REVA UNIVERSITY
Bengaluru, India
Established as per the section 2(f) of the UGC Act, 1956,
Approved by AICTE, New Delhi

Programme: B.Tech (EEE)
Class and Section: 5th semester-Open
Course Name: **Energy Conservation**
Course Code: **B22EEO501**
Unit 3-NOV-2025

ILLUMINATION SYSTEM

REVA UNIVERSITY
Bengaluru, India

- **Course content**

Types of lamps used, principle of discharge lamps, performance of fluorescent lamps, compact fluorescent lamps, Lamps efficacy, Colour rendering index (CRI), Installed load efficacy ration (ILER), Types of street lights, Streetlight controller, Occupancy sensors, Task oriented lighting system, Parameters influence on illumination system, Sizing of lighting equipments, Conventional coil wound ballasts, Electronic ballasts, Effect of voltage variation on lighting equipment, illumination level for different applications, LED lighting system, Induction lighting system and problems.

ILLUMINATION

- One-quarter of our electricity budget is been spent on lighting, or more than $37 billion annually
- Technologies developed cut lighting costs 30% to 60% while enhancing lighting quality and reducing environmental impacts

ILLUMINATION

REVA UNIVERSITY
Bengaluru, India

Introduction to Illumination

- Illumination refers to the process of lighting an area to make objects visible.
- It plays a vital role in industrial, commercial, residential, and street lighting applications.
- The objective is to provide adequate light for the task with maximum efficiency and visual comfort.

Basic definitions

Lux: It is the metric unit of measure for illuminance of a surface.

Lamps Efficacy: It is the amount of light (lumens) emitted by a lamp for each watt of power consumed by the lamp.

Unit: lumens per watt (lm/W)

CRI(Color Rendering Index): is a quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source.

- The ability to see colors properly is another aspect of lighting quality
- The color rendering index (CRI) scale is used to compare the effect of a light source on the color appearance of its surroundings.
- A scale of 0 to 100 defines the CRI.
- A higher CRI means better color rendering, or less color shift

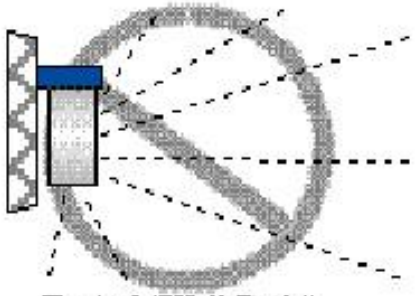
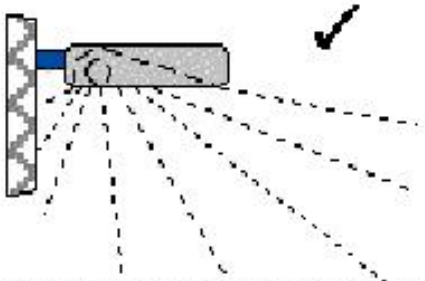
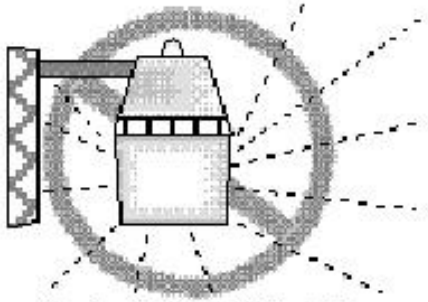
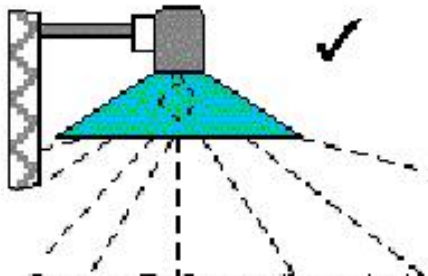
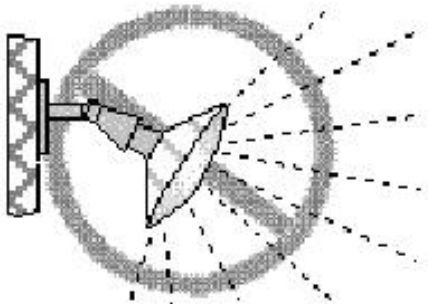
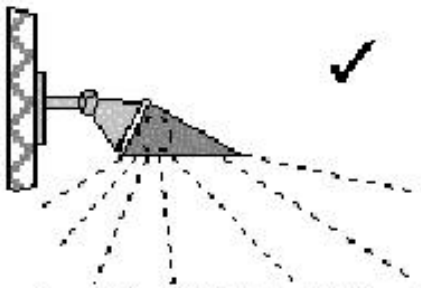
Installed load efficacy Ratio (ILER):

It is the average maintained illuminance provided on a horizontal working plane per circuit watt with general lighting of an interior.

ILER = (Actual $\mathrm{lux}/W/m2$)/Target ($\mathrm{lux}/W/m2$)

Unit: $\mathrm{lux}/W/m2$

EXAMPLES OF SOME COMMON LIGHTING FIXTURES

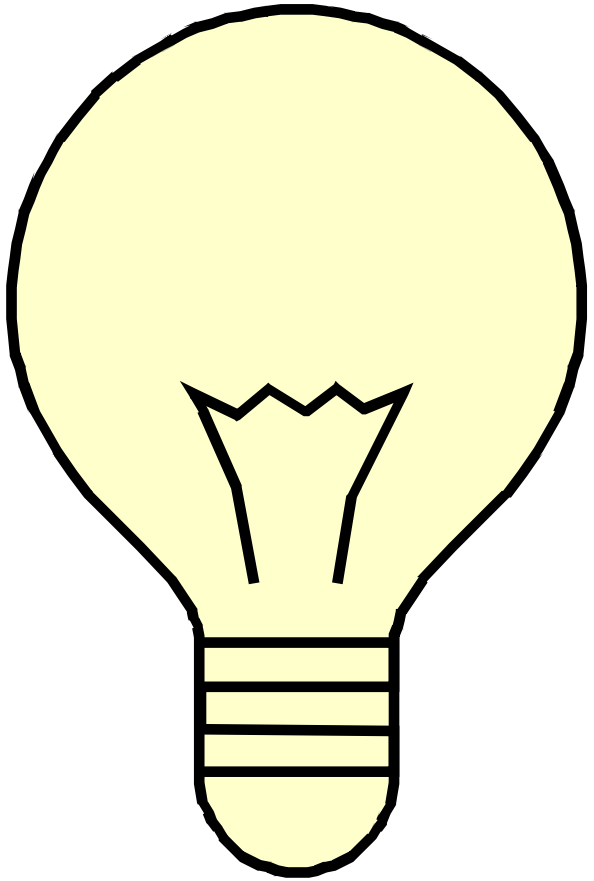
POOR	GOOD
 Typical "Wall Pack"	 Typical "Shoe Box" (forward throw)
 Typical "Yard Light"	 Opaque Reflector (lamp inside)
 Area Flood Light	 Area Flood Light with Hood

Types of Lamps Used

Lamp Type	Examples	Remarks
Incandescent Lamps	Tungsten filament lamp	Low efficiency, warm light
Discharge Lamps	Fluorescent, Mercury vapor, Sodium vapor, Metal halide	High luminous efficacy
Compact Fluorescent Lamps (CFL)	Spiral or folded tube	Energy-saving, replaces incandescent lamps
LED Lamps	Light Emitting Diodes	Very high efficiency and life
Induction Lamps	Electrodeless lamps	Long life, low maintenance

Incandescent Light

- It uses electric current to heat a tiny coil of tungsten metal inside a glass bulb to produce light.
- Convert most of their energy into heat rather than light
- shortest life & hence Inefficient



Types of Incandescent Bulbs

- Standard incandescent
  - Most common yet the most inefficient
  - Larger wattage bulbs have a higher efficacy than smaller wattage bulbs
- Tungsten halogen
  - It has a gas filling and an inner coating that reflect heat
  - Better energy efficiency than the standard A-type bulb
- Reflector lamps

Discharge lamps

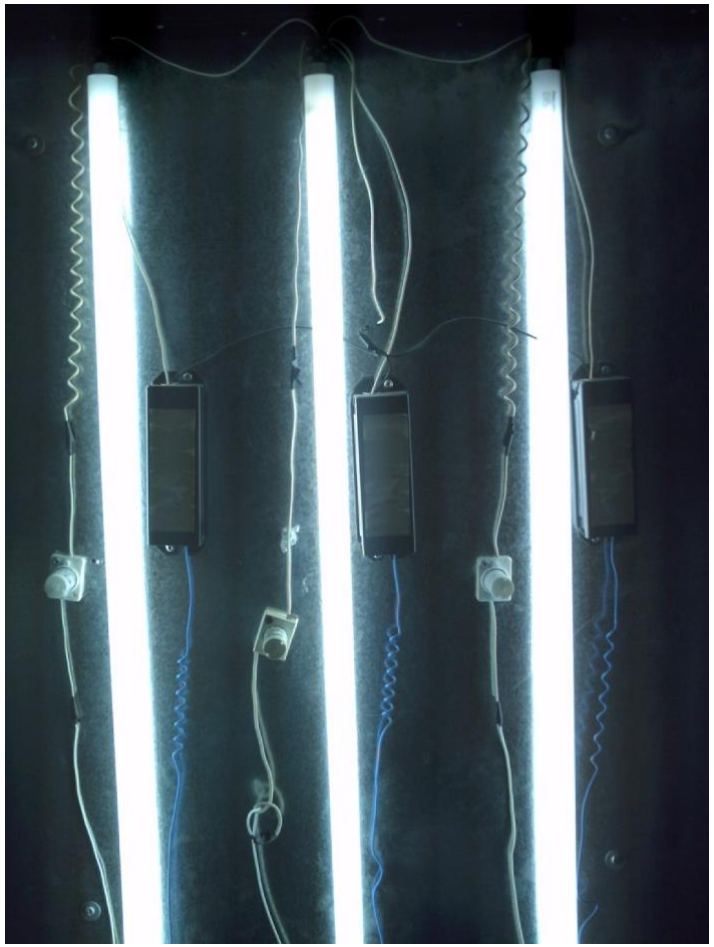
1. Fluorescent Bulbs

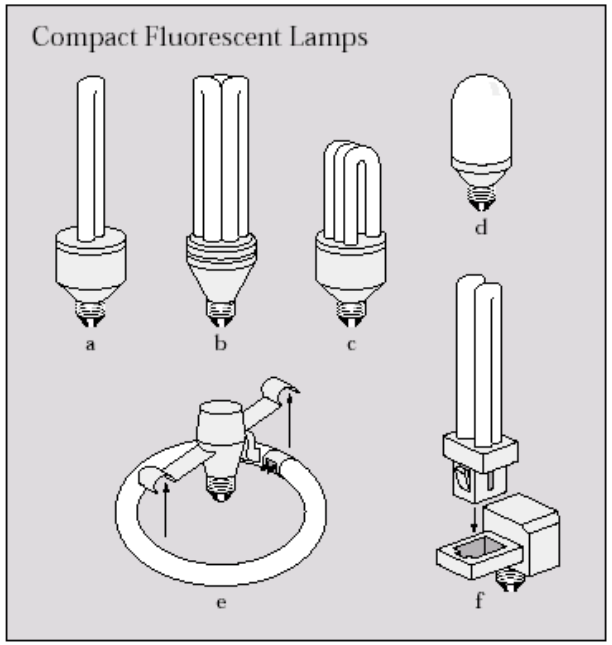
- Used mostly in commercial settings
- filled with an argon or argon-krypton gas and a small amount of mercury
- Coated inside with phosphors
- equipped with an electrode at both ends
- 3 to 4 times as efficient as incandescent lighting and lasts 10 times longer
- Fluorescent lights need ballasts (i.e., devices that control the electricity used by the unit) for starting and circuit protection
- Produces up to 100/lumens per watt (approximately)

Discharge lamps

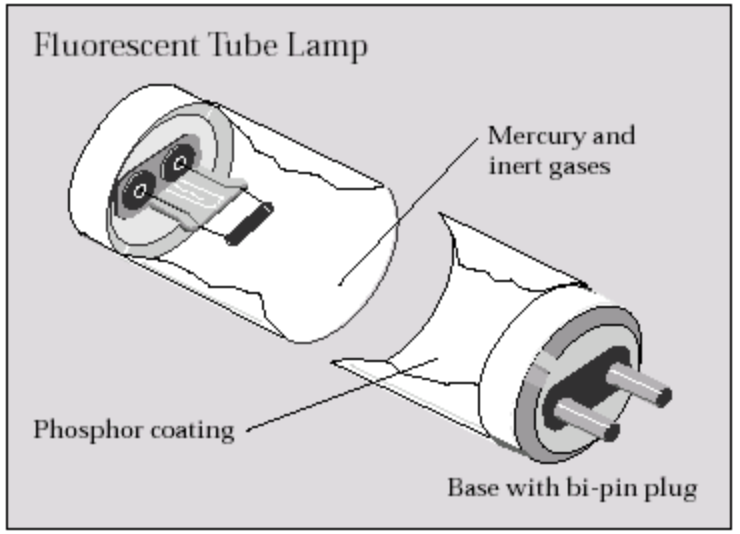
Fluorescent lamps

- An ***electric discharge (current)*** is maintained between the electrodes through the mercury vapor and inert gas.
- This current excites the mercury atoms, causing them to emit non-visible ***ultraviolet (UV) radiation***
- This UV radiation is converted into ***visible light*** by the phosphors coating in the tube





Compact fluorescent lamps (CFLs) come in a variety of sizes and shapes including (a) twin-tube integral, (b and c) triple-tube integral, (d) integral model with casing that reduces glare, (e) modular circline and ballast, and (f) modular quad-tube and ballast. CFLs can be installed in regular incandescent fixtures, and they consume less than one-third as much electricity as incandescent lamps do.

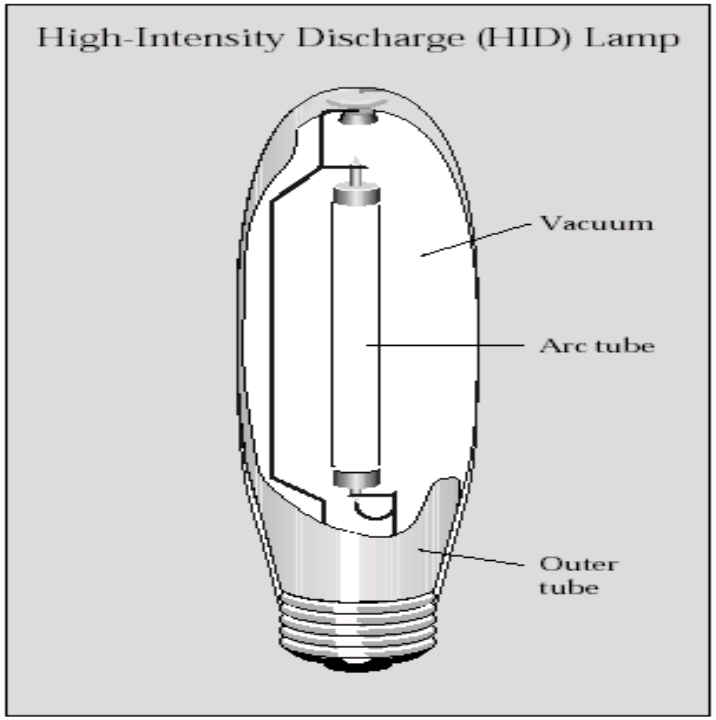


In fluorescent tubes, a very small amount of mercury mixes with inert gases to conduct the electrical current. This allows the phosphor coating on the glass tube to emit light.

Discharge lamps

High Intensity Discharge (HID) Lamp

- Highest efficacy
- Longest service life of any lighting type
- Used mainly for large area applications



In a high-intensity discharge lamp, electricity arcs between two electrodes, creating an intensely bright light. Mercury, sodium, or metal halide gases act as the conductor.

Discharge lamps

Types of HID lamps

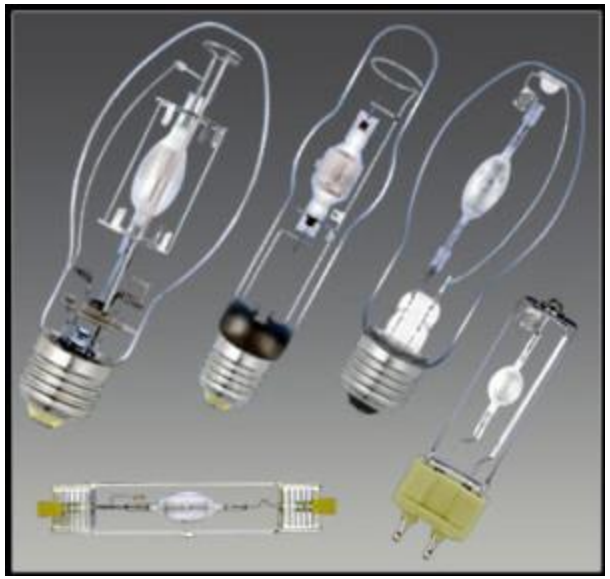
- Mercury vapor (MV)
- Metal halide (MH)
- High-pressure sodium
- Low-pressure sodium

– MV – being phased out
– Metal Halide – 100/lumens per watt
– HPS – up to 150/lumens per watt
– LPS - up to 200/lumens per watt

Discharge lamps

Metal halide (MH)

- It produces light by an electric arc through a gaseous mixture of vaporized mercury & metal halides.
- High efficiency
- CRI is more
- Luminous efficacy is 75-100 lumens per watt
- Lamp life is 6000 to 15000 hours
- Used for wide area overhead lighting(parking lots, sports arenas, factories & retail stores)



Discharge lamps

High-pressure sodium(HPS) Lamps

- Produces up to 100 lumens per watt
- Fair CRI (85)
- A life of 6000 – 12000 hours

Discharge lamps

Low-pressure sodium

- Used in outdoor applications
- Most efficient form of artificial lighting
- Maintain their light output better than other lamps
- Produces up to 200/lumens per watt
- Older technology, not many manufacturers producing new product

Compact Fluorescent Lamps (CFLs)

- CFLs can replace incandescent that are roughly 3 to 4 times their wattage
- They last 10 to 15 times as long
- best energy efficiency investments available
- cost from 10 to 20 times more than comparable incandescent bulbs

Lamps efficacy, Colour rendering index (CRI), Installed load efficacy ration (ILER), Types of street lights,

- **Lamps efficacy,** Lamp efficiency, also known as luminous efficacy, is the measure of how well a light source converts electrical power into visible light, expressed as the ratio of luminous flux (light output in lumens) to power consumed (in watts). The unit for lamp efficiency is lumens per watt (lm/W), indicating how much light a lamp produces for every watt of electricity it uses.

Colour rendering index (CRI)

- The Color Rendering Index (CRI) is a quantitative measurement of how faithfully a light source reveals the true colors of objects compared to a natural light source like the sun. It is rated on a scale of 0 to 100, with 100 being the highest quality, and indicates how accurate a light source is at reproducing colors. Higher CRI values (90 and above) are considered excellent, while lower values (below 80) are considered poor, as they can make colors appear distorted or washed out.

Colour rendering index

How it works

- Comparison to a reference: CRI measures the spectral colors of a light source against a reference illuminant, which is typically daylight.
- Scale: The rating ranges from 0 to 100. A CRI of 100 is considered perfect, like natural sunlight, while a CRI of 0 would mean the light is monochrome.
- Higher is better: A light source with a higher CRI will show colors more accurately. For example, a light with a CRI of 95 will render colors more vividly than a light with a CRI of 70.

Where CRI is important

- Home: In areas where accurate color is important, such as a bathroom for applying makeup or a kitchen for food preparation.
- Commercial: In places where color accuracy is critical for the quality of work or products. Examples include:
- Art galleries and museums
- Retail stores
- Hairdressing and beauty salons
- Printing and design studios
- Dental offices and hospitals

Installed load efficacy ration (ILER)

- Installed Load Efficacy Ratio (ILER) is a metric used to assess the energy efficiency of a lighting system by comparing its actual performance to a target or ideal performance. It is calculated as the ratio of the **installed load efficacy** (actual lighting performance in lux per watt per square meter) to the **target load efficacy** (desired performance for that type of space and application). A higher ILER indicates a more efficient lighting system, with a value of 1.0 representing the ideal.

ILER-Calculating the ILER

- Calculate the installed load efficacy:Measure the average maintained illuminance using a lux meter.Calculate the total power consumed by the lighting circuit in watts (including lamps and ballasts).
- Measure the floor area in square meters.Use the formula: Installed Load Efficacy = Average Maintained Illuminance (lux) / (Total Circuit Watts / Area (\(m^{2}\))).
- Determine the target load efficacy: This value is based on the specific application and room index, and is often provided in design guidelines.Calculate the ILER: Divide the installed load efficacy by the target load efficacy.ILER = (Installed Load Efficacy) / (Target Load Efficacy)

types of street lights

- Common types of street lights include High-Pressure Sodium (HPS), Metal Halide (MH), and Light Emitting Diode (LED) lamps, each with different applications, luminous efficacy, and characteristics.
- LED lights are increasingly common due to their energy efficiency and control over light direction, while HPS is still used for its effective visibility and glare limitation, especially in foggy areas, and MH lights are rarely used in new projects due to maintenance issues. Other types include solar street lights, which are suitable for off-grid areas like parks

High-Pressure Sodium (HPS), Metal Halide (MH)

High-Pressure Sodium (HPS)

Characteristics: Produces a yellow-orange light and has a high luminous efficacy, providing good visibility in foggy conditions.

Applications: Used for highways and foggy areas.

Metal Halide (MH)

Characteristics: Emits a bright white light with decent color rendering, but suffers from relatively short lifespan and high maintenance needs.

Applications: Historically used for commercial zones and stadiums, but is rarely used in new roadway projects.

Light Emitting Diode (LED)

- Characteristics: Highly energy-efficient, with a long lifespan and excellent control over light direction and uniformity. They can be designed to be highly efficient and provide energy savings.
- Applications: Widely used for urban roads, pedestrian pathways, and public squares.
- Solar:
- Characteristics: A type of street light that is powered by solar energy.
- Applications: Used in off-grid areas like parks or locations where traditional electricity is not available.

Syllabus-

- Streetlight controller, Occupancy sensors, Task oriented lighting system, Parameters influence on illumination system, Sizing of lighting equipments, Conventional coil wound ballasts, Electronic ballasts, Effect of voltage variation on lighting equipment, illumination level for different applications, LED lighting system, Induction lighting system and problems.

Streetlight controller:

- A streetlight controller is a device used for the intelligent management and automation of street lighting systems to improve energy efficiency, enable remote monitoring, and reduce maintenance costs.
- Modern street light controllers are available in various forms, including photocell, timer-based, and advanced IoT-based smart controllers that support individual lamp control and integration with smart city infrastructure.

Types of Streetlight Controllers

- Streetlight controllers can be broadly categorized by their functionality and installation method:Photocell Controllers: These use ambient light sensors to automatically switch lights on at dusk and off at dawn, avoiding manual operation or fixed schedules.
- Timer-Based Controllers: These rely on pre-programmed schedules or real-time clocks (RTC) to turn lights on and off at specific times, which helps with planned energy management.
- Smart/IoT Controllers: These advanced systems offer individual lamp control, dimming capabilities, and real-time monitoring through a central management system (CMS) via communication technologies like GSM, GPRS, LoRaWAN, Zigbee, or NB-IoT. They can also integrate with various sensors (motion, environmental, etc.) to adapt lighting to real-time conditions.

Smart/IoT Controllers:

- NEMA and Zhaga Interfaces: These are standardized physical and electrical interfaces (sockets) on luminaires that allow for easy, "plug-and-play" installation of compatible smart controllers from different manufacturers.
- Luminaire/Pole-Mount Controllers: These are installed inside the light fixture or on the pole, o

Key Features and Benefits- streetlight controllers

- Modern streetlight controllers offer significant advantages over traditional systems:Energy Efficiency: They can reduce energy consumption by up to 60-80% through features like adaptive dimming (adjusting brightness based on traffic or pedestrian presence) and precise on/off scheduling.
- Remote Management: A central management system (CMS) allows operators to monitor the entire lighting network, adjust settings, and receive real-time fault reports from a single dashboard, transforming reactive maintenance into predictive maintenance.
- Enhanced Public Safety: Adaptive lighting ensures adequate illumination when needed, improving safety while minimizing light pollution in unoccupied areas.
- Smart City Integration: Streetlight poles with smart controllers and constant power can serve as a backbone for other IoT devices, such as security cameras, air quality
-

Occupancy sensors

- An occupancy sensor is a device that detects the presence of people in a space to automatically control systems like lights, ventilation, and HVAC. Unlike a simple motion sensor, it can detect people even when they are not moving. These sensors use various technologies such as passive infrared, ultrasonic, and microwaves to monitor a room and save energy by turning things on or off as needed.
- **Functionality:**
- When a person enters a space, the sensor can turn on lights and ventilation. When the space is empty for a preset amount of time, the sensor automatically turns them off to conserve energy.

Technology:

- **Passive Infrared (PIR)**: Detects the heat emitted by a person.
- **Ultrasonic**: Sends out high-frequency sound waves and detects changes in the reflected signal caused by movement.
- **Microwave**: Uses microwave radiation to detect movement.
- **Optical/Computer Vision**: Uses cameras and sophisticated algorithms to detect people, often providing more detailed data.
-

Applications:

- **Energy Savings**: Reduces energy consumption by ensuring lights and HVAC are not running in unoccupied rooms.
- **Automation**: Provides convenience by eliminating the need to manually turn lights on and off.
- **Building Management**: In commercial settings, data from sensors can help optimize space usage and improve overall efficiency.
- **Specific uses**: They are commonly used in commercial buildings, public restrooms, and can be installed in homes as a smart home device.

occupancy sensor

- What is the occupancy sensor?
- An occupancy sensor is a device that detects the presence of people in a space to automatically control systems like lights, ventilation, and HVAC. Unlike a simple motion sensor, it can detect people even when they are not moving. These sensors use various technologies such as passive infrared, ultrasonic, and microwaves to monitor a room and save energy by turning things on or off as needed.

occupancy sensor

- Functionality: When a person enters a space, the sensor can turn on lights and ventilation. When the space is empty for a preset amount of time, the sensor automatically turns them off to conserve energy.
- Technology:
- Passive Infrared (PIR): Detects the heat emitted by a person.
- Ultrasonic: Sends out high-frequency sound waves and detects changes in the reflected signal caused by movement.
- Microwave: Uses microwave radiation to detect movement.
- Optical/Computer Vision: Uses cameras and sophisticated algorithms to detect people, often providing more detailed data.

Applications

- **Energy Savings**: Reduces energy consumption by ensuring lights and HVAC are not running in unoccupied rooms.
- **Automation**: Provides convenience by eliminating the need to manually turn lights on and off.
- **Building Management**: In commercial settings, data from sensors can help optimize space usage and improve overall efficiency.
- **Specific uses**: They are commonly used in commercial buildings, public restrooms, and can be installed in homes as a smart home device.

A task-oriented lighting system

A task-oriented lighting system, also known as task lighting, is a type of focused illumination designed to brighten specific areas for focused activities like reading, cooking, or working. Unlike general lighting that lights up a whole room, task lighting provides more direct and controlled light where it's needed most, which helps reduce eye strain and improve visibility and productivity. Examples include desk lamps, under-cabinet lighting in kitchens, and adjustable floor lamps.

Key features and benefits-A task-oriented lighting system

- Focused illumination: Provides concentrated light directly on a work surface, making it easier to see fine details.
- Reduces eye strain: By giving the eyes the right amount of brightness where needed, it prevents fatigue and discomfort.
- Increases productivity: Improved visibility and comfort allow for more efficient and accurate performance of tasks.
- Complements general lighting: It is used in addition to ambient lighting, which provides overall room illumination.
- Often adjustable: Many task lights are adjustable in direction and intensity to suit individual needs.

Examples of task lighting

- Desk lamps: Provide direct light for reading, writing, or using a computer.
- Under-cabinet lighting: Illuminates kitchen countertops for cooking and food preparation.
- Pendant lights: Can be used over a kitchen island or a dining table to focus light on the area below.
- Vanity lights: Used in bathrooms to provide focused light for tasks like applying makeup.

Parameters influence on illumination system

- Parameters like illuminance (light level), luminance (brightness of a surface), color temperature, and color rendering index (CRI) influence how an illumination system performs, affecting visual comfort, clarity, and the overall quality of light. Other factors include the luminance distribution, glare, flicker, and uniformity, which together determine the system's effectiveness for its intended application.

Key parameters and their influence

- **Illuminance and LuminanceColor:**
- **Color Temperature: Dictates the "warmth" or "coolness" of the light (e.g., warm white, cool white, daylight) and is measured in Kelvin (K).**
- **Color Rendering Index (CRI): Measures how accurately a light source reveals the true colors of objects compared to natural daylight. A higher CRI (closer to 100) is better for applications where color accuracy is critical.**

Distribution and Quality, Efficiency and Maintenance, Application-Specific Parameters

- Distribution and Quality:
- Uniformity: The evenness of light distribution. Poor uniformity can create distracting bright and dark spots.
- Glare: The effect of excessive brightness that causes visual discomfort. It's a key factor for visual comfort.
- Flicker: The rapid fluctuation in light output that can be imperceptible but can cause visual fatigue or headaches.
- **Efficiency and Maintenance: Luminous Efficacy, Maintenance Factor**
- **Application-Specific Parameters: Space Dimensions: Mounting Height, Usage and Environment**

Sizing of lighting equipments,

- Sizing lighting equipment involves determining fixture dimensions based on room size and purpose, or calculating the necessary light output (lumens or wattage) using formulas like lumens / area = lux. For fixtures, a common rule of thumb is to add the room's length and width in feet, and the sum equals the ideal diameter of the fixture in inches. For lighting output, you can calculate the required illumination level (measured in lux) by dividing the total lumens by the area in square meters to ensure adequate brightness for the intended use.

Fixture sizing

- Calculating lighting output Basic formula (for a single fixture): The required illumination (E-in lux) is equal to the luminous flux (F- in lumens) divided by the surface area (A-, in square meters).E=F/A
- The required illumination (E- in lux) is equal to the luminous flux (F), in lumens divided by the surface area (A in square meters).

Factors to consider-Fixture sizing

- Factors to consider:Purpose of the room: A workspace or study room will need more lumens than a living room.Maintenance factor: Use a maintenance factor (MF) in the formula, especially for outdoor applications where light may be blocked or lost.Number of lamps: If using multiple lamps, multiply the lumens of a single lamp by the number of lamps (Q).Advanced formula: E=(FX QX MF)/A.

Numerical example

- Example: For a 3x3 meter room with a 4500 lumen light, the illumination would be E=4500/3X 3=500lux.

What is a conventional ballast?

REVA UNIVERSITY
Bengaluru, India

- What is a conventional ballast?
- The conventional ballast consists of a coil. In simple terms, this coil ensures that the fluorescent tube is supplied with an operating voltage of 50V - 100V.
- And there are two types of ballasts in each family: magnetic and electronic. Magnetic ballasts are the older ballast technology. For the fluorescent family, both T12 linear fluorescents and two-pin CFLs use magnetic ballasts. For HIDs, some metal halides and HPS lamps use magnetic ballasts.

What is the purpose of ballast?

- It also has an electrical function, as a device used to regulate current in lamps like fluorescent lights
- Compared to conventional ballast, electronic ballast is more flexible since it allows more than one lamp to be fitted to a single ballast. In addition, the electronic ballast has no copper windings, it has smaller power losses and longer service life (i.e. lower light output depreciation).

What is the difference between conventional ballast and electronic ballast?

What is the difference between conventional ballast and electronic ballast?

Feature	Conventional Ballast (Magnetic Ballast)	Electronic Ballast
Operating Principle	Works using electromagnetic induction (coil & core)	Uses electronic circuits (semiconductors, rectifiers, ICs)
Frequency	Operates at low frequency (50–60 Hz)	Operates at high frequency (20–60 kHz)
Size & Weight	Bulky and heavy	Compact and lightweight
Energy Efficiency	Less efficient, higher power loss	More efficient, lower power loss
Starting Method	Requires starter for tube lights	No starter needed (instant start)
Flicker	Flickering is common	No flicker due to high-frequency operation
Noise	Produces humming sound	Silent operation
Lamp Life	Shorter lamp life	Longer lamp life
Heat Generation	Generates more heat	Generates less heat
Cost	Lower initial cost	Higher initial cost but saves energy

Effect of voltage variation on lighting equipment,

- Voltage variations negatively impact lighting equipment by causing dimmer or brighter light, flickering, reduced lifespan, and potential burnout. High voltage can lead to overheating and premature failure, while low voltage can make lights dim or fail to operate correctly. Specifically, LED drivers are sensitive, and fluctuations can lead to flickering and shorter lifespans.

Effects of high voltage

- Increased brightness: Lights may appear brighter than normal.
- Overheating: High voltage can cause excessive heat, damaging components and leading to premature failure.
- Burnout: A severe voltage surge can cause a bulb to burn out or blow out.
- Increased power consumption: Equipment may consume more power, leading to higher energy bills.
- Reduced lifespan: Higher voltage shortens the lifespan of a lamp significantly.

Effects of low voltage

- Dimmer light: Lights will appear dimmer.
- Flickering: This can be a symptom of low voltage, especially in LED systems.
- Incorrect operation: Equipment may not work properly or may cycle on and off repeatedly.
- Increased lifespan: Low voltage can actually double the life of some lamps.

Effects on LED lighting

- Flickering: LED drivers are particularly sensitive to fluctuations, which can cause visible and uncomfortable flickering.
- Reduced lifespan: Voltage variations can cause premature failure and reduce the overall lifespan of LED systems.
- Driver failure: Poor power quality from voltage fluctuations can cause the LED driver to malfunction or fail.
- **Flickering:** LED drivers are particularly sensitive to fluctuations, which can cause visible and uncomfortable flickering.
- **Reduced lifespan:** Voltage variations can cause premature failure and reduce the overall lifespan of LED systems.
- **Driver failure:** Poor power quality from voltage fluctuations can cause the LED driver to malfunction or fail.

standard illumination levels (in lux) recommended for different applications as per common lighting guidelines (IES/ISO/CIBSE standards):

- **1. Residential Areas**
- **Living room / Bedroom:** 100–300 lux
- **Kitchen (general):** 300–500 lux
- **Kitchen (task areas like chopping):** 500–750 lux
- **Study room / Reading:** 300–500 lux
- **Bathroom / Washroom:** 200–300 lux

standard illumination levels (in lux) recommended for different applications as per common lighting guidelines (IES/ISO/CIBSE standards):

- **2. Educational Buildings**
- **Classrooms:** 300–500 lux
- **Laboratories:** 500–750 lux
- **Libraries (reading areas):** 300–500 lux
- **Libraries (stack areas):** 200–300 lux
- **3 Commercial & Office Spaces**
- **General office work:** 300–500 lux
- **Computer workstations:** 300–500 lux
- **Conference rooms:** 300 lux
- **Reception areas:** 200–300 lux
- **Designer studios / detailed drafting:** 750–1000 lux

standard illumination levels (in lux) recommended for different applications as per common lighting guidelines (IES/ISO/CIBSE standards):

- **Industrial Areas**
- **General factory work:** 200–300 lux
- **Medium-precision work:** 300–500 lux
- **High-precision work / QC inspection:** 750–1500 lux
- **Warehouses (active):** 100–200 lux
- **Warehouses (inactive):** 50–100 lux

standard illumination levels (in lux) recommended for different applications as per common lighting guidelines (IES/ISO/CIBSE standards):

- **Outdoor Lighting**
- **Street lighting (main roads):** 10–30 lux
- **Street lighting (residential roads):** 5–15 lux
- **Parking lots:** 10–30 lux
- **Sports grounds (amateur):** 200–500 lux
- **Stadium (professional):** 1000–2000 lux
- **Healthcare Facilities**
- **General wards:** 100–200 lux
- **Examination rooms:** 300–500 lux
- **Operation theatre:** 1000–2000 lux

Induction Lighting System and Its Problems

- **Induction Lighting System – Working Principle**
- Induction lamps operate **without electrodes or filaments**. They work using:

1.High-frequency generator (ballast)

2.Induction coil

3.Magnetic field to excite gas inside the lamp

Induction Lighting System and Its Problems

- **Steps:**
- The electronic generator produces high-frequency AC.
- A magnetic field is created around the induction coil.
- This field excites the gas inside the lamp.
- Gas produces UV radiation → hits phosphor coating → light output.
- Because there are **no filaments**, the lamp has a **very long life (60,000–100,000 hours)**.

Problems/Disadvantages in Induction Lighting

- in general, the major issues are:

1. **Electromagnetic Interference (EMI)**
    1. High-frequency operation may cause interference with radios or sensitive electronic devices.
2. **High Initial Cost**
    1. The electronic generator and system are expensive.
3. **Large Size**
    1. Induction lamps are bulky, not suitable for compact fixtures.
4. **Dimming Challenges**
    1. Dimming requires special electronic circuits.
5. **Maintenance of Electronic Components**
    1. Although the lamp lasts long, the electronic generator may fail earlier.
6. **Lower Adoption**
    1. LED technology has overtaken induction lighting, reducing its use.

THANK YOU