all of the requirements of the elements, performance criteria and range of conditions on at least two separate occasions and include:

- applying product knowledge of lighting effects, including determining the most appropriate advice
- applying relevant work health and safety (WHS)/occupational health and safety (OHS) requirements, including implementing risk control measures
- preparing and providing advice on the application of lighting for ambient and aesthetic effects, including:
    - referring technical and costing inquiries to appropriate person/s
    - responding to and documenting inquiries and responses
- Using questioning techniques and active listening when dealing with customers.

2.2 Light and Manufactures' Data

Lighting manufacturer

We are a lighting manufacturer with many years of presence on the market, which is why we know everything about luminaires and lighting systems: we examine their possibilities and design, test and manufacture them. We strive for continuous development, which is why we are one of the best manufacturers of luminaires in the country.

Trends and Insights

- **Manufacturers struggle to compete with imports.** Low operating costs overseas and a strengthening US dollar have made imported lighting fixtures more affordable domestically, enhancing price-based competition.
- **Demand for residential lighting fixtures benefited from a boom in residential construction.** However, elevated inflation and interest rate hikes in 2022 caused demand from the residential sector to shrink.
- **Strong construction activity lures manufacturers to the West.** The region is home to a large portion of the population, resulting in a steady flow of construction projects.
- **Imports pose a significant threat to domestic producers.** Foreign manufacturers satisfy close to half of domestic demand, mainly because of their lower operating costs and similar product quality.

Outdoor electrical components

- Outdoor fixtures and outlets have weatherproof covers and seals.
- All outdoor outlets have GFCI protection.
- Outdoor equipment like landscape lighting and pool pumps have proper grounding.
- There are no signs of exposure or wear on outdoor wiring.
- Outdoor connections are secure and protected from the elements.

LED lamps produced by Cree with high efficiency include Lamp LEDs, which are designed for general and specialized illumination.

The J Series® of light-emitting diodes offer exceptional value across an extensive range of applications, including those that necessitate specialized illumination.

High-brightness surface-mount (SMD) and through-hole (SMD) LEDs are designed for use in niche illumination and displays.

Kitchen Lighting, an established brand with a history dating back to 1938, is widely recognized for its expertise in outdoor lighting, ceiling fans, and residential and **commercial lighting**.

Luceco plc, a manufacturing firm worth £170 million, is the owner of the **global lighting brand** Luceco located in London, England which provides LED luminaires that are high-efficiency and energy-saving to customers in the trade.

Panasonic, a global leader in consumer electronics and appliances, is also a prominent player in the LED lighting industry.

The eight key factors in lighting design include:

- The owner's project requirements (OPR) that include project costs and schedule
- The basis of design (BOD)
- Codes and standards, including energy guidelines
- Sustainability certifications
- Recommended lighting levels
- Lifecycle costs
- Safety and security
- Maintenance and warranty.

Factor 1: OPR

This is a document prepared by the owner of the building. This can also be the tenant if the space being designed is a tenant space that is rented. The OPR should include:

- The goal for the design of the project
- How the building/space will be used
- The budget cost of the project (construction and soft costs)
- The schedule for construction completion
- Energy efficiency goals (e.g., Energy Star)
- Standards and codes including energy codes

- Sustainability goals
- Types of materials to be used
- Return on investment (ROI) and lifecycle costs requirements
- Safety and security requirements
- Training requirements
- Warranty requirements.

Leadership in Energy and Environmental Design *(LEED)*

The commissioning authority (CxA) is required to have the OPR so that the commissioning team can validate that what is being designed and built meets the owner's vision through the OPR.

Factor 2: BOD

The BOD is a document developed by the architectural and engineering firms and before the schematic design phase. It is based on the OPR and describes the technical approach planned to meet the OPR.

The BOD should list applicable codes and standards if they are not found in the OPR.

Factor 3: Codes and standards

The OPR calls for light switches to be used for private offices. It does not state what type of control to use for non-offices.

Some various types of controls are: **on/off light switches**, bi-level switches, dimmers, occupancy/vacancy sensors, and a time-of-day lighting controller.

The lighting designer needs to ensure that the entire design team is using the same energy code.

The International Energy Conservation Code (IECC) to be used as the energy code for a project.

Factor 4: Lighting levels

The IES is the recognized authoritative reference on the science and application of lighting. provides recommended lighting levels based upon the type of space and the use of the space, as well as the age of the majority of the occupants in the space.

Factor 5: Color temperature and CRI

Lighting designers should understand through the OPR what color temperatures and CRI to incorporate into the design.

The lighting design shall also consider CRI when selecting light sources. Typically, the cost of a lamp increases as the CRI increases

Factor 6: ROI and lifecycle costs

Many owners would consider a higher upfront cost for certain lighting fixtures and/or controls if a certain ROI is achieved.

The lifecycle costs include the material costs required for replacement of lamps, ballasts, drivers, etc., including the labor costs for replacing these items.

Factor 7: Safety and security

A lighting designer should confirm if the OPR contains safety- and security-related items. If it does not, the designer should ask that these items be added

2.3 Light Advice Requirement

Obtain approval for lighting

The Lighting Designer is responsible for the design, installation, and operation of the lighting and special electrical effects used in the production.

Precisely for this reason, lighting design is the key to success in any **architectural or interior design projec**t, and here we explain everything you need to take into account to get the best results.

Document of lighting design

lighting design is a process that is part of any architectural and interior design project where the designer has to know all the **important aspects of lighting that can influence a space.**

Negotiate the design with relevant person(s) of organization's policy.

Lighting was the original purpose of electricity, and numerous standard-making bodies address nearly every aspect of Efficient Lighting and LED safety, performance, testing, and illumination levels. Lighting standards are also frequently revised and amended to take into account the latest technology or the needs of particular industries.

Electrical Design/Documentation consisting of continued development and expansion of electrical Schematic Design Documents and development of outline specifications or materials lists to establish:
Electrical Design/Documentation services during the Construction Document Phase shall consist of the preparation of the drawings, based on the approved Design Development Documents.
In accordance with the approved Preliminary Design and Construction Schedule and based upon approval of and comments made by the Owner regarding the Concept Design Studies, the Design Professional shall prepare and submit to the Owner Schematic
Design Development Documents In accordance with the approved Preliminary Design and Construction Schedule and based upon approval of and comments made by the Owner regarding the Schematic Design Documents,

Commercial Electrical inspection checklist

General safety and compliance

- Technicians are wearing insulated gloves, flame-resistant clothing, and safety glasses, appropriate for high-voltage environments.
- PPE is in good condition and rated for the higher voltage and current levels common in commercial
- Hard hats and hearing protection are worn in environments with heavy machinery or high noise levels.
- Arc flash hazard labels are visible and legible on electrical panels and large commercial equipment.
- Technicians are trained in arc flash safety protocols, and proper signage is prominently displayed.
- Arc-rated PPE and tools are used when working near or on energized commercial components.
- Outlets, panels, and wiring meet NEC standards for commercial installations.
- Circuits are clearly labeled, and grounding systems are installed and maintained per NEC standards.
- Circuit breakers and fuses are rated for the higher loads typically found in commercial properties.
- Inspection reports are complete, accurate, and securely stored for future reference, including documentation of commercial equipment performance.
- Permits, compliance documents, and certifications required for commercial operations are up to date and accessible.
- Repairs or deviations from standard procedures are documented with an emphasis on their impact on commercial operations.

NEC compliance

- All electrical systems and components meet NEC standards.
- For specialized equipment, all electrical panels, outlets, and switches are labeled with installation and operating instructions.
- Grounding systems and bonding connections are compliant with NEC guidelines.
- Conduit sizing and placement follow NEC rules for commercial installations.
- Check for proper sizing of conductors and overcurrent protection devices according to NEC Article 310 and 240.

Current ratings and openings

- Check interrupting current ratings on circuit breakers and fuses to verify they can safely interrupt fault currents.

- Assess short-circuit current ratings to confirm compatibility with the system load and fault conditions.
- Check for proper coordination of overcurrent protective devices to ensure selective tripping.
- Verify the available fault current at the service entrance and distribution points.
- Look for proper closure of unused openings in panels and junction boxes to prevent exposure to energized components.
- All electrical devices and conductors are rated for the current they're carrying.

Contamination and damage

- Panels and enclosures are free of dust and moisture that could affect performance.
- There's no wear or corrosion to components and wiring.
- Identify any electrical equipment that needs to be cleaned, repaired, or replaced.
- There are surge protection devices for sensitive electronic equipment.
- The areas around electrical components aren't exposed to any chemicals or contaminants.
- There are no signs of overheating or arcing in switchgear and motor control centers.

Mounting and ventilation

- Electrical panels and transformers are level and securely mounted.
- There are no blockages or restrictions in ventilation openings that could lead to overheating.
- Supports and mounting brackets are rated for the weight and type of equipment.
- Installations comply with NEC rules on spacing and ventilation. Some equipment, like transformers, may have clearance requirements that differ from general NEC rules.

Terminations and splices

- Splices are properly insulated and connected securely to prevent electrical hazards.
- Splices are compatible with the wire size and type used in the system.
- All terminations are rated for the operating temperature of the connected equipment.
- All terminations are made with listed lugs or connectors appropriate for the conductor material (copper or aluminum).
- Check torque specification terminations are to prevent overheating or loose connections.
- Anti-oxidation compounds are properly applied to aluminum conductors and terminations.
- All splices and connectors use UL-listed materials.

Clearances and directories

- Working space clearances meet NEC requirements, including the distance from walls.
- The space and headroom around electrical equipment is easily accessible for inspection.
- Circuit directories are complete and accurate, with clear labels for each circuit.
- The access to electrical panels and disconnects is unobstructed and clearly marked.

Residential inspection checklist

When performing an electrical inspection in a home, it's important to focus on everything from general safety standards to specific components like wiring, outlets, and appliances. Below, we'll break down what to include in a residential checklist you and your workers can use:

General safety and compliance

- Technicians are wearing insulated gloves, flame-resistant clothing, and safety glasses.
- PPE is in good condition and rated for the voltage at hand.
- Hard hats and hearing protection are worn in the appropriate environment.
- Technicians are trained in arc flash safety protocols and proper signage is displayed.
- Technicians are using arc-rated PPE and tools when working near energized components.
- Outlets, panels, and wiring follow National Electrical Code (NEC) guidelines for electrical installation and safety.
- Circuits are properly labeled, and systems are grounded according to NEC standards.
- Circuit breakers and fuses are appropriately rated for the connected loads.
- Inspection reports are complete, accurate, and stored securely for future reference.
- All necessary permits and compliance documents are available and up to date.
- Any repairs, upgrades, or deviations from standard procedures are noted.

Wires and outlets

- Cords are routed away from walkways to prevent tripping hazards.
- Wires have intact insulation and no exposed conductors.
- Wires are housed in conduits or raceways where necessary to prevent damage.
- Outlets and switches operate correctly and supply power as expected.
- Use a circuit tester to identify issues like reversed polarity or open grounds.
- Feel outlets for excessive heat, which could indicate loose connections or overloading.

- Check for GFCI (Ground Fault Circuit Interrupter) protection in wet areas like kitchens and bathrooms.
- There are no burn marks, cracks, or discoloration on outlets and switches.
- There are no loose connections or missing screws on outlet plates.
- Cords aren't frayed or pinched,
- No cords are running under carpets or rugs.
- Cords are routed away from walkways to prevent tripping hazards.

Lighting

- Bulbs match the recommended wattage for each fixture to avoid overheating.
- Non-IC-rated fixtures are kept clear of insulation.
- Dimmer switches operate smoothly without the lights buzzing or flickering.
- There are no loose or faulty connections that may cause flickering.
- Light fixtures have no damage, rust, or loose components.
- Suggest LED upgrades for improved energy efficiency and longevity.

Electrical panel

- The panel is labeled, including an accurate circuit directory.
- There are no signs of corrosion, damage, or rust on the panel.
- Check the panel temperature to detect overheating or potential overloads.
- Test each circuit breaker to confirm it trips properly and resets without any issues.
- Look for breakers that frequently trip or show signs of wear.
- If double-tapped breakers are present, those need to be removed as often not permitted in homes.
- There's a whole-house surge protector or point-of-use protector. Recommend adding surge protection if none is present.
- Compare the panel's rated capacity to the current electrical load to avoid overloading.
- Identify panels nearing their limit and recommend upgrades.

Appliances

- High-power appliances use heavy-duty plugs.
- Appliances operate properly.
- Appliances don't have any damaged cords or components.
- There are no signs of overheating, such as scorch marks near plugs.

- Major appliances like air conditioners are plugged directly into an outlet rather than into an extension cord. Some appliances (like refrigerators), use special appliance extension cord.
- Remind homeowners not to yank cords from the outlets, but instead hold on to the plugs directly.

Electrical fire prevention

- A class C fire extinguisher rated for electrical fires is easily accessible.
- Test all detectors to confirm they sound an alarm. Replace batteries if needed.
- Detectors are installed in key areas like hallways and kitchens.
- Flammable items are stored away from appliances and outlets.
- Check for AFCI (Arc Fault Circuit Interrupter) protection, which is required in many areas of modern homes for fire prevention.

Office Electrical Safety Checklist

- Make sure all electrical equipment is properly grounded. This includes outlets, plugs, cords, and light fixtures.
- Inspect electrical equipment regularly for signs of wear or damage. If you see frayed wires, cracked insulation, or other damaged parts, replace the equipment immediately.
- Do not overload outlets or extension cords. This can cause a fire hazard.
- Use only properly rated extension cords and power strips.
- Keep cords and cables away from areas where they could be tripped over.
- Don’t place cords under carpets or rugs.
- Use only surge protectors that are UL-listed.
- Avoid using electrical equipment in wet or damp areas.
- Do not use damaged electrical plugs or outlets. Have them repaired or replaced by a qualified electrician.
- Do not touch electrical equipment or cords if you are wet or standing in water.
- Report any electrical problems to a qualified electrician immediately. Do not attempt to repair the problem yourself.

Benefits of using an inspection checklist

An electrical inspection checklist offer many advantages for you and your clients. Some of the benefits:

Comprehensive inspection: A checklist helps you stay organized, so you don’t overlook any critical areas during an inspection.

Improves safety: Identifying potential electrical safety risks, a checklist protects both the technician and the people using the system.

Reduces liability risks: An inspection documented with a thorough checklist can help minimize liability, showing that you followed all necessary procedures.

Enhances customer trust: Using a structured approach demonstrates your commitment to high standards, building confidence with clients.

Identifies potential issues before they become major problems: A checklist makes it easier to spot early warning signs, preventing dangerous situations down the road.

Inspection checklist

An inspection checklist can be used in many situations to check that electrical equipment is safe, functional, and compliant. Here are some situations where you should rely on one:

During initial installations: Whether installing new electrical equipment like lighting systems, outlets, panels, a checklist ensures all components are properly connected, grounded, and compliant with codes.

For routine maintenance inspections: Regular maintenance keeps electrical equipment in safe and efficient working condition. A checklist helps you identify wear, damage, or potential hazards like loose connections or overloaded circuits.

When troubleshooting electrical issues: Flickering lights or outlets that don't work can be frustrating for clients. Using a checklist allows you to systematically diagnose and fix the issue without overlooking anything.

After renovations or major electrical work: Renovations often involve upgrades or changes to the electrical system. A checklist helps confirm that all new installations are up to code and function properly.

In preparation for safety audits: Commercial clients may need an inspection to meet regulatory requirements. A checklist helps their systems pass inspections and remain compliant with safety regulations.

2.4 Types and Features of Outdoor Luminaries

Outdoor Lighting

Used to illuminate the area around the home or outdoor living space. Generally refers to any hardwired, low-voltage or solar powered lighting that is used for illuminating outdoor areas. They can enhance your home, patio and landscape.

Outdoor lights

Recreate that feeling of arriving at a stylish hotel every time you pull onto your driveway with our range of outdoor lighting. The welcoming exterior lights of a home proudly showcase castle in all its glory; there is nothing more inviting than a well-lit outdoors in the evening. You could use outside lights to Outdoor wall lights are an easy way to add focus to the parts of your home exterior you are most proud of while also making it easier to navigate your outdoor space in the dark. If you are looking to illuminate a pathway in your front or back garden, you'll find a choice of post lights and spike lights, or ground lights as they are sometimes called, which are easy to install and have a choice of power to suit your needs

Figure 2.1: output light principles

Five Principles for Responsible Outdoor Lighting

Light where you need it, when you need it, in the amount needed, and no more. If light is deemed useful and necessary, follow these guidelines to prevent, or when that's not possible, minimize light pollution.

Responsible outdoor lighting is:

Useful: Use light only if it is needed all light should have a clear purpose. Consider how the use of light will impact the area, including wildlife and their habitats.

Targeted: Direct light so it falls only where it is needed use shielding and careful aiming to target the direction of the light beam so that it points downward and does not spill beyond where it is needed.

Low level: Light should be no brighter than necessary to use the lowest light level required. Be mindful of surface conditions, as some surfaces may reflect more light into the night sky than intended.

Controlled: Use light only when it is needed use controls such as timers or motion detectors to ensure that light is available when it is needed, dimmed when possible, and turned off when not needed.

Warm-colored: Use warmer-color lights where possible limit the amount of shorter wavelength (blue-violet) light to the least amount needed.

Types of outside Light.

Front door wall lights are the most common styles of lights. They allow you to see clearly to walk to the door, get your key out and find the keyhole. They also guide a path for visitors. They can be modern or traditional. Be on a bracket or fit flat to the wall. We've put together an at a glance sheet for your consideration and linked each type to the website as a short cut link for you.

Flush Porch Light

A flush fit porch light is a fitting which mounts to a surface with minimal projection.

Hanging Lantern

A hanging lantern is a pendant light for exterior use.

Coach Lamp (Upward)

A coach lamp is a traditionally styled wall lantern for outdoor use.

Coach Lamp (Downward)

A coach lamp is a traditionally styled wall lantern for outdoor use.

Bulkhead/Porthole Light

A robust and often industrial style light suitable for outdoor use.

Wall Mounted Marker Lights

Exterior wall lights which wash light upward or downward to illuminate pathways.

Deck/Ground Lights

Small recessed ground lights for illuminating outdoor decking areas.

Ground Spike Lights

Lighting designed to stick into the ground and highlight features,walls or pathways.

Flood Light

Designed to illuminate a wide outdoor area.

Pedestal Light

An exterior light for mounting to a post or bollard.

Lamp Post

A tall exterior standing lamp for lighting large areas.

Sensor Lighting

Outdoor lights with an in built PIR motion sensor, great for security.

Solar Lighting

Outdoor lights with an in built solar panel allowing it to be powered through sunlight.

Festoon Lights

Exterior string lights for functional or decorative use.

Figure 2.2: outside light types

Installing outdoor luminaires

Basic rules you should always follow.

Conditions in the driveway and garden are completely different. If it is warm and dry indoors, we can expect wetness and cold outdoors - depending on the season. This also means completely different challenges for the installed luminaires. Challenges that you should take into account when selecting a luminaire.

Rule 1: Material

Moisture lurks everywhere outside, and not only in the rain or cold. Excessive humidity in the summer also takes its toll on the luminaire body. It is therefore particularly important to use corrosion-resistant, i.e. **rust-free material**. Where the luminaire is installed in the garden or terrace is irrelevant. Only use luminaires made of **stainless steel or aluminium**, for example. You are also on the safe side with copper or brass and do not have to worry about complaints.

Rule 2: Protection class

Water can damage the luminaire not only from the outside. If moisture penetrates the inside of the luminaire, this can lead not only to a defect but also to life-threatening injuries - and not only for children playing nearby. That is why all luminaires you install outdoors must have a **protection rating of at least IP44**. Then they will not be affected by splashing water, no matter which direction it comes from. **Near a pond or pool, however, you should go straight for IP65**. Luminaires with this degree of protection are not even affected by water jets.

Rule 3: Connection

By choosing the right material and protection class, you are on the safe side, especially with regard to the appearance of the outdoor luminaire. However, what is not immediately visible is almost more important: the right connection. Power cables and co. must also be protected from the weather and **laid in cable ducts**. Moreover, not every cable is intended for installation in the ground. So make sure you use the right material here, too.

Rule 4: Type of luminaire

We now know some basic characteristics that distinguish outdoor luminaires from their indoor counterparts. Now it's time to put this knowledge to good use. In plain language, this means: choose the right outdoor luminaire based on the desired installation location. We are not only referring to protection class and material. The type of luminaire also plays a decisive role.

Rule 5: Uniform photograph

If different installation locations also require different luminaire types, this does not necessarily mean that you have to do without a uniform light and luminaire image. The SLV product families are characterized by the fact that a **uniform luminaire design is reflected in different luminaire types**. In this way, you receive ceiling, wall and free-standing luminaires with the same look and thus create a uniform light image. Above all, this ensures calmness in the eye of the beholder and a pleasant atmosphere.

Types of Light Fixture Installations

Considered the light installation cost and the different types of light fixture installations

a. Chandeliers

Chandeliers can be a stunning addition to any room, but their installation can be complex and expensive. The weight of your chandelier, the number of light bulbs, and the intricacy of the design all contribute to the installation difficulty.

b. Recessed Lights

Recessed lighting offers a sleek, modern look and can provide excellent task lighting. Even so, installing recessed lighting typically requires cutting into your ceiling drywall to accommodate the housing cans. The cost of recessed lighting installation can vary depending on the number of lights being installed and the complexity of the job.

c. Track Lighting

Track lighting is a versatile option for light fixture installation that allows you to adjust the direction and position of the light fixtures. Installing track lighting typically involves mounting the track on the ceiling or wall and then connecting the individual light fixtures to the track.

d. Wall-Mounted Lights

Wall-mounted lights, such as sconces or vanity lights, are a great way to add accent lighting or task lighting to a bathroom, hallway, or bedroom. Installing wall-mounted lights typically involves running

wires from the existing electrical box to the fixture location. The complexity of the installation will depend on the location of the existing electrical box and the accessibility of the wall space.

e. LED Light Strips

LED strips are a popular choice for under-cabinet lighting or accent lighting. They're relatively easy to install and can be cut to size to fit your specific needs. Some LED light strips are self-adhesive and can be simply stuck to a clean, dry surface.

f. Ceiling-Mounted Lights

Ceiling-mounted lights, such as flush mount or semi-flush mount fixtures, are a common and versatile option for general room lighting.

g. Pendant Lights

Pendant lights suspended from the ceiling by a cord or chain are a popular choice for kitchens, dining rooms, or breakfast nooks. Installing a pendant light typically involves mounting a ceiling plate and connecting the wires to the existing electrical box.

h. Fluorescent Lights

Fluorescent lights are a common choice for garages, basements, or laundry rooms. They're relatively inexpensive but can be less aesthetically pleasing than other lighting options. Installing fluorescent lights typically involves mounting the fixture to the ceiling and connecting it to the existing electrical box.

i. Light Bars

Light bars are long, linear fixtures that can be mounted on walls or ceilings. They're often used in kitchens, bathrooms, closets, or garages to provide task lighting.

j. Holiday Lights

While holiday lights are not permanent fixtures, installing them can be a time-consuming and frustrating task if you're not used to stringing lights all over your home or yard. Sometimes, hiring help for both indoor and outdoor holiday light installation can free up your valuable time and help you ensure that your home is beautifully lit for the holidays.

Choosing the Right Lighting Fixtures

Choosing outdoor LED lights involves several considerations, from their purpose to their impact on the environment and local regulations. Here is a guide to help you make an informed decision:

- **Purpose of the Lights**

Start by identifying the reason you need the lights. Are they for security, highlighting a pathway, or highlighting some landscape features? Security lights often require brighter lighting. Meanwhile, path and landscape lighting can be softer and more decorative.

- **Environment Conditions**

The location where you will install the lights crucially influences your exterior LED lighting selection. Make sure to choose fixtures that are weather-resistant, durable, and energy-efficient. Outdoor lighting in Canada will not have the same requirements as in Miami, for instance. If you are close to a beach, you will need lights that can withstand salty air and possibly sand. Marine-grade stainless steel or powder-coated aluminum fixtures would be suitable options for such conditions.

- **Lighting Impact on Flora and Fauna**

Outdoor lighting can affect plants and nocturnal animals, like birds. Use warm-colored lights instead of bright white or blue lights to limit the disruption of wildlife's natural patterns. Also, consider downward-facing lights to minimize light pollution – The color temperature for such areas range from 2200K in Florida for instance, to 3500K.

- **Lighting Codes & Regulations**

Consult with your local city government or homeowners' association for any regulations concerning outdoor lighting. Some areas have "Dark Sky" laws that regulate the type, direction, and intensity of outdoor lights to reduce light pollution.

- **Light Trespass & Pollution**

Be mindful of your neighbors when installing outdoor lights. Aim the lights so that they only illuminate your property to prevent light trespass. Shields on lights can direct light downwards. This prevents light from spilling onto other properties or into the night sky.

Energy Consumption

Efficacy

The ratio of light produced to energy consumed. It's measured as the number of lumens produced divided by the rate of electricity consumption (lumens per watt).

Light Quantity

Illumination: The distribution of light on a horizontal surface. The purpose of all lighting is to produce illumination.
Lumen: A measurement of light emitted by a lamp. As reference, a 100-watt incandescent lamp emits about 1600 lumens.

Foot candle: A measurement of the intensity of illumination. A foot candle is the illumination produced by one lumen distributed over a 1-square-foot area. Most home and office work, 30–50 foot candles of illumination is sufficient. For detailed work, 200 foot candles of illumination or more allows more accuracy and less eyestrain.

Light Quality

Color temperature: The color of the light source. By convention, yellow-red colors (like the flames of a fire) are considered warm, and blue-green colors (like light from an overcast sky) are considered cool. Color temperature is measured in Kelvin (K) temperature. Confusingly, higher Kelvin temperatures (3600–5500 K) are what we consider cool and lower color temperatures (2700–3000 K) are considered warm. Cool light is preferred for visual tasks because it produces higher contrast than warm light.
Color rendition: Color quality, or how colors appear when illuminated by a light source. Color rendition is generally considered to be a more important lighting quality than color temperature. Most objects are not a single color, but a combination of many colors, and certain light sources may change the apparent color of an object. The Color Rendering Index (CRI) is a 1–100 scale that measures a light source's ability to render colors the same way sunlight does.

Glare: The excessive brightness from a direct light source that makes it difficult to see what one wishes to see. A bright object in front of a dark background usually will cause glare. Bright lights reflecting off a television or computer screen or even a printed page produces glare. Intense light sources -- such as bright incandescent lamps -- are likely to produce more direct glare than large fluorescent lamps.

Lighting Uses

Ambient lighting: Provides general illumination indoors for daily activities, and outdoors for safety and security.
Task lighting: Facilitates particular tasks that require more light than is needed for general illumination, such as under-counter kitchen lights, table lamps, or bathroom mirror lights.

Accent lighting: Draws attention to special features or enhances the aesthetic qualities of an indoor or outdoor environment.

2.5 Light Distribution and Beam Spread Types

Beam spread, or beam angle, measures the spread of light (the width of the beam) from a reflected light source. As light moves away from a reflected light source, it spreads out and becomes less intense.

There are six standard beam spreads:

Narrow Spot 2x2

The narrow spot distribution is ideal for applications where a tighter beam is required. It is also excellent for applications with far setbacks or longer distances such as flagpoles or tall trees.

Narrow Flood 4x4

Ideal for accenting sculptures, landscape and facade lighting with farther setbacks, narrow flood distribution provides a tight and symmetrical concentrated beam.

Horizontal Flood 5x3

Horizontal flood provides a wide horizontal beam with a narrow vertical concentration. It is ideal for applications that require a wide horizontal coverage with a shorter setback. It is a great distribution for grazing and accentuating architecture.

Vertical Flood 3x5

Great for tall facades and signs with a limited setback, vertical flood provides tall, tight distribution.

Medium Flood 5x5

Designed for applications that require a wider uniform pattern with a medium setback, medium flood is ideal for facades, under canopies, signs and general landscape applications.

Wide Flood 6x6

Wide flood distribution provides a large and uniform light pattern. Good for applications that require a shorter setback, wide flood can be used for signs, large facades, and broad landscape foliage. it can also be used for pole mounted applications for general area lighting.

Beam spread is classified into NEMA Types.

NEMA indicates how wide or narrow the light is projected out of the flood light. Horizontal and vertical beam spread angles are used to distinguish NEMA types. Example: If the horizonal beam spread is 120° and the vertical beam spread is 140°, then the NEMA type is 6x7.

Table 2.1: table of **Beam spread**.

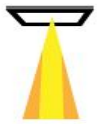
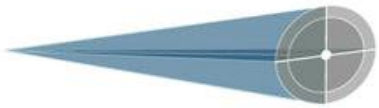
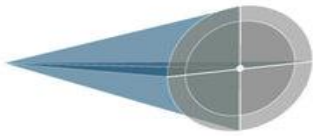
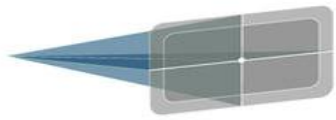
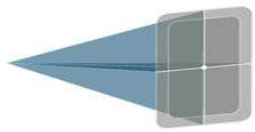
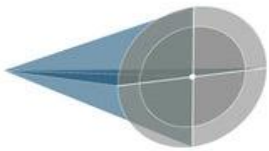
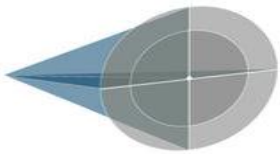
Figure of light spread	Beam Spread (°)	NEMA Type	Beam Description	Beam Projection Distance
	10°-18°	1	Very Narrow	240 ft+
	> 18° - 29°	2	Narrow	200 - 240 ft
	> 29° - 46°	3	Medium Narrow	175 - 200 ft
	> 46° - 70°	4	Medium	145 - 175 ft
	> 70° - 100°	5	Medium Wide	105 - 145 ft

Figure of light spread	Beam Spread (°)	NEMA Type	Beam Description	Beam Projection Distance
	> 100° - 130°	6	Wide	80 - 105 ft
	> 130°+	7	Very Wide	Under 80 ft

Table 2.2: NEMA Beam Spread Classifications

Beam Spread	NEMA Type	Beam Description
10° to 18°	1	Very Narrow
18° to 29°	2	Narrow
29° to 46°	3	Medium Narrow
46° to 70°	4	Medium

Table 2.3: Six Standard Beam Spreads

	**Narrow Spot** 2 x 2: The narrow spot distribution is ideal for applications where a tighter beam is required. It is also excellent for applications with far setbacks or longer distances such as flagpoles or tall trees.
	**Narrow Flood** 4 x 4: Ideal for accenting sculptures, landscape and facade lighting with farther setbacks, narrow flood distribution provides a tight and symmetrical concentrated beam.
	**Horizontal Flood** 5 x 3: Horizontal flood provides a wide horizontal beam with a narrow vertical concentration. It is ideal for applications that require a wide horizontal coverage with a shorter setback. It is a great distribution for grazing and accentuating architecture.
	**Vertical Flood** 3 x 5: Great for tall facades and signs with a limited setback, vertical flood provides tall, tight distribution.
	**Medium Flood** 5 x 5: Designed for applications that require a wider uniform pattern with a medium setback, medium flood is ideal for facades, under canopies, signs and general landscape applications.
	**Wide Flood** 6 x 6: Wide flood distribution provides a large and uniform light pattern. Good for applications that req

NEMA Classifications

NEMA classifications detail both vertical and horizontal beam angles, crucial for precision in directional lighting such as floodlights and spotlights. NEMA defines beam spread in degrees. They define the angles where the light is at 50% and 10% of the maximum. This is important because it allows you to control the light for your specific needs.

Here's a quick recap of the differences:

- **How They Measure**: IESNA measures the horizontal spread at the half-maximum candela. NEMA measures the specific angles where the light is at 50% and 10%.
- **What they're For**: IESNA classifications are tailored for area lighting with broader applications, while NEMA is better suited for specific, targeted lighting scenarios such as floodlighting and spotlighting.
- **Types of Classifications**: IESNA offers types based on the shape of light distribution, and NEMA provides a spectrum of types defined strictly by beam angles.

How many NEMA street light distributions are there?

NEMA classifies beam spreads into seven types. They range from very narrow to very wide. Knowing these types helps you select the right light for different distances and areas. This makes it easier to choose the right light for your outdoor and industrial lighting needs. It also makes it easier to have good lighting while saving energy.

Types of Lighting Distribution for Area Lights

Area lights are most often installed in open spaces like sidewalks, parking lots and roadways. The goal is to illuminate the targeted areas without intruding on adjacent areas where lighting is not desired.
Lighting Engineers are tasked with the job of installing fixtures for well lit areas, but they have to be careful so the lights don't bother nearby neighbors, pollute the night sky or introduce too much glare to the space.
As a result, the IES (Illuminating Engineering Society) have come up with some guidelines to help classify the different types of distributions for area lights.
These classifications are not only useful to know the projection of the light but it also aids in spacing and placement of the light poles.

Type I - Narrow Spread

The Type I distribution type is narrow and projects light far out side to side but barely projects out in front of it. It is used in very narrow pathways or on islands in the middle of the roadway. Type I fixtures are rarely found in the US. It is very much a niche case.

Type II - Narrow spread with a more forward throw

Fixtures with a type II distribution type are used in narrow roadways and larger center islands. This distribution type has a more of a forward throw than type I but with less projection side to side.
For Spacing Type II fixtures next to each other, it's important to note that the rule of thumb is that they project out around 3x the mounting height side to side and 1x the mounting height out front. For example, two fixtures mounted 15 ft high will provide adequate lighting if they are spaced 90ft apart.

Here is how we it works

Side to Side projection of each fixture at 3x = 3 x 15ft = 45 ft for each fixture
Fixture 1 covers 45 ft + 45 ft from fixture 2 = 90ft spacing.

TYPE III - most common distribution type

Type III distribution type is the most common as it can be found on most standard size streets or throughout open parking lot spaces. Type III fixtures are most commonly installed along the side of an open space.
These types of fixtures have more of a forward throw while the side to side projections are more narrow. General rule of thumb for type III fixtures is that they project out 1.5x out in front and about 2.5 side to side.
In our previous example of two 15ft high fixtures, type III lights would have to be spaced closer to each other at 75 ft.
15 ft x 2.5 = 37.5 ft for each fixture
37.5x2 = 75 ft.

The forward projection also comes into play in areas like parking lots where two fixtures can be installed across from each other. at 1.5x the mounting height , a 45 ft wide parking lot would have adequate light uniformity with the fixtures installed at said height. For wider parking lots, the installer would need to mount the fixture at a little higher.

Type IV - Highest Forward Projection

The type IV distribution type has the most forward projection. Type IV fixtures are typically used on the perimeter of parking areas, especially in lots that do not have any poles in the interior. Since the Type IV fixtures project out so far, they can cover a lot of ground but that's at the expense of the side to side projection. This means that the installer would need more fixtures installed closer to each other on the perimeter compared to Type III fixtures.

Type IV distribution typically projects out front up to 4x the mounting height. Side to side projections are about 1.75x the mounting height.
In our 15ft pole example, a type IV light will project out about 60ft forward, while the space between fixtures would only be about 53.5 ft (26.25 ft for each fixture).

TYPE V & TYPE VS - EVEN PROJECTION ALL AROUND

A type V distribution type provides the same amount of projection in all directions around the fixture. The surface covered by one type V picture results in a perfectly round shape as it's symmetrical all around.

Below is a good rule of thumb to follow when picking higher mounting heights.

up to 75 Watts (up to 5000 lumens) - up to 15 ft Mounting Height
75-150 Watts (5000-20000 lumens) - 15-25 ft Mounting Height
300 Watts Fixtures (40000 lumens - 30 ft + Mounting Height

2.4 Technical and Costing Inquiries

Best Practices in Lighting Design

When working on a lighting design project, keep these best practices in mind:

Layer Lighting: Combine ambient, task, and **accent lighting** for a balanced look.

Use Dimmers: They provide flexibility in controlling light levels to match different activities and moods.

Focus on Energy Efficiency: Choose energy-saving bulbs and consider **natural light** to reduce electricity use.

Think About Placement: Position **lighting fixtures** to avoid glare and shadows.

Consider the Color Temperature: Warm light (yellow tones) is cozy and relaxing, while cool light (blue tones) is energizing and better for focus.

Lighting Design Principles

Understanding **lighting design principles** is essential for creating effective and appealing spaces. These principles help ensure that lighting enhances both **form and function**.

Key Principles of Lighting Design

The key principles of lighting design include several important aspects:

- **Uniformity**: Ensuring that light is distributed evenly to eliminate dark spots.
- **Contrast**: Using different light levels to create interest and highlight features.
- **Color Consistency**: Maintaining the same color of light throughout the space to avoid visual discomfort.
- **Glare Control**: Minimizing direct exposure to bright light sources to reduce eye strain.

For instance, in a living room setting, you might use a combination of **ambient lighting** from ceiling fixtures, task lighting from floor lamps, and accent lighting to highlight artwork.

The mathematical principle to determine illumination (\textit{E}) of a space can be calculated using:

E=Luminous Flux (ϕ)Area (A) where:

- **Luminous Flux (\phi)** is measured in lumens (lm).
- **Area (A)** is measured in square meters (m^2).

Accent Lighting Methods

Accent lighting is used to highlight specific features within a space, such as artwork, **architectural elements**, or plants. It adds depth and visual interest by creating points of focus.

- **Spotlights**: Directed beams of light that highlight specific objects or areas.
- **Wall Washers**: Broad beams of light that wash over a wall to highlight textures or large features.
- **Display Lights**: Small, focused lights used in showcases or display cabinets.

The specified illumination or brightness levels of lighting required to be achieved by a lighting installer is usually expressed as an amount of 'lux', for example 150 or 400 lux, but what does this actually mean?

Definition of Lux

Lux is a standardized unit of measurement of light level intensity, which is commonly referred to as "illuminance" or "illumination".

So what is exactly 1 lux?

A measurement of 1 lux is equal to the illumination of a one metre square surface that is one metre away from a single candle.

The diagram below helps to visualise this more easily.

One lux (1 lux) of light is a measure of the light density, equivalent to 1 lumen per square metre (lm / m^2).

To place the amount of 1 lux into context, examples of the wide ranging lux of a natural ambient light conditions are given in the table below:

Table 2.4: Type of light lux and nature conditions.

Natural Light Condition	Typical Lux
Direct Sunlight	32,000 to 100,000
Ambient Daylight	10,000 to 25,000
Overcast Daylight	1000
Sunset & Sunrise	400
Moonlight (Full moon)	1
Night (No moon)	< 0.01

Sunlight provides between many thousand of lux to only a few hundred depending on the weather conditions & time of day. The lux of artificial indoor lighting, however, is typically 1000 lux or below, as can be seen in the following commercial lighting installation examples:

Table 2.5: Type of light lux and environmental conditions

Environment	Typical Lux
Hospital Theatre	1,000
Supermarket, Sports Hall	750
Factory, Workshop	750
Office, Show Rooms, Laboratories, Kitchens	500
Warehouse Loading Bays	300 to 400
School Classroom, University Lecture Hall	250
Lobbies, Public Corridors, Stairwells	200
Warehouse Aisles	100 to 200
Homes, Theatres	150
Family Living Room	50

For commercial & industrial environments where specialized tasks are performed e.g. professional indoor sport, detailed drawing or mechanical work, prolonged small size & low contrast visual work etc., this can require illumination levels from 1,500 all the way up to 20,000 lux in extreme cases.

The lighting output of a light fitting is typically reported as a **lumens output** - the intensity of light on a surface (the lux) is dependent on the intensity of the light source (i.e. its lumens output) and the desired surface area to be lit.

Definition of Lighting Lumens

The lumen is a standardized unit of measurement of the total "amount" of light packets (or quanta if you want to get technical!) that is produced by the light source - such as a lamp, tube or LED chip. This total measured light may also be referred to by commercial or industrial lighting engineers as "luminous flux".

Some examples of total lumens output (as measured in lumens) from common commercial & industrial light sources are given below:

Table 2.6: Type of Light Fixture and Example Uses

	Lumens	Example Uses
400W Metal Halide lamp	38,000	high bay **factory lighting** or **warehouse lighting** lighting installations
200W LED array in a high bay fitting	20,000	energy efficient replacement for 400W metal halide and sodium high bays
150W High pressure sodium bulb	12,000	street/outdoor area lighting
100W Incandescent bulb	1,700	general domestic & task lighting applications
32W T5 or T8 Fluorescent tube	1,600	office ceiling lighting panel installations

* Please note that these are sample figures for example purposes only & the actual output can vary.

Relationship between Lumens & Lux

One lux (1 lux) is defined as being equivalent to one lumen spread over an area of one square metre. To put it another way:

A specification in lux tells you how many Lumens (total light output) you need given the measured area you are trying to illuminate.

So 1,000 lumens, concentrated into an area of one square metre, lights up that square metre with an illuminance level of 1000 lux. The same 1,000 Lumens, spread out over ten square metres, produces an illuminance level of only 100 Lux.

Lighting larger areas to the same necessary lux levels will requires a larger measured level of lumens – this is usually achieved by increasing the number of light fixtures (and hence the power consumed). Bigger commercial & industrial buildings (such as factories and warehouses) have large open spaces so a large number of high power light fittings ('high bay' and 'low bay' types)are generally required.

Efficacy: the relationship between Lumens & Watts

The power required to operate an installed light fitting (or luminaire) is measured as a rated Wattage (Watts being Joules of energy per second). The rated wattage of a light source refers to the entire power consumed in creating the light Lumens and includes the:

- Energy required in creating "visible" light emitted from the lamp
- Heat output generated (including the infra-red part of the lighting spectrum)
- Other parasitic power losses (such as inefficiencies of the control gear/ballast) of the light fixture

A light engineering term exists for the measurement of the rate at which a lamp is able to convert electrical power (Watts) to Light (Lumens) – this is referred to as **luminous efficacy** (or just efficacy) – and is expressed in Lumens per watt (LPW) or Lumens per circuit Watt

The **Luminous Efficacy** is a measure of how efficiently a light source produces visible light.

Some examples of luminous efficacy in common commercial & industrial light sources are given below (Please note that these only refer to the light sources and not the light fitting):

Table 2.7: Type of Light Fixture and Example Uses

Lighting Fixture	Lumens/ Watt	Typical Uses
200W LED array in a LED high bay fitting	100	an energy efficient replacement for 400W metal halide and sodium high bays
400W Metal Halide lamp	90-95	high bay fittings - factory lighting & warehouse lighting
150W high pressure sodium bulb	80	street lighting
32W T5 or T8 Fluorescent tube	50	general office ceiling lighting installation
100W Incandescent bulb	17	general task lighting applications

NOTE: All of the measurements above relate to installed light sources which are new and have not dropped in efficiency - the gradual decay of lighting levels must be taken into account when performing lux calculations prior to light system installation in commercial buildings such as warehouses, factories etc. - find out more details below.

The "Real" Lumen Output of Lamps and Light Fittings

Up to now this article has covered the technical definitions of Lux, Lumens & Watts but this is only part of the necessary understanding.

In the specification of lighting for real-world industrial & commercial applications (such as a **factory** or **warehouse**) it cannot be assumed that:

- 100% of the lamp output will be emitted from the fitting over its useful lifetime
- The light output will be constant over its useful lifetime.

To assist with further understanding - the concepts of 'Light Output Ratio' and 'Lumen Depreciation' are explained further below.

The Light Output Ratio of a Commercial Light Fitting

The actual total illumination levels provided by an installed light fitting (such as one installed in a **factory** or **warehouse** will be critically dependent on the Light Output Ratio:

The **Light Output Ratio** is the ratio of the total amount of measured lumen output of a light fitting (containing a lamp) to that of just the lamp in isolation.

The light output ratio is required in commercial lighting installation because lamp is positioned in a light fitting (such as an industrial 400W metal halide high bay) losses of light occur within the fitting itself.

Usually light needs to be directed towards the working area (e.g. - downwards from roof to floor), however, light radiates from lamps and bulbs in all directions (upwards, sideways etc.)

The use of highly polished aluminium reflectors will redirect most of the light downwards - however a proportion will always be 'trapped' in the fitting (and ultimately lost as heat). Its worth noting that directional light sources (such as LED chips in a commercial LED high bay light) do not suffer from this problem to the same extent - here light is emitted as a beam in a singular direction - therefore the LOR will typically be higher for LEDs.

Lumen Loss from Pre-Installed Commercial Light Fittings

The LOR of a light fitting will also be affected over time as debris &/or dust builds up on reflectors, as well as protective covers in the case of fittings with an 'IP' rating. This will particularly be the case in industrial & factory buildings which have many different processes (.e.g chemical, manufacturing etc.) being undertaken.

Lumen Loss from Lamps & Light Sources

Lumen depreciation refers to the process of gradual decline in light output that is observed from most light sources over time. This includes (but is not limited to):

- Gradual light filament/electrode deterioration
- Blackening/discoloration of the lamp surface

In other words:
LED lighting modules do not die instantly like most conventional light sources do - they slowly dim until the lumens output is no longer acceptable.
It should, however, be noted that lower cost high power LEDs (such as those required for large industrial buildings such as a **factory** or **warehouse**) can suffer a rapid initial loss of lumens, rapidly reducing the lighting lux to below the intended lighting lux requirements in only a short time.

2.5 Document Inquiries and Responses

Lighting Design Considerations and Concepts

Lights can seem like a simple decision if you don't overthink it, but when you consider all of the different factors that go into making a workspace well-lit, you see just how complicated the process may be. Here are a few lighting design considerations and concepts to consider when choosing office lighting:

- Light Distribution and Brightness
- Conservation of Energy
- The Appearance of the Space and Luminaires
- Glare
- The Appearance of Color
- Lighting Control and Flexibility
- Lighting of Faces
- Cost of Implementation
- Installation
- Maintenance

Energy Conservation

Many older lighting design types, like incandescent and fluorescents, consume comparatively huge amounts of energy. In traditional incandescent bulbs, **90% of the energy** they emit is given off as heat, making them a very wasteful option. Changing bulb types to more efficient LEDs can be one of the best ways to save energy, which is good for both the environment and your bottom line. LED stands for light-emitting diodes, and they work through a process called electroluminescence, which generates light as an electric current passes through a semiconductor material.

LED bulbs **have several benefits** that make them the ideal choice for an office environment. They are:

More efficient: LEDs can use anywhere from 25 to 80% less energy than their incandescent counterparts. These savings offer significant reductions in operational costs. Compare the annual energy cost for a light bulb used for two hours a day at 11 cents per kilowatt-hour. For a 60-watt traditional incandescent, the yearly energy cost is $4.80, but a 12W LED would only cost $1.00.

Longer lasting: LED lights also save money through replacements. They can last up to 25 times longer than traditional incandescent, which also reduces maintenance needs.

Cooler: With a lower heat output, these lights are safer and help you maintain your desired temperature without added warmth.

Dimmable: Colors are varied and flexible, allowing for lighting fixtures that can adapt to your needs. The color rendition of LED bulbs is excellent, so your office can look just how you intended.

Outdoor Lighting Compliance Documents

This section contains information about required outdoor lighting documentation, including outdoor lighting plan check documents

- **Overview**

This section describes the documentation (compliance forms) recommended for compliance with the nonresidential outdoor lighting requirements of the 2013 Standards.

- **Submitting Compliance Documentation**

At the time a building permit application is submitted to the enforcement agency, the applicant also submits plans and energy compliance documentation. This section describes the recommended compliance documentation (forms) for complying with the nonresidential outdoor lighting requirements of the Standards. It does not describe the details of the requirements.

- **Varying Number of Rows per Document**

The paper prescriptive compliance documents have a limited number of rows per section for entering data. Some designs may need fewer rows, and some designs may need additional rows. If additional rows are required for a particular design, then multiple copies of that page may be used.

- **Compliance Documentation Numbering**

Following is an explanation of the 2013 nonresidential lighting compliance documentation numbering:

- NRCC Nonresidential Certificate of Compliance
- NRCA Nonresidential Certificate of Acceptance
- NRCI Nonresidential Certificate of Installation

- LTI Lighting, Indoor
- LTO Lighting, Outdoor
- LTS Lighting, Sign
- 01 The first set of compliance documents in this sequence
- E Primarily used by enforcement authority
- A Primarily used by acceptance tester

- **Certificate of Compliance Documents**

Nonresidential outdoor lighting Certificate of Compliance documents are listed below:

- Certificate of Compliance:; Outdoor Lighting
- Certificate of Compliance: Outdoor Lighting Controls
- Certificate of Compliance: Outdoor Lighting Power Allowances

- **Instructions for Completing Certificates of Compliance**

- Certificate of Compliance: Outdoor Lighting

The Certificate of Compliance form is in six pages. Each page, if required (see below), must appear on the plans (usually near the front of the electrical drawings). A copy of these forms should also be submitted to the enforcement agency along with the rest of the compliance submittal at the time of building permit application

Self-check #2

Part: I Choose the best answer from the give alterative

1) The is a document developed by the architectural and engineering firms and before the schematic design phase

A. BOD B. OPR C. Checklist D. Light document

2) _____ is a measure of how efficiently a light source produces visible light

A Luminous Efficacy B. Illumination C. Light source D. Beam spread

3) _____is a standardized unit of measurement of light level intensity, which is commonly referred to as "illuminance" or "illumination

A Lux B Lumens C. Candela D. Light intensity

4) Directed beams of light that highlight specific objects or areas.

A. Spotlights: B. Wall Washers C. Foot candle D. Efficacy

5) Broad beams of light that wash over a wall to highlight textures or large features.

A Spotlights: B. Wall Washers C. Foot candle D. Efficacy

6) A measurement of light emitted by a lamp. As reference, a 100-watt incandescent lamp emits about 1600 lumens. A. Lux B. Lumens C. Candela D. Light intensity

7) A measurement of the intensity of illumination. A foot candle is the illumination produced by one lumen distributed over a 1-square-foot area.

A Spotlights: B. Wall Washers C. Foot candle D. Efficacy

8) The ratio of light produced to energy consumed. It's measured as the number of lumens produced divided by the rate of electricity consumption (lumens per watt).

A Spotlights: B. Wall Washers C. Foot candle D. Efficacy

9) Which one is advantages electrical inspection checklist offer many for you and your clients

A Improves safety B. Reduces liability risks C. Enhances customer trust D. all

Part II : Fill Blank space

1. _____is the tenant if the space being designed is a tenant space that is rented.
2. _____is an established brand with a history dating back to 1938, is widely recognized for its expertise in outdoor lighting, ceiling fans, and residential and commercial lighting
3. _____is produced by Cree with high efficiency include Lamp LEDs, which are designed for general and specialized illumination
4. Many older lighting design types, like incandescent and fluorescents, consume comparatively huge amounts of energy

Operation sheet # 1

Operation Title: Prepare Electrical Inspection Checklist

Purpose: -Supervise and evaluate site work procedures and prepare checklist of monitoring performance.

Instruction: To Identify condition of building electrical installation performance on site, visit your work shop or your site compound with your teacher or Trainer where the electrical fault distribution boards, sub distribution boards, effective lighting design and final circuits found and prepare checklist.

Required tools and equipment: - Use measuring instrument and other tools like: Multi meter, test light, meter, pliers, A4 paper etc.

Precautions:

- Use appropriate Personnel protective equipment and correctly check function of circuits:
- Safe handling of hand tools, testing instruments and components
- Don't give supply before checking your system installation.

Procedures: -When prepare checklist and supervise site follow electrical standard and the following step of performance.

Step of the task

1. Prepare necessary materials
2. Observe and identify building electrical installation site
3. Supervise and evaluate site work procedures
4. Identify condition of site works
5. Develop method of Safe Electrical installation and lighting design
6. Make report and documentations

Quality Criteria: To ensure effectively light designing and fulfill code and standards, Selection and identification of building electrical installation site works with appropriate layout/ design system

References

1. Ethiopian Building Code Standard (EBCSs) 10 edition
2. Architectural Lighting Designing with Light and space [Herce Descotte]
3. Lighting Modern Buildings [Dark Phillips]
4. Stage Lighting Design second edition
5. Master Specifications http://www.cfm.va.gov/TIL/spec.asp
6. Design and Construction Procedures (PG-18-3) http://www.cfm.va.gov/TIL/spec.asp
7. Design Manuals (PG-18-10) http://www.cfm.va.gov/til/dManual.asp
8. Design Guides (PG-18-12) http://www.cfm.va.gov/til/dGuide.asp

Developer Profile

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