

# Building Electrician

45 Hours Training Program - TEVT Sector

## Teaching - Learning Material



Project Implementation Unit

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## 1. Introduction

The Electrician/Electrical Wiring Training Program is an intensive, vocationally based course designed to prepare trainees for employment in the Electrical/Wiring sector. This training consists of theoretical training as well as practical exercises, introducing students to both domestic and small industrial electrical installations. This training program helps you understand the basic principles of electricity, the wiring competence that an electrician must have, and also the Safe working practices around electrical installation.

## 2. Training Objectives

1. To understand the concepts of current, voltage, and the AC/DC difference in electricity.
2. Develop an understanding of how to use standard electrical tools and materials in a safe and proper manner
3. Implement basic wiring codes and colour standards that are used in residential and small-scale electrical systems.
4. Explain simple wiring codes and colour codes for residential and low-voltage installations.
5. Design and analyse basic electrical circuits, including series and parallel circuits.
6. Design and implement basic domestic wiring layouts, including distribution boards and grounding systems.

## 3. Training Learning Outcomes (TLOs)

### TLO 1:

Trainees will attain the skill set to recognize and operate a wide variety of electro-technical equipment with the emphasis on safety principles. In so doing, they will acquire skills on how to use these tools and equipment in a safe and fruitful manner. To avert the electrical dangers, the students will use Personal Protective Equipment (PPE) properly and will comply with the lockout/tagout procedures.

### TLO 2:

Hands-on training is going to be concentrated on the application of measurement equipment like Multimeters to get accurate readings of the resistance, voltage, and current. In order to improve cooperation in working environments, Trainees are going to be able to identify the major elements of electrical systems and domestic devices, a simple electrical representation and schematic, and exchange information well with clients and colleagues.

## 4. Assessment Structure:

| Component                           | Marks | Passing Criteria   |
|-------------------------------------|-------|--|
| Theory (MCQs + Short Questions)     | 30    | 50% (15 marks)   |
| Practical (Capstone + Presentation) | 70    | 60% (42 marks)   |
| Total                               | 100   | To be eligible for the Certificate of Competency in Building Electrician, trainees must maintain at least 75% attendance and successfully pass both the theory and practical components of the assessment. |



## 5. Training Module and Delivery Plan:

|                                    |  |
|------------------------------------|--|
| Total Training Hours               | 45 Hours   |
| Training Methodology               | <b>Theory:</b> 9 Hours (20%)<br><b>Practical:</b> 36 Hours (80%) |
| Medium of Instruction & Assessment | English & Urdu   |

## MODULE 1: Introduction to Electrical Fundamentals and Safety.

### 1. LU1.1: Basics of electricity

#### Voltage:

Voltage is the measure of the electric potential difference between two points in a circuit. It tells you how much energy per unit charge is available to move electrons through a conductor.

Here's a quick breakdown:

- **Symbol:** V
- **Unit:** Volt (V)
- **Definition:**  
 $V=W/Q$   
where  
W = work or energy (in joules)  
Q = charge (in coulombs)

#### Explanation

- Think of voltage as **electrical pressure** that pushes electric charge through a circuit — like water pressure pushes water through pipes.
- High voltage means more energy available to push electrons.

#### Types of Voltage

- **DC Voltage (Direct Current):** Constant in time (e.g., a battery provides 12 V DC).
- **AC Voltage (Alternating Current):** Changes direction and magnitude periodically (e.g., household mains power).  
Examples
  - AA battery → **1.5 V DC**
  - Car battery → **12 V DC**
  - Household outlet → **120 V or 230 V AC**, depending on your country

#### What is Current:

**Current** is the flow of electric charge — it tells you **how much charge passes through a point in a circuit per unit time**.

#### Basic Definition

$$I=Q/t$$

where



- $I$  = electric current (in **amperes**, A)
- $Q$  = electric charge (in **coulombs**, C)
- $t$  = time (in **seconds**, s)

## Explanation

Think of **current** like the **flow rate of water** in a pipe:

- Voltage is the *pressure* pushing the water.
- Current is the *amount of water* flowing per second.

In electricity, instead of water molecules, **electrons** are moving.

## Types of Current

- **Direct Current (DC)**: Flows in one direction only (e.g., from a battery).
- **Alternating Current (AC)**: Changes direction periodically (e.g., household electricity).

## Unit

- **Ampere (A)** — named after André-Marie Ampère.  
1 ampere = 1 coulomb of charge flowing per second.

## What is Resistance:

**Resistance** is the opposition that a material or component offers to the flow of electric current.

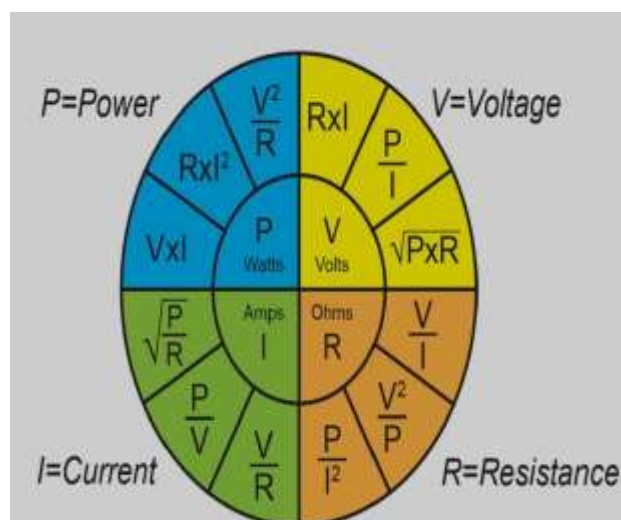
It determines **how easily current can pass** through a conductor — the higher the resistance, the harder it is for current to flow.

$$R = V/I$$

where:

- $R$  = resistance (in **ohms**,  $\Omega$ )
- $V$  = voltage (in **volts**, V)
- $I$  = current (in **amperes**, A)

This relationship is known as **Ohm's Law**.



## Intuitive Analogy

Think of electricity like water flowing through a pipe:

- **Voltage** = water pressure
- **Current** = flow rate of water
- **Resistance** = the narrowness or roughness of the pipe



## What is Power

**Electric power** is the rate at which electrical energy is **transferred, used, or converted** in a circuit. It tells you **how fast electrical energy is being consumed or produced** — for example, by a light bulb, motor, or generator.

$$P=W/t$$

where:

- P = power (in **watts**, W)
- W = electrical work or energy (in **joules**, J)
- t = time (in **seconds**, s)

## LU 1.2: OHM'S, POWER CALCULATIONS.

**Ohm's Law** is one of the most fundamental relationships in electricity.

It states that **the current flowing through a conductor between two points is directly proportional to the voltage across the two points**, provided the temperature and other physical conditions remain constant.

### Formula

$$V=I \times R$$

where:

- V = Voltage (in **volts**, V)
- I = Current (in **amperes**, A)
- R = Resistance (in **ohms**,  $\Omega$ )

### Power Formula

$$P=V \times I$$

where:

- P = Power (in **watts**, W)
- V = Voltage (in **volts**, V)
- I = Current (in **amperes**, A)

| Known quantities             | Formula          | Example                       |
|------------------------------|------------------|-------------------------------|
| Voltage (V) & Current (I)    | $P=V \times I$   | $12V \times 2A = 24W$         |
| Current (I) & Resistance (R) | $P=I^2 \times R$ | $(2A)^2 \times 3\Omega = 12W$ |
| Voltage (V) & Resistance (R) | $P=V^2/R$        | $(12V)^2/3\Omega = 48W$       |

## LU1.3: AC vs DC power systems

**An AC system** is an electrical system in which the current and voltage periodically change direction and magnitude.

### 1. Generation

- Electricity is produced using **alternators** in power plants (thermal, hydro, nuclear, or wind).



- The output is **AC** because it's easy to generate by rotating machines.

## 2. Transmission

- The generated AC is **stepped up** to very high voltages (e.g., 132 kV–765 kV) using **transformers**.
- High voltage → low current → **less power loss** over long distances.

## 3. Distribution

- Before reaching homes or industries, the voltage is **stepped down** (e.g., to 230 V for households).
- Final distribution uses **three-phase or single-phase AC** systems.

A **DC system** is an electrical system in which the **current flows in one constant direction** — it does **not reverse** like in an AC system.

## 5. DC Power System

A DC power system typically includes these stages:

### 1 Generation

- DC is produced by:
  - Batteries
  - Solar panels
  - Fuel cells
  - DC generators (dynamos)

### 2 Transmission

- For long distances, High-Voltage DC (HVDC) systems are used.
- HVDC transmission is very efficient and reduces losses for interconnecting distant grids.

### 3 Distribution

- Used in **electronic systems**, data centers, telecom equipment, EVs, etc.
- Often supplied by rectifiers that convert AC → DC.

## LU1.4: Electrical hazards and shock prevention

Electrical hazards are **dangers or risks** that arise when electrical energy is improperly used or controlled. They can cause **injury, death, fires, or equipment damage**.

### 1. Main Types of Electrical Hazards

| Type   | Description  | Possible Effects                                 |
|--|--|--|
| <b>Electric shock</b>                                  | Current passes through the human body                  | Burns, muscle contractions, heart failure, death |
| <b>Burns</b>   | From heat of current or arc flash                      | Skin or internal tissue damage                   |
| <b>Arc flash</b>                                       | Sudden high-temperature explosion from a short circuit | Fire, blindness, severe burns                    |
| <b>Arc blast</b>                                       | Shockwave from arc fault                               | Hearing damage, physical injury                  |
| <b>Fire</b>  | Overheated wires or short circuits ignite materials    | Property damage, fatalities                      |
| <b>Explosion</b>                                       | Sparks in flammable environments                       | Severe injury or death                           |
| <b>Equipment damage</b><br>Overload or improper wiring | Malfunction, costly repairs                            |  |





6.

## 2. SHOCK PREVENTION METHODS

### 1. Proper Insulation

- Use insulated tools and wires rated for the voltage.

### 2. Grounding (Earthing)

- Connect metallic parts of equipment to the earth to provide a safe path for fault current.

### 3. Circuit Protection Devices

- **Fuses** and **circuit breakers** cut off current when overload occurs.
- **Residual Current Devices (RCDs)** or **Ground Fault Circuit Interrupters (GFCIs)** trip when leakage current is detected (saves lives).

### 4. Dry Working Conditions

- Avoid operating electrical equipment in wet or damp areas.
- Use rubber mats and wear dry shoes/gloves.

### 5. Lockout–Tagout (LOTO)

- Before maintenance, de-energize and lock power sources to prevent accidental switching ON.

### 6. Proper Training

- Workers must be trained to recognize hazards and follow safety protocols.

## LU1.5: Personal Protective Equipment (PPE)

**PPE** stands for **Personal Protective Equipment**. In the context of **electrical safety**, PPE is designed to **protect people from electric shock, burns, arc flashes, and other hazards** when working with or near electrical systems.

| PPE                      | Purpose                           |
|--------------------------|-----------------------------------|
| Insulated gloves         | Prevent contact shock             |
| Rubber-soled boots       | Prevent current path through body |
| Face shield / helmet     | Protection from arc flash         |
| Flame-resistant clothing | Reduces burn injuries             |
| Safety glasses           | Eye protection from sparks        |

## 1. Common Types of Electrical PPE

| PPE                                     | Purpose   | Notes   |
|---|---|---|
| <b>Insulated gloves</b>                 | Prevent electric current from passing through hands     | Rated for voltage; check for wear and punctures |
| <b>Rubber-soled or insulating boots</b> | Prevent current from grounding through feet             | Especially important in wet areas               |
| <b>Hard hats / helmets</b>              | Protects head from shocks and falling objects           | Often used with face shields for arc flash      |
| <b>Face shields / safety goggles</b>    | Protect eyes and face from sparks and arc flash         | Flame-resistant shields preferred               |
| <b>Flame-resistant clothing</b>         | Protects body from burns caused by arcs or sparks       | Avoid synthetic fabrics that melt               |
| <b>Hearing protection</b>               | Protects ears from loud arc blast noises                | Earplugs or earmuffs                            |
| <b>Insulating mats</b>                  | Stand on these to avoid grounding and reduce shock risk | Used in high-voltage environments               |
| <b>Tools with insulated handles</b>     | Prevent current flow through tools                      | Always check insulation rating                  |



LU1.7:

## Electrical motor fundamentals

### 1. DEFINITION:

An **electric motor** is a device that **converts electrical energy into mechanical energy** using the principles of **electromagnetism**.

- Input: Electrical energy (AC or DC)
- Output: Mechanical motion (rotation or linear motion)

### 2. BASIC PRINCIPLE:

Electrical motors operate on the **interaction between magnetic fields**:

1. A current-carrying conductor placed in a **magnetic field** experiences a **force**.
2. This force causes **rotation or linear motion** according to **Fleming's left-hand rule**:



### 3. Main Components of an Electric Motor

| Component                     | Function   |
|-------------------------------|--|
| <b>Stator</b>                 | Stationary part; produces magnetic field                       |
| <b>Rotor / Armature</b>       | Rotating part; interacts with magnetic field to produce motion |
| <b>Commutator</b> (DC motors) | Reverses current direction in rotor windings                   |
| <b>Brushes</b> (DC motors)    | Conduct current between stationary and rotating parts          |
| <b>Shaft</b>                  | Transfers mechanical output                                    |
| <b>Frame / Housing</b>        | Supports motor and protects components                         |

### 4. Types of Electric Motors

#### 1. DC Motors

- Powered by **Direct Current**
- Speed can be controlled easily
- Types:
  - **Series Motor** – high starting torque
  - **Shunt Motor** – constant speed
  - **Compound Motor** – combination of series and shunt

#### 2. AC Motors

- Powered by **Alternating Current**
- Types:
  - **Induction Motor (Asynchronous)** – rotor rotates slower than stator field
  - **Synchronous Motor** – rotor rotates at same speed as stator field

#### 3. Special Motors

- **Stepper Motor** – precise position control
- **Servo Motor** – used in robotics and automation

#### 4. Applications

- **DC Motors:** Electric vehicles, robotics, conveyors
- **AC Motors:** Fans, pumps, compressors, industrial machinery
- **Stepper/Servo Motors:** CNC machines, 3D printers, automation

## LU1.8: INDUCTIVE LOAD AND APPLIANCE POWER RATING

### 1. Inductive Load

An **inductive load** is an electrical device in which the **current lags behind the voltage** due to the presence of **inductance (L)**.

Inductance opposes changes in current, which creates a **phase difference** between voltage and current.

#### Key Characteristics

- Causes **lagging power factor** (current lags voltage)
- Draws **reactive power (VAR)** in addition to active power (W)
- Typically produces **magnetic fields** for operation

#### Examples of Inductive Loads

- **Motors** (AC induction motors, fans, pumps)
- **Transformers**
- **Chokes / Inductors**
- **Fluorescent lamps** (with magnetic ballast)



### Power in Inductive Loads

- **Active (real) power (P)** → actually does work, in watts (W)
- **Reactive power (Q)** → stored and returned by the magnetic field, in volt-amperes reactive (VAR)
- **Apparent power (S)** → combination of P and Q, in volt-amperes (VA)

$$S = V \cdot I$$

$$P = V \cdot I \cdot \cos\phi$$

$$Q = V \cdot I \cdot \sin\phi$$

$\phi$  = phase angle between voltage and current

## 2. Appliance Power Rating

The **power rating** of an appliance indicates the **amount of electrical power it consumes** when operating at its rated voltage.

### Units

- **Watts (W)** for resistive loads (heaters, bulbs)
- **Volt-amperes (VA)** or **kilovolt-amperes (kVA)** for devices with reactive components (motors, UPS, transformers)

## LU1.9: INTRODUCTION TO DIAGNOSTICS

### 1. Definition of Diagnostics

2. Diagnostics is the process of detecting, **identifying, and analyzing faults or abnormalities in a system to ensure it functions correctly.**

- In electrical/electronic systems, diagnostics helps to **prevent failures, reduce downtime, and ensure safety.**
- Essentially, it's "finding what's wrong and why."

### 2. PURPOSE OF DIAGNOSTICS

1. **Fault Detection** – Identify malfunctions or abnormal behavior in circuits or equipment.
2. **Fault Isolation** – Locate the exact component, wire, or section causing the problem.
3. **Preventive Maintenance** – Predict failures before they occur to avoid breakdowns.
4. **Performance Verification** – Ensure the system operates within desired specifications.
5. **Safety Assurance** – Prevent accidents caused by faulty electrical equipment.

### 3. Types of Diagnostics

| Type                               | Description                                       | Example  |
|------------------------------------|---|--|
| <b>Manual Diagnostics</b>          | Performed by human inspection or testing          | Using a multimeter to check voltage                          |
| <b>Automated Diagnostics</b>       | Using sensors, software, and tools                | Smart meters detecting faults in a grid                      |
| <b>Predictive Diagnostics</b>      | Uses data analysis and trends to predict failures | Vibration sensors on motors predicting bearing wear          |
| <b>Condition-Based Diagnostics</b> | Monitoring system parameters in real-time         | Temperature, current, and voltage monitoring of transformers |

### 4. Tools and Equipment Used

- **Multimeter** – Measures voltage, current, and resistance
- **Clamp Meter** – Measures current without breaking the circuit



- **Oscilloscope** – Visualizes voltage waveforms and signals
- **Insulation Tester (Megger)** – Checks insulation resistance

## 7. LU1.10: NEC/OSHA STANDARDS OVERVIEW.

### 1. NEC (National Electrical Code)

#### Definition

The **NEC** is a **set of safety standards for electrical wiring and equipment installation** in the United States.

- Published by **NFPA (National Fire Protection Association)**.
- Ensures **safe installation and operation** of electrical systems to prevent **fires, shocks, and hazards**.

#### Scope

- Electrical wiring and equipment in **residential, commercial, and industrial settings**
- Covers **grounding, overcurrent protection, wiring methods, and equipment ratings**

### 2. OSHA (Occupational Safety and Health Administration)

#### Definition

**OSHA** is a U.S. federal agency that **sets and enforces workplace safety regulations**.

- Ensures **employees are protected from hazards** including electrical, chemical, mechanical, and environmental risks.

## OSHA Requirements

#### Requirement

#### Purpose

|                              |  |
|------------------------------|--|
| Electrical hazard assessment | Identify risks before work                             |
| Training & certification     | Ensure workers understand hazards                      |
| PPE usage                    | Protect workers from shock and arc flash               |
| Safe work practices          | Procedures like de-energizing circuits, lockout/tagout |
| Inspection & maintenance     | Regular checks to prevent failures                     |

## 7. 3. NEC vs OSHA – Quick Comparison

| Feature     | NEC                                   | OSHA                                       |
|-------------|---------------------------------------|--|
| Focus       | Electrical installation safety        | Workplace safety overall                   |
| Type        | Code / standard                       | Regulation / law                           |
| Authority   | NFPA (non-governmental)               | Federal government (enforceable)           |
| Coverage    | Wiring, equipment, grounding, devices | Employee safety, PPE, LOTO, hazard control |
| Enforcement | Adopted by states/local jurisdictions | Federal law; violations can incur fines    |

## MODULE NO 02: WIRING AND CIRCUITS

### LU2.1: Conductors vs. insulators

#### 1. Definition of Conductors

A **conductor** is a material that **allows electric current to flow easily** due to the presence of **free electrons**.

- **Electrical current** is the flow of electrons.
- Conductors have **low resistance**, making them ideal for transmitting electricity.

## 8. 2. Common Types of Conductors

| Type                 | Material | Characteristics                           | Uses   |
|----------------------|----------|---|--|
| <b>Copper (Cu)</b>   | Metallic | Excellent conductivity, flexible, durable | Household wiring, motors, transformers             |
| <b>Aluminum (Al)</b> | Metallic | Lighter than copper, good conductivity    | Overhead power lines, large cables                 |
| <b>Silver (Ag)</b>   | Metallic | Highest conductivity                      | High-performance electronics, specialized circuits |



|                  |              |                                     |                           |
|------------------|--------------|-------------------------------------|---------------------------|
| <b>Gold (Au)</b> | Metallic     | Corrosion-resistant, good conductor | Electronics, connectors   |
| <b>Carbon</b>    | Non-metallic | Moderate conductivity, resistive    | Batteries, carbon brushes |
| <b>Graphite</b>  | Non-metallic | Conductive in certain applications  | Electrodes, brushes       |

### 1. Definition of Insulator

An **insulator** is a material that **resists the flow of electric current**.

- Unlike conductors, insulators have **very few free electrons**, so they **do not allow electricity to pass easily**.
- They are used to **protect people and equipment from electric shocks** and to **prevent short circuits**.

### 2. Common Types of Insulating Materials

| Material                     | Characteristics                         | Typical Uses                          |
|------------------------------|---|---------------------------------------|
| <b>Rubber</b>                | Flexible, high resistance               | Gloves, mats, cable insulation        |
| <b>Plastic / PVC</b>         | Lightweight, durable                    | Wire and cable insulation             |
| <b>Glass</b>                 | Hard, brittle, high dielectric strength | High-voltage insulators, transformers |
| <b>Ceramic</b>               | Heat resistant, strong                  | Power line insulators, bushings       |
| <b>Paper (oiled/treated)</b> | Flexible, good dielectric               | Capacitors, transformer insulation    |
| <b>Mica</b>                  | Heat resistant, durable                 | Motors, electrical heating elements   |

## 9. LU 2.2: Types of wires (THHN, NM-B, grounding)

### 1. THHN Wire (Thermoplastic High Heat-Resistant Nylon-coated)

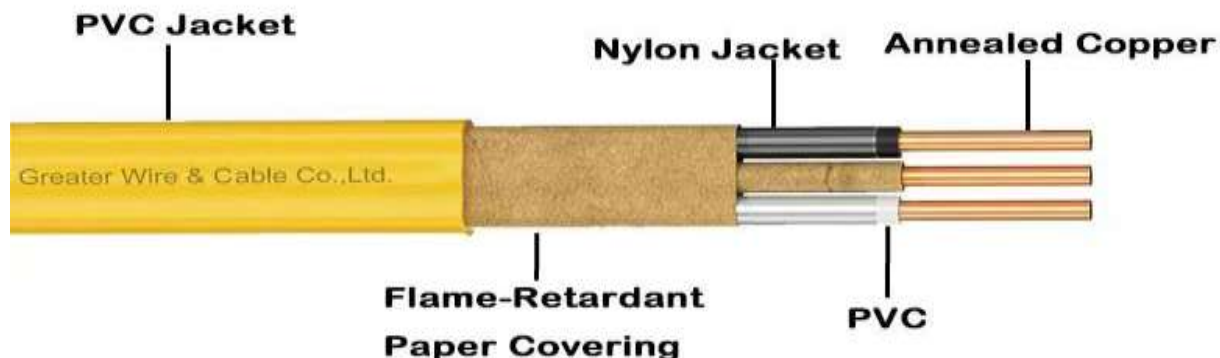
#### Definition

- THHN is a **single conductor wire** with **thermoplastic insulation** and **nylon coating**.
- Designed for **high-temperature and dry locations**.

#### Applications

- Building wiring in **conduits**
- Industrial, commercial, and residential circuits**
- Motor connections and control panels

### 2. NM-B WIRE (NON-METALLIC SHEATHED CABLE)



#### Definition

- NM-B wire is a **multi-conductor cable** with **plastic insulation inside a non-metallic sheath**.
- Commonly called **"Romex"** (brand name).

#### Applications





- **Residential wiring** for lighting, outlets, and switches
- Indoor, dry locations only

### 3. GROUNDING WIRE (EQUIPMENT GROUNDING CONDUCTOR, EGC)

#### Definition

- A **ground wire** provides a **safe path for fault current** to protect people and equipment from electric shock.

#### Applications

- Electrical panels and service entrances
- Outlets, appliances, and equipment frames
- Lightning protection and bonding

## LU 2.3: Series vs. parallel circuits.

### 1. Definition of Series Circuit

A **series circuit** is an electrical circuit in which **all components are connected end-to-end** so that **there is only one path for current to flow**.

- The same **current** flows through all components.
- **Voltage** is divided across the components depending on their resistance.

### 2. Characteristics of Series Circuits

| Feature               | Description   |
|-----------------------|---|
| <b>Current (I)</b>    | Same through all components   |
| <b>Voltage (V)</b>    | Divided among components: $V_{\text{total}} = V_1 + V_2 + \dots + V_n$                                      |
| <b>Resistance (R)</b> | Total resistance is the <b>sum of individual resistances</b> : $R_{\text{total}} = R_1 + R_2 + \dots + R_n$ |
| <b>Power (P)</b>      | Each component consumes power according to $P = I^2 R$  |
| <b>Failure effect</b> | If one component fails (like a bulb), <b>entire circuit stops</b>   |

## 02. Parallel circuit

A **parallel circuit** is a type of electrical circuit in which components (like resistors, bulbs, or other devices) are connected **across the same two points**, creating multiple paths for the electric current to flow. Each component has its own separate path to the power source.

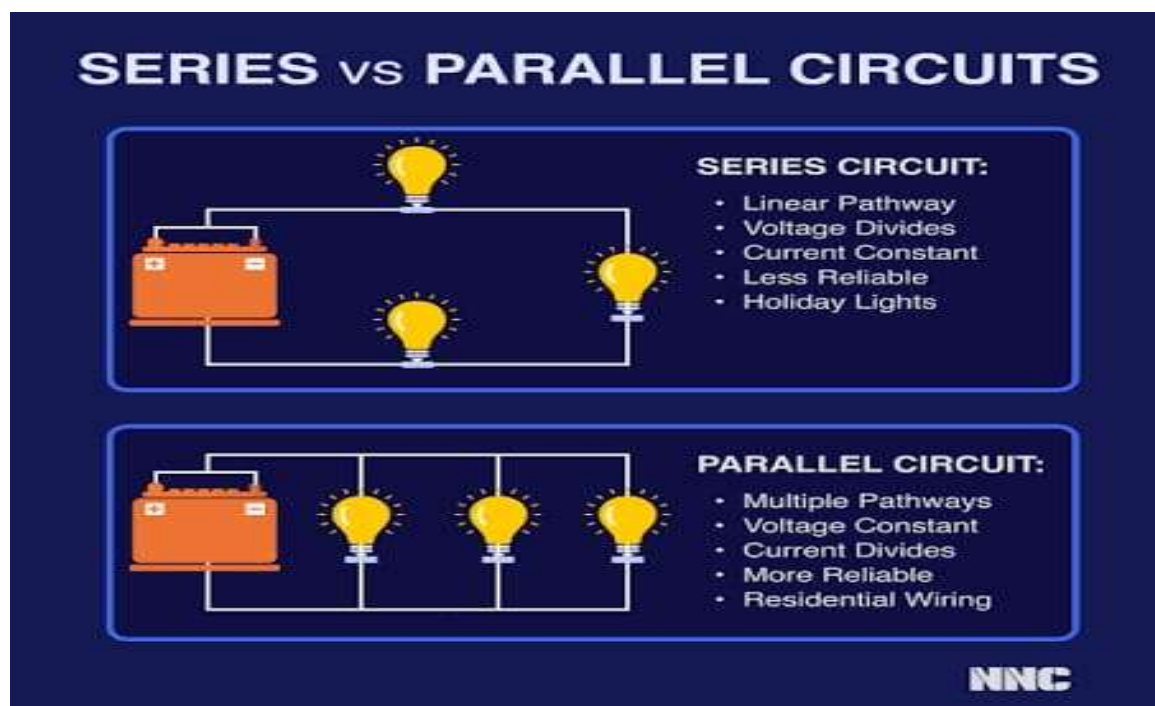
Here's a detailed breakdown:

### Key Characteristics of a Parallel Circuit:

1. **Multiple paths for current**
  - The total current in the circuit is divided among the different branches.
  - If one branch is broken, current can still flow through the other branches.
2. **Voltage across each component is the same**
  - Every component connected in parallel experiences the full voltage of the power source.
3. **Current is shared among branches**
  - Each branch's current depends on its resistance:  
 $I_n = V/R_n$
4. **Total resistance decreases**
  - The total (equivalent) resistance of a parallel circuit is always **less than the smallest individual resistance**:  
 $1/R_{\text{total}} = 1/R_1 + 1/R_2 + \dots + 1/R_n$

### Advantages of a Parallel Circuit:

- Devices can operate independently.
- If one device fails, others continue to work.
- Voltage across each device remains constant.



## LU 2.4: OVERCURRENT PROTECTION (BREAKERS, FUSES).

**Overcurrent protection** is a safety mechanism used in electrical systems to prevent damage caused by **excess current**—currents that exceed the rated capacity of wires, devices, or circuits. Overcurrent can happen due to **short circuits**, **overloads**, or **faulty equipment**. The two most common protection devices are **fuses** and **circuit breakers**.

### 1. Fuses

- **Function:** A fuse contains a thin metal strip that melts when current exceeds a certain level, **interrupting the circuit**.
- **Operation:** It works **once**—after it blows, it must be **replaced**.
- **Advantages:** Simple, reliable, fast response to overcurrent.
- **Disadvantages:** Single-use, needs replacement after a fault.

### 2. Circuit Breakers

- **Function:** Automatically **disconnects** the circuit when current exceeds safe limits. Unlike fuses, they can be **reset** after tripping.
- **Operation:** Can be **electromagnetic** (magnetic trip for short circuits) or **thermal** (bimetallic strip for overloads).
- **Advantages:** Reusable, can be manually or automatically reset, provides protection against both overload and short circuit.
- **Types:**



- **Miniature Circuit Breaker (MCB):** For small loads, residential use
- **Molded Case Circuit Breaker (MCCB):** For higher current industrial loads
- **Earth Leakage Circuit Breaker (ELCB/RCCB):** Detects leakage to earth for safety

### Key Points

| Feature         | Fuse                 | Circuit Breaker                                 |
|-----------------|----------------------|---|
| Reusable        | No                   | Yes   |
| Response Time   | Fast                 | Fast to moderate                                |
| Cost            | Low                  | Higher  |
| Maintenance     | Replacement required | Reset after trip                                |
| Protection Type | Overcurrent          | Overcurrent + sometimes short-circuit & leakage |

## LU 2.5: Box fill calculations (NEC guidelines)

**Box fill calculations** are crucial in electrical installations—they ensure that **electrical boxes** (like junction boxes, outlet boxes, or switch boxes) are **large enough to safely contain all wires, devices, and clamps** without overcrowding. The **NEC (National Electrical Code)** has clear rules for this. Let's go step by step.

### 1. Purpose

- Prevents overheating and fire hazards.
- Ensures that wires have room to move.
- Provides space for safe splicing and connections.

### 2. NEC Box Fill Rules (Simplified)

The **total box fill count** is calculated in “**unit volumes**,” which are in cubic inches. Each type of wire, device, or fitting **counts as one or more units**.

#### Step 1: Count Conductors

1. **Current-carrying conductors** entering the box (hot and neutral)
  - Each counts as **1 unit**.
  - Example: 2 hot wires + 2 neutral wires = 4 units.
2. **Ground wires**
  - All ground wires together count as **1 unit**, no matter how many.
3. **Devices** (switches, outlets)
  - Each device counts as **2 units**.
  - Multiple devices mounted on a single yoke? Count **2 units per yoke**, not per device.
4. **Clamps inside the box**
  - Each internal cable clamp counts as **1 unit**.

#### Step 2: Determine Conductor Size Multiplier

The NEC has a table (NEC 314.16(B)) with **cubic inch allowances per conductor based on wire gauge**:

| Wire Gauge | Cubic Inches per Conductor |
|------------|----------------------------|
| 14 AWG     | 2                          |

|        |      |
|--------|------|
| 12 AWG | 2.25 |
| 10 AWG | 2.5  |
| 8 AWG  | 3    |
| 6 AWG  | 3.5  |

### Step 3: Add Device and Clamp Volumes

- Devices: Multiply the number of devices by **their NEC unit volume** (usually 2 units per device × conductor volume).
- Internal clamps: Multiply number of clamps by **1 unit × conductor volume**.

## LU 2.7: WIRE COLOR CODES AND INSULATION TYPES

### 1. Wire Color Codes (US/NEC)

Wire colors indicate the **function of the conductor** in AC circuits.

| Function                      | Notes                              |
|-------------------------------|------------------------------------|
| Hot / Line (current-carrying) | Phase 1 in single-phase            |
| Hot / Line (current-carrying) | Phase 2 or switched line           |
| Hot / Line (current-carrying) | Often used in 3-phase or travelers |

### Module No 03.









### Electrical Panel and Distribution

### LU 3.1: Main Service Panel vs. Subpanels

#### 1. Main Service Panel (MSP)

The **main service panel** is the primary distribution point for electricity coming from the utility. It receives

power  
through  
the  
service  
entrance

|                              | Single Phase  | Three Phase   |
|------------------------------|---|---|
| Phase Conductor (Line)       | <br><b>Red</b><br>or<br><br><b>Yellow</b><br>or<br><br><b>Blue</b> | <br><b>Line 1 Red</b><br><br><br><b>Line 2 Yellow</b><br><br><br><b>Line 3 Blue</b> |
| Neutral Conductor            | <br><b>Black</b>  |   |
| Protective Conductor (Earth) | <br><b>Green-and-Yellow</b>   |   |

**conductors** and distributes it to branch circuits in a building.

### Functions

1. **Overcurrent protection** for the entire building (via main breaker).

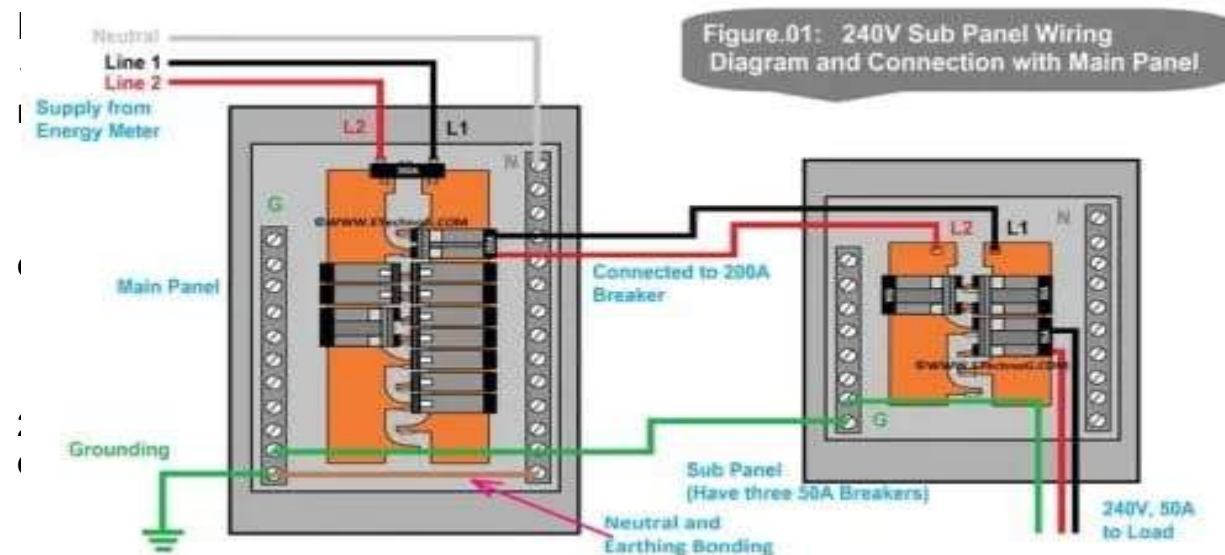
2. **Circuit distribution** to branch circuits.
3. **Neutral-to-ground bonding:** Neutral and ground are connected at the main panel only.

## 2. Subpanel

A **subpanel** is a secondary panel fed from the main service panel. It is used to **extend power to other areas** (e.g., garage, basement, addition).

### Functions

1. Reduces the length of branch circuit runs (easier wiring).
2. Provides additional circuit capacity.
3. Localized overcurrent protection for branch circuits in remote areas



- HVAC systems
- Subpanel feeders

## LU3.3: CALCULATING LOAD CAPACITY

### 1. Definition

**Load capacity** is the **maximum electrical load** that a circuit, panel, or service can safely carry **without overloading**. It is usually expressed in **amperes (A)**.

### 2. Steps to Calculate Load Capacity

#### Step 1: List All Loads

- Identify all devices, appliances, and fixtures on the circuit.
- Determine each device's **wattage (W)** or **amperage (A)**.

#### Example:

- Light fixtures:  $6 \times 60W = 360W$
- Outlet loads:  $1200W$
- Small appliance:  $1500W$

#### Step 2: Convert Watts to Amps (if needed)

$$I = P/V$$

Where:

- $I$  = current in amperes
- $P$  = power in watts
- $V$  = voltage (typically 120V or 240V in residential)

#### Example:

- Total wattage:  $360 + 1200 + 1500 = 3060W$





- Voltage: 120V
- $$I = 306 / 120 = 25.5A$$

#### Step 4: Choose Circuit Rating

- **Circuit breaker and wire size must exceed calculated load.**
- Standard practice:
  - Continuous loads → size for **125% of load**.
  - Non-continuous loads → size for **100% of load**.

#### Example:

- Load = 25.5A (from Step 2)
- Continuous load allowance:  $25.5 \times 1.25 = 31.875A$
- Closest standard breaker size = **40A**

### LU3.4: NEUTRAL AND GROUND BAR FUNCTIONS

#### 1. Neutral Bar (Neutral Bus)

##### Purpose:

- The neutral bar provides a return path for current in an electrical system.
- It is connected to the **neutral wire** (usually white or gray in the U.S.) from circuits in the panel.
- In a main service panel, it is also bonded to the ground bar and the service entrance ground, creating a reference point at 0 volts.

##### Key Functions:

1. **Completes the circuit:** Provides a return path for current back to the power source.
2. **Voltage reference:** Keeps the system voltage stable relative to ground.
3. **Connection point for all neutrals:** All neutral wires from branch circuits terminate here.

#### 2. Ground Bar (Ground Bus)

##### Purpose:

- The ground bar is used for **safety**, not for carrying current during normal operation.
- It connects all equipment grounding conductors (bare or green wires) and may connect to a grounding electrode (like a ground rod or water pipe).

##### Key Functions:

1. **Safety path for fault current:** Provides a low-resistance path to trip breakers if a short occurs.
2. **Bonding:** Connects metal parts of the electrical system to prevent electric shock.





3. **Connection to earth:** Ensures the panel and circuits are at earth potential

### LU3.5: VOLTAGE DROP CALCULATIONS

#### 9. 1. What is Voltage Drop?

Voltage drop is the **reduction in voltage** along a conductor due to the resistance (and sometimes reactance) of the wire when current flows through it. Too much voltage drop can cause electrical devices to **inefficiently** or even **fail**.

#### 10.2. Voltage Drop Formula

For **AC or DC circuits**, the basic formula is:

$$V_d = I \times R \times L$$

Where:

- $V_d$  = voltage drop (volts)
- $I$  = current (amps)
- $R$  = resistance of the conductor (ohms per unit length)
- $L$  = length of the conductor (one-way distance in feet or meters)

#### Calculating Wire Resistance

$$\text{Wire length} = 1500 \text{ ft} \times 2$$

$$\text{Wire length} = 3000 \text{ ft}$$

$$\text{Total resistance} = 3000 \text{ ft} \times \frac{26 \Omega}{1000 \text{ ft}}$$

$$\text{Total resistance} = 78 \Omega$$

run

#### Calculating Voltage Drop

$$\text{Voltage drop} = 78 \Omega \times 0.02 \text{ A}$$

$$\text{Voltage drop} = 1.56 \text{ V}$$

$$10 \text{ V} - 1.56 \text{ V} = 8.44 \text{ V}$$

### LU3.6: 3-WAY AND 4-WAY SWITCHING THEORY

#### 3-WAY SWITCH

##### Purpose

Controls one light from **two locations**.

##### Components

Each 3-way switch has:

- **1 Common terminal** (usually darker-colored screw)
- **2 Traveler terminals** (usually brass-colored screws)
- **1 Ground terminal**

#### 4-WAY SWITCH

##### Purpose

Controls one light from **three or more locations**.

##### Components

A 4-way switch has:

- **4 traveler terminals** (two pairs)
- **1 Ground terminal**
- **NO common terminal** (it only passes travelers through)

### LU3.7: PANEL SAFETY AND ARC FLASH RISKS

**Panel safety** refers to safe practices when working on or near electrical distribution panels, breaker panels, or switchboards.

The goal is to prevent:

- Electric shock
- Arc flash or arc blast
- Burns, fire, or explosion
- Equipment damage

## MODULE NO 04. LIGHTING SYSTEMS AND CONTROLS

### LU4.1: Types of lighting (LED, CFL, Halogen)



## 1. What Is an Arc Flash?

An **arc flash** is a **sudden release of electrical energy** through the air when a high-voltage gap exists and current flows through it.

It can be caused by:

- Accidental contact between energized conductors
- Loose or corroded connections
- Dust or moisture buildup
- Dropped tools or improper maintenance

## 2. LED (Light Emitting Diode)

### How It Works

LEDs produce light when **electrical current passes through a semiconductor**, emitting photons directly — no filament or gas.

### Key Features

| Property             | LED                                      |
|----------------------|--|
| Efficiency           | Very high (80–90% efficient)             |
| Lifespan             | 25,000–50,000+ hours                     |
| Heat Output          | Very low (cool to touch)                 |
| Instant On           | Yes                                      |
| Dimmable             | Many models are                          |
| Environmental Impact | No mercury, recyclable                   |
| Color Options        | Wide range (2700K warm → 6500K daylight) |

## 3. CFL (COMPACT FLUORESCENT LAMP)

### How It Works

CFLs use an **electric current through mercury vapor** to create ultraviolet (UV) light, which excites a **phosphor coating** inside the bulb to produce visible light.

### Key Features

| Property             | CFL                                   |
|----------------------|---------------------------------------|
| Efficiency           | Moderate to high (60–75% efficient)   |
| Lifespan             | 8,000–15,000 hours                    |
| Heat Output          | Moderate                              |
| Instant On           | Usually delayed or flicker on startup |
| Dimmable             | Limited models                        |
| Environmental Impact | Contains small amount of mercury      |

## 3. HALOGEN LAMP

### How It Works

A **type of incandescent lamp** that uses a **tungsten filament** enclosed in a small quartz capsule filled with halogen gas.

The halogen cycle redeposits vaporized tungsten back onto the filament, extending life and maintaining brightness.

### Key Features

| Property   | Halogen                |
|------------|------------------------|
| Efficiency | Low (20–30% efficient) |



|                             |   |
|-----------------------------|---|
| <b>Lifespan</b>             | 2,000–4,000 hours                       |
| <b>Heat Output</b>          | Very high                               |
| <b>Instant On</b>           | Yes                                     |
| <b>Dimmable</b>             | Yes                                     |
| <b>Environmental Impact</b> | No mercury, but high heat = energy loss |

## LU4.2: LIGHTING CIRCUIT DESIGN

**lighting circuit design** is a fundamental topic in electrical installation and design work.

### 1. Purpose of a Lighting Circuit

A lighting circuit provides controlled power to lamps or luminaires.

Key design goals:

- Safe and reliable operation
- Adequate illumination (lux level)
- Energy efficiency
- Easy maintenance and control

### 2. Types of Lighting Circuits

#### a. One-Way Switch Circuit

Controls a single light from one location.

**Typical use:** Bedrooms, bathrooms, storage rooms.

#### b. Two-Way (3-Way US) Switching

Controls one light from **two locations**.

**Typical use:** Hallways, stairs, long rooms

#### c. Intermediate (4-Way US) Switching

Controls one light from **three or more locations**.

## LU4.3: Dimmer switches

### What Is a Dimmer Switch?

A **dimmer switch** controls light intensity by reducing the **average voltage** delivered to the lamp.

This is usually done by “**chopping**” **part of the AC waveform** — turning the current on and off very quickly during each AC cycle.

### 1. Leading-Edge Dimmer (Triac Dimmer)

#### How It Works

- Uses a **TRIAC** (Triode for Alternating Current) to **cut the start** of each AC half-cycle.
- Current is delayed slightly after the zero-crossing point — the waveform’s *leading edge* is chopped.

### 2. Trailing-Edge Dimmer (MOSFET Dimmer)

#### How It Works

- Uses **MOSFET or IGBT transistors** to **cut the end** of each AC half-cycle.



- Current starts at the zero-crossing, then turns off partway through the cycle — the *trailing edge* is chopped.

## LU4.4: Motion and occupancy sensors

### 1. What Are Motion and Occupancy Sensors?

These devices **detect people in an area** and **control lights or other loads** accordingly.

They help:

- Save energy (lights only on when needed)
- Increase safety and convenience
- Automate lighting, HVAC, or security systems

| Feature             | Motion Sensor   | Occupancy Sensor   |
|---------------------|---|--|
| <b>Purpose</b>      | Detects <i>movement</i>   | Detects <i>presence</i> (movement + ongoing occupancy)   |
| <b>Operation</b>    | Turns lights <b>on when motion is detected</b> , off after <b>no motion</b> | Turns lights <b>on automatically</b> when someone enters, <b>keeps on while occupied</b> , off when <b>empty</b> |
| <b>Use Case</b>     | Outdoor lighting, security  | Offices, restrooms, classrooms, corridors  |
| <b>Sensitivity</b>  | Movement only   | Movement + fine motion or presence   |
| <b>Control Type</b> | Simple on/off   | More advanced with adjustable time delay and sensitivity   |

#### b. Ultrasonic Sensor

*How It Works:*

- Emits **high-frequency sound waves** (inaudible to humans) and measures **reflections**.
- Detects motion from **Doppler shift** (change in reflected frequency).

#### c. Dual Technology (PIR + Ultrasonic) Sensor

*How It Works:*

- Combines both **PIR** and **ultrasonic** sensing.
- Light turns on only when **both** detect presence, reducing false triggers.

| Type       | Detects            | Pros                           | Cons                | Best For             |
|------------|--------------------|--------------------------------|---------------------|----------------------|
| PIR        | Heat/motion        | Reliable, low power            | Needs line of sight | Corridors, bathrooms |
| Ultrasonic | Movement (Doppler) | Sensitive, wide coverage       | Can false-trigger   | Offices, classrooms  |
| Dual-Tech  | Heat + motion      | Accurate, fewer false triggers | Costly              | Conference rooms     |
| Microwave  | Motion (radar)     | Long range, through walls      | Too sensitive       | Outdoor/industrial   |



## LU4.5: Emergency lighting requirements

### 1. What Is Emergency Lighting?

**Emergency lighting** automatically provides **illumination when the normal (mains) power supply fails**. It ensures occupants can **see, move safely, and evacuate** a building during an emergency such as a power outage, fire, or other hazard.

### 2. Main Objectives

- Prevent panic
- Enable safe movement to exits
- Illuminate fire safety equipment (e.g. extinguishers, alarms)
- Support emergency responders
- Meet **legal and code** requirements

### 3. Emergency Lighting Power Sources

Emergency luminaires operate on **battery backup** or **central power supply** when mains power fails.

#### a. Self-Contained (Single Point) Units

- Each fitting has its own **integral battery** and charger.
- Simple and cheap to install.
- Common in small to medium buildings.

#### b. Central Battery System

- Batteries located in a **central room** supply multiple lights.
- Easier to test and maintain for large sites.
- Used in hospitals, airports, and complexes.

## LU4.6: Smart lighting ( Wi-Fi / Zigbee controls )

### 1. What Is Smart Lighting?

**Smart lighting** refers to lighting systems that can be **controlled digitally** — via smartphone, voice assistant, automation, or building management system — instead of traditional switches alone.

### 2. Key Components

| Component                | Function  |
|--------------------------|---|
| Smart bulb / luminaire   | Built-in wireless module (Wi-Fi, Zigbee, BLE, etc.)                       |
| Smart switch / dimmer    | Replaces traditional wall switch; communicates wirelessly                 |
| Hub / Gateway (optional) | Acts as a bridge between devices and the internet (used by Zigbee/Z-Wave) |
| App or Controller        | Mobile or desktop interface for configuration and control                 |



|                              |  |
|------------------------------|--|
| <b>Cloud or Local Server</b> | Enables remote control, voice assistants, automation rules |
|------------------------------|--|

#### A. Wi-Fi Smart Lighting

##### *How It Works*

- Each light or switch connects **directly to your Wi-Fi router** (2.4 GHz band).
- Controlled through a **cloud service or local app**.

##### *Features*

| Aspect                | Description   |
|-----------------------|---|
| <b>Connection</b>     | Direct to router (no hub)                               |
| <b>Speed</b>          | Fast — suitable for instant commands                    |
| <b>Range</b>          | Limited to Wi-Fi coverage                               |
| <b>Power Use</b>      | Higher (each device maintains its own Wi-Fi connection) |
| <b>Setup</b>          | Simple — ideal for home users                           |
| <b>Example Brands</b> | TP-Link Kasa, Philips Wiz, LIFX, Tuya-based lights      |

#### B. Zigbee Smart Lighting

##### *How It Works*

- Uses a **low-power mesh network** (2.4 GHz band).
- Devices connect to a **Zigbee hub** or gateway (e.g., Philips Hue Bridge, Amazon Echo with Zigbee).
- Each device can **relay** signals — extending range.

##### *Features*

| Aspect                | Description                                 |
|-----------------------|---|
| <b>Connection</b>     | Through a hub (not directly to Wi-Fi)       |
| <b>Network Type</b>   | Mesh (devices relay signals)                |
| <b>Range</b>          | Long (each node extends coverage)           |
| <b>Power Use</b>      | Very low — ideal for sensors and switches   |
| <b>Reliability</b>    | High — less interference and latency        |
| <b>Example Brands</b> | Philips Hue, IKEA TRÅDFRI, Sengled, GE Link |

### LU4.7: Troubleshooting flickering lights

#### 1. Understand the Flicker

Before troubleshooting, identify **when** and **how** the light flickers:





| Type of Flicker                  | Likely Cause                              |
|----------------------------------|---|
| Constant or rhythmic flicker     | Power supply or driver issue              |
| Flickers when dimmed             | Incompatible dimmer or driver             |
| Random flicker                   | Loose connections or voltage fluctuations |
| Multiple lights flicker together | Supply or circuit problem                 |
| Only one light flickers          | Faulty lamp or fixture                    |

## 2. Common Causes of Flickering Lights

### A. Loose Electrical Connections

- Loose **neutral** or **live** wire at lamp holder, switch, or terminal.
- Causes intermittent contact → rapid voltage fluctuations → flicker.

#### ✓ Check:

- Tighten all terminals in the switch, lamp holder, and junction box.
- Inspect for discolored or burned insulation (sign of arcing).

| Lamp Type          | Common Cause                            | Solution   |
|--------------------|---|--|
| <b>LED</b>         | Incompatible dimmer, cheap driver       | Use trailing-edge dimmer, better lamp              |
| <b>CFL</b>         | Worn-out lamp or poor starter           | Replace lamp/starter                               |
| <b>Fluorescent</b> | Failing ballast or starter              | Replace ballast and tube                           |
| <b>Halogen</b>     | Loose connection or voltage dip         | Tighten terminals, stabilize supply                |
| <b>Smart LED</b>   | Wi-Fi signal interference, software bug | Update firmware, reboot, use Zigbee/Matter systems |

### Module No 05.

### Residential Electrical Installations

#### NM-B vs. conduit wiring

#### 1. What is NM-B Cable?

NM-B (Nonmetallic Sheathed Cable) — **also known as Romex® in the U.S.** — is a factory-assembled cable **with** two or more insulated conductors and a bare ground wire, **all wrapped in a nonmetallic (PVC) outer jacket.**

Common types:

- **NM-B 14/2** → 2 conductors + ground (for 15A circuits)



- **NM-B 12/2** → 2 conductors + ground (for 20A circuits)
- **NM-B 12/3** → 3 conductors + ground (for 3-way switches or multiwire circuits)

## 2. What is Conduit Wiring?

**Conduit wiring** uses **individual insulated wires (THHN/THWN)** pulled through **electrical conduit**, which can be **metallic or nonmetallic**.

The conduit provides **mechanical protection** and sometimes **acts as the ground path**.

| Feature                       | NM-B Cable                    | Conduit Wiring  |
|-------------------------------|-------------------------------|---|
| <b>Type of Conductors</b>     | Pre-sheathed multi-wire cable | Individual conductors (THHN/THWN)                       |
| <b>Mechanical Protection</b>  | Minimal (outer jacket only)   | Excellent (inside conduit)                              |
| <b>Grounding</b>              | Bare copper inside cable      | Separate ground wire or metallic conduit acts as ground |
| <b>Installation</b>           | Faster, simpler               | Slower, more labor-intensive                            |
| <b>Flexibility</b>            | Fixed once installed          | Easy to modify or add circuits later                    |
| <b>Cost</b>                   | Lower (materials and labor)   | Higher (conduit, fittings, bending, labor)              |
| <b>Typical Voltage Rating</b> | 600 V                         | 600 V or higher depending on wire type                  |
| <b>Heat Dissipation</b>       | Limited (sheath traps heat)   | Better (air space inside conduit)                       |
| <b>Code Limitations</b>       | Indoor dry locations only     | Indoor, outdoor, wet, or hazardous locations            |
| <b>Aesthetic / Durability</b> | Not for exposed areas         | Can be exposed in garages, basements, outdoors          |

### LU5.2: Box types (plastics, metal)

#### 1. What is an Electrical Box?

An **electrical box** is a protective enclosure for:

- Switches
- Receptacles (outlets)
- Light fixtures
- Splices or junctions

It **supports devices, contains wiring, and prevents accidental contact** with live conductors.

---

#### 2. Materials: Plastic vs. Metal

##### A. Plastic Boxes (PVC / Polycarbonate)

- Made from **PVC, polycarbonate, or nylon**



- Non-conductive → **no grounding required**
- Lightweight and easy to cut or drill
- Resistant to corrosion and moisture (good for damp areas if rated)

### Applications:

- Residential walls (dry locations)
- Switches, outlets, junction boxes
- Ceiling or wall-mounted light boxes (plastic-rated)

### B. Metal Boxes (Steel, Aluminum)

- Made from **galvanized steel** or aluminum
- Conductive → **must be grounded**
- Strong and durable → excellent for exposed or industrial environments
- Can handle heavier fixtures

### Applications:

- Commercial buildings
- Exposed areas (garages, workshops)
- Metallic conduit (EMT, IMC, RMC) systems
- High-current or high-heat applications

## LU 5.3: Dedicated Circuit

### 1. What is a Dedicated Circuit?

A **dedicated circuit** is a branch circuit that **serves a single appliance or load**.

### Key features:

- Only one device or appliance is connected
- Circuit breaker and wiring sized specifically for that load
- Reduces risk of **overloading** and **voltage drops**

### Common Examples:

- Electric ranges
- Refrigerators
- Microwave ovens

| Appliance / Load | Typical Voltage | Recommended Circuit | Notes                                 |
|------------------|-----------------|---------------------|---------------------------------------|
| Refrigerator     | 120 V           | 15–20 A dedicated   | Avoid sharing with countertop outlets |
| Microwave        | 120 V           | 15–20 A dedicated   | Especially in kitchen                 |



|   |       |                   |  |
|---|-------|-------------------|--|
| Electric Range / Oven                   | 240 V | 40–50 A dedicated | High-current load                        |
| Dishwasher                              | 120 V | 15–20 A dedicated | Some codes allow GFCI                    |
| Garbage Disposal                        | 120 V | 15–20 A dedicated | Can share with small loads in some cases |
| Electric Water Heater                   | 240 V | 30 A dedicated    | Must be sized for heater rating          |
| Electric Dryer                          | 240 V | 30 A dedicated    | Includes neutral for 4-wire connection   |
| HVAC Unit (Air Conditioner / Heat Pump) | 240 V | 30–50 A dedicated | Must follow manufacturer specs           |
| Furnace / Boiler                        | 120 V | 15–20 A dedicated | For controls and blower motor            |

#### LU5.4: AFCI requirements (Bedrooms)

##### 1. What is an AFCI?

An **Arc-Fault Circuit Interrupter (AFCI)** is a device designed to **detect dangerous electrical arcs** that can c **circuit** before ignition occurs.

- **Types of arcs detected:**
  - **Parallel arcs:** Between hot and neutral
  - **Series arcs:** Along a single conductor
- **Function:** Prevent fires caused by damaged wires, loose connections, or faulty devices.

##### Exceptions / Notes

1. **Dedicated circuits for appliances**
  - Circuits serving **kitchen, bathroom, laundry** appliances typically **do NOT require AFCI**, but may require GFCI protection.
2. **Multiwire Branch Circuits**
  - AFCI protection is required on the **ungrounded (hot) conductor** serving bedroom outlets.
3. **Combination with GFCI**
  - Sometimes required near wet areas → **dual AFCI/GFCI breakers** are available
4. **Existing circuits**
  - Older homes may be **grandfathered**; NEC applies mainly to **new or renovated circuits**

##### Why AFCI is Important in Bedrooms

- Bedrooms often have **lamps, chargers, electronics** plugged in
- Common causes of **residential fires**:
  - Frayed cords
  - Damaged wires in walls
  - Loose connections at outlets or switches
- AFCI trips before arcs can ignite insulation or building materials

#### LU5.5: Grounding and Bonding



### Grounding:

- Connecting **electrical systems or equipment to the earth**
- Provides a **path for fault current** to safely dissipate
- Examples: Ground rods, metal water pipes, concrete-encased electrodes

### Bonding:

- Connecting **metal parts together** to ensure they are at the **same electrical potential**
- Prevents shock if one metal part becomes energized
- Examples: Bonding water pipes, metal boxes, conduit, equipment frames

---

## 2. NEC Key Requirements

### A. System Grounding (NEC 250.20 – 250.30)

- The **neutral of a service or separately derived system** must be grounded
- Common methods:
  - Ground rods (minimum 8 ft, NEC 250.53)
  - Metal underground water pipe (250.52(A)(1))
  - Concrete-encased electrode (Ufer ground, 250.52(A)(3))
- Grounding conductor connects **service neutral to earth**
- Required for **overcurrent protection and shock prevention**

---

### B. Equipment Grounding (NEC 250.120 – 250.130)

- **Metal boxes, appliances, and raceways** must be connected to **equipment grounding conductor (EGC)**
- EGC provides **low-resistance path** for fault current to trip breaker
- Must be sized based on **overcurrent device** (NEC 250.122)

---

### C. Bonding Requirements (NEC 250.104 – 250.112)

- Bond **metal parts of electrical system** that may become energized
- Common bonding targets:
  - Metal water piping
  - Gas piping (where permitted)
  - Conduit, panels, and enclosures
  - Lightning protection systems
- Methods:
  - Mechanical bonding (nuts, clamps, lugs)
  - Exothermic welding (for underground)



## LU5.6: Outdoor and Wet Location Wiring

### 1. Definition of Wet and Damp Locations

#### Term

#### Definition

|                      |  |
|----------------------|--|
| <b>Wet location</b>  | Exposed to <b>direct water or rain</b> , or condensation occurs (e.g., outdoor outlets, landscape lighting)      |
| <b>Damp location</b> | Protected from direct water but <b>subject to moisture</b> , such as covered porches, basements, or some garages |
| <b>Dry location</b>  | Indoors, protected from moisture (typical residential interior walls)  |

- Damp location → NEC 100, 300.6

### 2. Approved Wiring Methods

#### A. Outdoor / Wet Location Wiring

##### 1. Types of Cable

- **UF-B (Underground Feeder, Waterproof)**
  - Can be **direct-buried** or run in conduit outdoors
- **THWN-2 Conductors** (in conduit)
  - Wet-rated, suitable for outdoor conduits

##### 2. Conduit

- **PVC, EMT, or RMC** can protect conductors outdoors
- Must be **UV-resistant** if exposed to sunlight
- **Conduit fill rules** must be followed (NEC 310.15, 300.17)

##### 3. Boxes and Enclosures

- **Weatherproof boxes** with gasketed covers
- **"In-use" covers** required for outlets exposed to rain or snow (NEC 406.9(B))

##### 4. Burial Depth

- NEC Table 300.5 specifies minimum cover depth:
  - **UF cable:** 24 inches for residential
  - **PVC conduit:** 18 inches
  - Depth depends on voltage and insulation type

---

#### B. Damp Location Wiring

- Can use **NM-B cable** (Romex) inside **covered porches or garages**
- **Metal boxes** or standard indoor enclosures may be sufficient if protected from direct water
- Avoid **direct exposure to rain or sprinklers**

### 3. Outdoor Outlet Requirements

#### 1. GFCI Protection

- All outdoor outlets must be **GFCI-protected** (NEC 210.8(A)(3))





## 2. Weatherproof Covers

- Use **“while-in-use” covers** for receptacles where cords are plugged in

## 3. Location

- Accessible height above grade (typically 12–18 inches)
- Away from standing water and sprinklers if possible

## LU5.7: Service Entrance components

The **service entrance** is the portion of the electrical system that **connects the utility power to the building’s electrical system**.

It generally includes:

- **Overhead or underground service drop** from utility
- **Service mast or conduit**
- **Meter socket**
- **Service disconnect** (main breaker or fused disconnect)
- **Grounding system**

### Service Entrance Configurations

#### A. Overhead Service

- Utility power delivered by overhead lines
- **Service mast or weatherhead** guides wires into the building
- Wires terminate at **meter socket** and then **main panel**

#### B. Underground Service

- Utility power runs through **direct-buried conduit or raceway**
- Service wires enter building through **conduit stub-up**
- Meter socket and main panel as usual

## Module No 06.

### Switches, Sockets, and Distribution System & Troubleshooting.

#### LU 6.1: Switch and Socket types

##### 1. Switch Types

Switches control the flow of electricity to **lights or other loads**. Their type depends on how many locations you want to control the load from.

#### Wiring Notes:

- **1-way (single-pole)**: Simple, two terminals (hot in, hot out)
- **3-way**: Three terminals (common + two travelers)
- **4-way**: Four terminals (two travelers in, two travelers out)
- **Multi-gang switches**: Combine multiple switches in one box



## 2. Socket / Outlet Types

Electrical outlets (sockets) provide **connection points for appliances**.

### 3. Switch and Socket Combinations

- **Switch + outlet combo:** One device controls a light, the other gives power

## LU6.2: Fuses, Breakers, and Circuit Protection

### Purpose of Circuit Protection

Circuit protection devices **prevent damage to electrical systems, appliances, and people** by interrupting overcurrent (too much current) or fault conditions.

#### Main goals:

- Prevent overheating of wires
- Prevent electrical fires
- Protect equipment
- Protect people from shock (in conjunction with GFCI/AFCI)

### Fuse

| Feature       | Description  |
|---------------|--|
| Operation     | Contains a <b>metal strip that melts</b> when current exceeds rating |
| Installation  | Screwed into fuse holder or cartridge                                |
| Advantages    | Simple, reliable, fast response                                      |
| Disadvantages | Must be <b>replaced after tripping</b> ; not resettable              |
| Types         | Glass, ceramic, blade, cartridge                                     |
| Ratings       | Specified in <b>amperes</b> and sometimes voltage                    |

### 3. Circuit Breakers

**Circuit breakers** are **resettable overcurrent protection devices**.

| Feature    | Description  |
|------------|--|
| Operation  | <b>Mechanical switch trips</b> when overcurrent or short occurs                    |
| Types      | Standard thermal-magnetic, GFCI breaker, AFCI breaker                              |
| Advantages | Can <b>reset</b> after trip; combines protection for overcurrent and short-circuit |



|               |   |
|---------------|---|
| Disadvantages | More complex and expensive than fuses                   |
| Ratings       | Specified by amperage (15A, 20A, 50A, etc.) and voltage |
| Location      | Installed in main panel / subpanel                      |

#### 4. Overcurrent Protection Principles

##### 1. Overload Protection

- Current exceeds conductor rating but not an immediate short circuit
- Thermal protection trips device after **a few seconds to minutes**

##### 2. Short Circuit Protection

- Hot conductor touches neutral or ground
- Magnetic trip or fuse **instantly interrupts current**

##### 3. Coordination

- Select breaker/fuse rating **slightly above normal load** but below conductor rating
- NEC Table 310.15 & 240.4 for conductor protection

### LU 6.3: Domestic electrical layout

A **domestic electrical layout** is the **plan showing how power is delivered from the main supply to outlets, lights, and appliances** throughout a house. It ensures **safety, convenience, and compliance with code**.

Key goals:

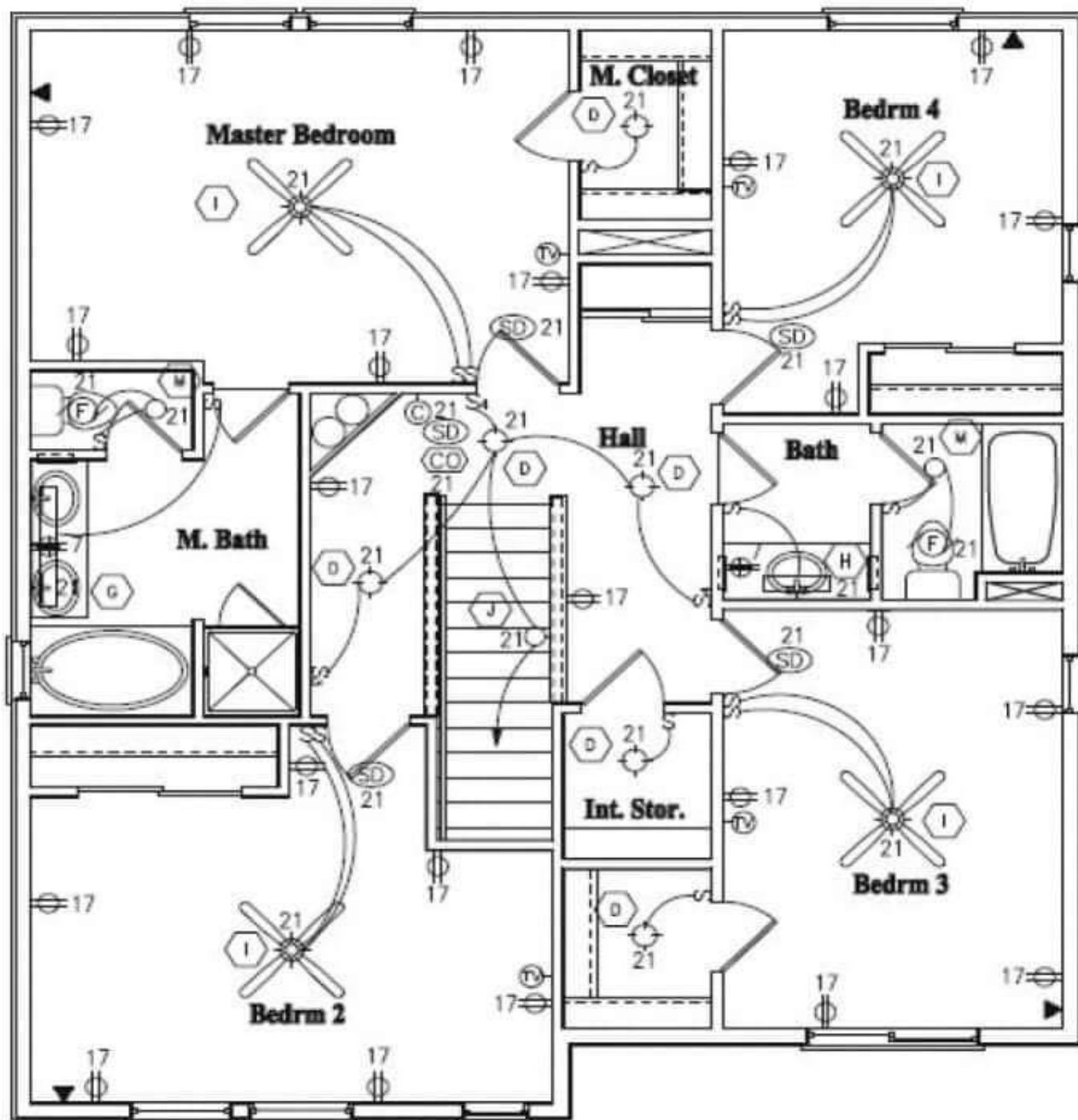
- Proper distribution of **lighting and power circuits**
- Adequate **protection with breakers and fuses**
- Correct **wiring methods, conduit, and cable types**
- Compliance with **GFCI/AFCI and grounding/bonding rules**

---

#### 2. Typical Components in a Domestic Layout

| Component                 | Purpose  |
|---------------------------|--|
| <b>Main Service Panel</b> | Receives power from utility; houses main breaker and branch breakers |
| <b>Branch Circuits</b>    | Separate circuits for lighting, sockets, and appliances              |
| <b>Sockets / Outlets</b>  | Power points; standard, GFCI, 240 V for heavy appliances             |
| <b>Lighting Circuits</b>  | Typically 1-way switches, sometimes 2-way or 3-way for hallways      |
| <b>Special Circuits</b>   | Dedicated circuits for ovens, water heaters, HVAC                    |
| <b>Protective Devices</b> | Breakers, GFCI, AFCI   |

|                                |  |
|--------------------------------|--|
| <b>Grounding &amp; Bonding</b> | Safety path for fault current; reduces shock/fire risk             |
| <b>Conduits / Cabling</b>      | NM-B (Romex) inside; UF-B or conduit outdoors; protective raceways |



#### 11. 4. Switching and Control

- **1-way switch:** Lights controlled from one location
- **2-way / 3-way switches:** Control same light from two locations
- **Dimmers / Smart switches:** For adjustable lighting and automation
- **Motion sensors:** Hallways, porches for energy efficiency



## LU6.4: Load calculation and planning

### 1. Purpose of Load Calculation

Load calculation determines:

- The **total electrical demand** of a building
- Proper **service size** (amperage)
- Appropriate **circuit sizing and protection**
- Compliance with **NEC requirements**

Key objectives:

- Prevent **overloading circuits**
- Avoid **voltage drops**
- Ensure **safety and energy efficiency**

---

### 2. Types of Loads

| Load Type                                     | Description   |
|---|---|
| <b>General Lighting &amp; Receptacle Load</b> | Standard outlets and lighting circuits; typically calculated per square foot (W/ft <sup>2</sup> ) |
| <b>Small Appliance Load</b>                   | Kitchen and laundry outlets; NEC requires <b>2 20 A circuits</b> for kitchen appliances           |
| <b>Dedicated Appliance Load</b>               | Oven, dryer, water heater, HVAC; rated at appliance nameplate amperage                            |
| <b>Motor Load</b>                             | Refrigerators, pumps, fans; consider <b>starting surge current</b>                                |
| <b>Special Loads</b>                          | Pool equipment, EV chargers, spa; usually dedicated circuits                                      |

---

### 3. Step-by-Step Load Calculation (NEC Method)

#### A. General Lighting Load

1. Use **3 VA per ft<sup>2</sup>** (residential, NEC 220.12)
2. Multiply by **total floor area** → gives **general lighting load in VA**

#### B. Small Appliance & Laundry Circuits

1. **Kitchen & laundry circuits:** 2 × 1500 W per circuit (minimum)
2. Add to general lighting load

#### C. Demand Factor Application



- NEC allows **demand factors** for multiple branch circuits
- For example:
  - First 10 kVA → 100%
  - Remaining → 40%–65% depending on NEC table 220.42

#### D. Appliance & HVAC Loads

- Use **nameplate ratings in watts or amps**
- Apply **demand factors if allowed**

### 4. Circuit Planning

1. **Group loads logically:**
  - Lighting circuits separate from general-purpose outlets
  - Dedicated circuits for high-load appliances
2. **Balance loads across phases** in split-phase or three-phase panels
3. **Select conductor size** based on:
  - Load current (amps)
  - Distance / voltage drop
  - NEC Table 310.15
4. **Plan protection devices:**
  - Breakers or fuses
  - GFCI / AFCI where required
5. **Plan for future expansion:**
  - Extra breaker slots
  - Conduits for additional circuits





| Sr. No. | Equipment Name  | Number of Equipments | Wattage     | Total Wattage | Working Hours | Watt hours    |
|---------|-----------------|----------------------|-------------|---------------|---------------|---------------|
| 1.      | Tube light      | 3                    | 40          | 120           | 10            | 1200          |
| 2.      | Fan             | 3                    | 80          | 240           | 10            | 2400          |
| 3.      | Television      | 1                    | 150         | 150           | 5             | 750           |
| 4.      | Fridge          | 1                    | 350         | 350           | 12            | 4200          |
| 5.      | Air Conditioner | 1                    | 1500        | 1500          | 5             | 7500          |
| 12.     | <b>Total</b>    |                      | <b>2120</b> | <b>2360</b>   |               | <b>16,050</b> |

## LU6.5: Fault Diagnosis strategies

### 1. Purpose of Fault Diagnosis

Fault diagnosis is the **process of identifying and locating electrical problems** to prevent damage, ensure safety, and restore normal operation.

#### Key objectives:

- Detect overloads, short circuits, open circuits, or ground faults
- Identify faulty equipment or wiring
- Prevent hazards like fire, shocks, or equipment failure

### 2. Common Types of Electrical Faults

| Fault Type           | Description                        | Typical Cause                         | Symptoms   |
|----------------------|------------------------------------|---------------------------------------|--|
| <b>Open Circuit</b>  | Break in the wiring or connection  | Cut wire, tripped breaker, blown fuse | No power to device or outlet                     |
| <b>Short Circuit</b> | Hot wire touches neutral or ground | Damaged insulation, loose connections | Circuit breaker trips immediately, smoke, sparks |
| <b>Ground Fault</b>  | Hot wire contacts grounded metal   | Moisture, damaged insulation          | GFCI trips, breaker may not trip if unprotected  |
| <b>Overload</b>      | Current exceeds circuit rating     | Too many devices on one circuit       | Breaker trips after time delay, wires hot        |

### 3. Step-by-Step Fault Diagnosis

#### Step 1: Visual Inspection

- Look for signs of overheating, burn marks, melted insulation



- Check outlets, switches, and devices for visible damage

### Step 2: Check Power Supply

- Test with a multimeter or voltage tester
- Verify if circuit breaker is tripped or fuse blown

### Step 3: Isolate the Circuit

- Turn off the breaker, unplug all devices
- Test wiring and outlets individually

### Step 4: Test Continuity and Resistance

- Use a **multimeter** to check continuity of wires
- Measure resistance across connections to detect high resistance (loose or corroded)

### Step 5: Check for Ground Faults

- Use a GFCI tester on outlets in wet areas
- Identify if tripping occurs due to moisture or damaged equipment

### Step 6: Check Load Devices

- Disconnect devices one by one to see if fault clears
- Faulty appliance may cause repeated tripping

### Step 7: Inspect Connections and Terminals

- Ensure all screws, lugs, and connectors are tight
- Look for signs of arcing or corrosion

## 5. Safety Tips

- Always **turn off power** before inspecting or testing wires
- Use **proper PPE** (insulated gloves, goggles)
- Be cautious of **live circuits** when testing for voltage
- Confirm **grounding and bonding** integrity before repairs

## LU6.6: Reading Electrical schematics and wiring Diagram

### 1. Understanding the Basics

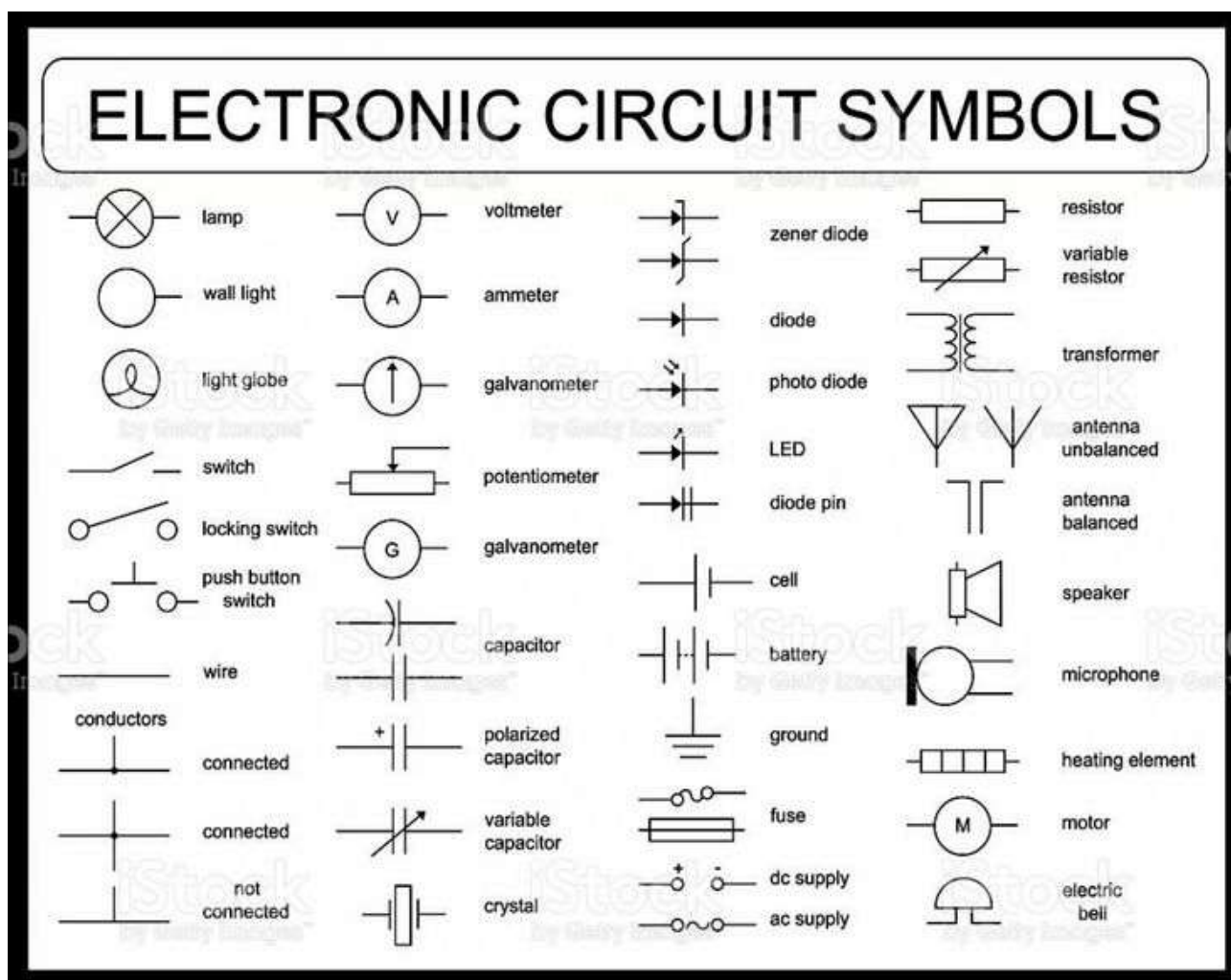
Electrical schematics are symbolic representations of electrical circuits — they show how components are **connected**, not necessarily how they are **physically arranged**.

**Two main types:**

- **Schematic Diagram:** Focuses on function and connections using standardized symbols.
- **Wiring Diagram:** Shows physical layout — where wires and devices are located and how they're connected.

## 2. Common Electrical Symbols

Here are a few of the most common ones you'll see:



### LU6.7: Common Faults (open neutral, ground faults)

#### 1. Open Neutral

An **open neutral** occurs when the neutral (return) wire is broken, loose, or disconnected somewhere in the circuit.

*Effect:*

- The circuit **loses its return path**, so current can't flow properly.
- Lights or devices may **flicker, dim, or go off entirely**.



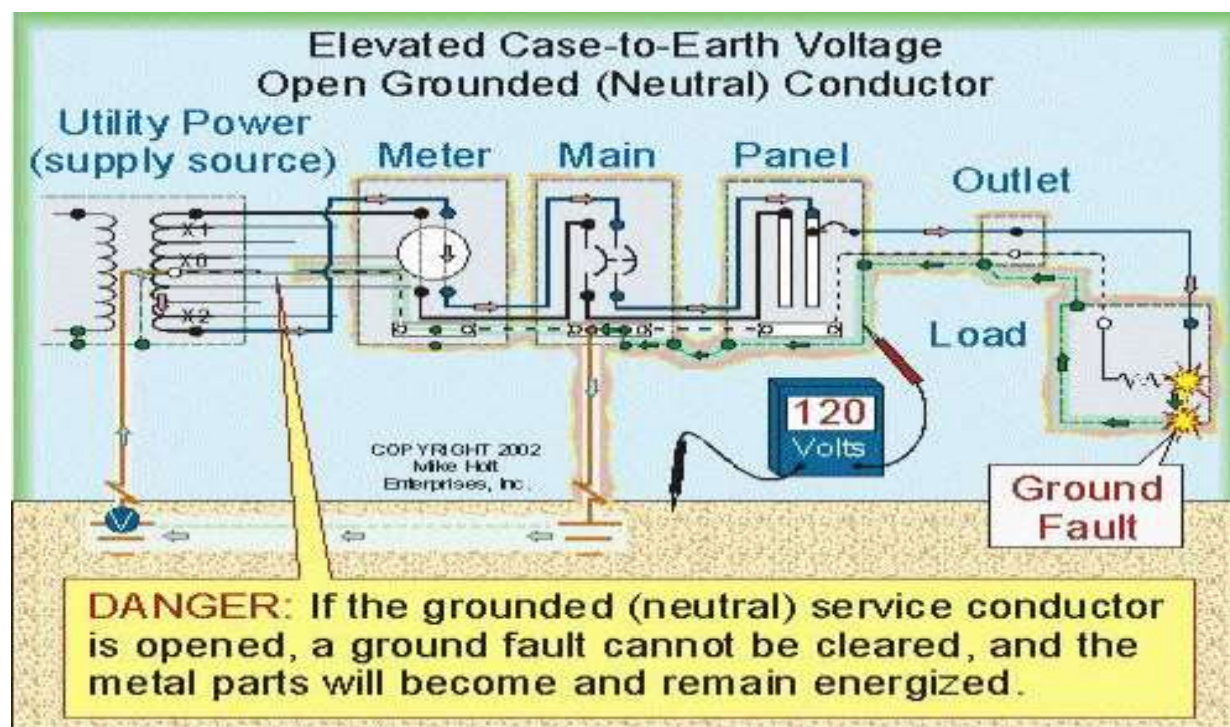
- In multi-wire branch circuits, **voltage imbalance** can occur — one leg may get **overvoltage** (damage risk).

## 2. Ground Fault

A **ground fault** happens when current unintentionally flows from the hot conductor to **ground** (earth), bypassing the normal load.

*Effect:*

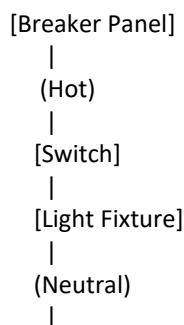
- Causes a **shock hazard** if a person provides a path to ground.
- Trips **GFCI (Ground Fault Circuit Interrupter)** or breaker.
- May cause **arcing, sparks, or fire** if severe.



## LU6.9: Using wiring diagrams and schematics

### 1. Understanding the Wiring Diagram

Here's a simple **lighting circuit wiring diagram** for reference:





[Neutral Bar]

|

[Ground Bar] — (to all metal boxes, fixtures, outlets)

- **Hot (black)** wire carries power from the breaker.
- **Neutral (white)** wire carries current back to the panel.
- **Ground (green or bare)** wire is for safety — not normally carrying current.

---

## 2. Using the Diagram to Locate a Fault

### How to Trace Using Diagram:

1. Start at the **load** (light fixture).
2. According to the wiring diagram, trace the **neutral path** back to the panel:
  - Fixture → Junction Box → Neutral Bar.
3. Check each neutral connection along that path.

### Testing (using multimeter):

- **Hot to Neutral** → should read 120V.
  - If not, neutral is open somewhere between fixture and panel.
- **Hot to Ground** → should read 120V (verifies hot is good).

### Fault Type 2: Ground Fault

#### Symptoms:

- Breaker or GFCI trips instantly.
- Sometimes shocks or burning smell.

### How to Trace Using Diagram:

1. Look at all points where **hot and ground** are close together (fixtures, metal boxes, appliances).
2. Use the wiring diagram to locate every device sharing that hot line.
3. Disconnect loads one at a time to isolate the fault.

### Testing:

- With power **off**, check for continuity between **hot and ground**:
  - You should have **no continuity** (open circuit).
  - If you do — a **ground fault** exists beyond that point.
- Turn power **on** (carefully) and test for voltage between **neutral and ground** (should be near 0V).
  - If higher than 2V, some leakage or grounding problem exists.





### 13. LU6.10: Basic jobsite skills communication and practices Etc

#### 14. 1. Jobsite Communication Skills

##### Verbal Communication

- **Be clear and concise** — say exactly what needs to be done, and repeat back instructions to confirm understanding.
- **Use proper terminology** — e.g., “breaker,” “neutral,” “conduit,” instead of slang.
- **Ask questions** when unsure — guessing can lead to dangerous mistakes.
- **Confirm before energizing** circuits or starting work near others.

##### Written Communication

- Read and understand **work orders, drawings, and schematics**.
- Fill out **job logs, permits, and reports** accurately.
- Mark **as-built changes** on drawings — future workers rely on them.

##### Radio / Digital Communication

- Use professional, brief, and respectful language.
- Confirm messages:
  - “Copy that,” “Confirmed,” or “Repeat last” (instead of “yeah” or “uh-huh”).

#### 15. 2. Safe Work Practices

- Always **assume circuits are live** until tested.
- **Lockout/Tagout (LOTO)** — disconnect and tag power before work.
- Use **voltage-rated gloves and insulated tools** when required.
- Keep **metal jewelry off** when working on energized circuits.

##### General Site Safety

- Wear **PPE**: hard hat, safety glasses, gloves, boots, hearing protection.
- Keep your **work area clean** — avoid trip hazards and clutter.
- Know where the **first aid kit** and **fire extinguisher** are.
- Report **unsafe conditions** immediately to a supervisor.

##### Ladder & Tool Safety

- Use the **right ladder height** and maintain 3 points of contact.
- Inspect power tools before use; report damaged cords.
- Use **GFCI protection** on all temporary power outlets.

#### 16. 4. Reading and Following Plans

- Read **schematics, wiring diagrams, and blueprints** before starting work.
- Identify:
  - Power sources





- Cable routes
- Panel numbers
- Device labels
- Ask for clarification if anything is unclear on the drawing.

✓ *Tip:* Mark up your copy of the drawings — note wire numbers, conduit runs, or load locations as you go.

## 5. Work Habits and Efficiency

- **Plan your tasks** — know what materials and tools you need before starting.
- **Label wires and devices** as you install them.
- **Test as you go** — don't wait until the end to check for errors.
- Keep tools **organized and in good condition**.
- **Clean up** after every job or phase — it's part of professionalism.

## 6. Problem Solving and Critical Thinking

- When troubleshooting:
  - Refer to the **schematic or wiring diagram**.
  - **Isolate** sections of the circuit.
  - Test logically — power, neutral, ground.
- Don't jump to conclusions; use your **meter and mind**, not guesses.

## 7. Respect and Site Etiquette

- Respect other trades — plumbers, HVAC, carpenters, etc.
- Communicate before moving someone else's work.
- Keep noise, debris, and cords from blocking pathways.
- Treat clients' property like it's your own.

## 8. Documentation and Reporting

- Fill out:
  - **Daily reports** (what was done, issues found)
  - **Material requests**
  - **Incident or near-miss reports**
- Report all **accidents, shocks, or tool failures** immediately — even minor ones.

## ENTREPRENEURSHIP



## What is Entrepreneurship?

**Entrepreneurship** is the process of **identifying an opportunity**, **developing an idea**, and **organizing resources** to create and grow a **business venture** for profit and/or social impact.

An **entrepreneur** is a person who:

- Takes the **initiative** to start something new.
- **Assumes risks** (financial, personal, and professional).
- **Innovates** — offering new products, services, or methods.
- **Creates value** for customers and society.

## Importance of Entrepreneurship

- Drives **economic growth** and job creation.
- Encourages **innovation** and competition.
- Solves **social and environmental problems**.
- Promotes **self-reliance** and community development.

## Types of Entrepreneurship

| Type                                     | Description  | Example                                       |
|--|--|---|
| <b>Small Business Entrepreneurship</b>   | Local businesses serving a community.                      | Electrician service, retail shop, restaurant. |
| <b>Scalable Startup Entrepreneurship</b> | Starts small but designed to grow rapidly with investment. | Tech startups, apps, online platforms.        |



| Type                                      | Description   | Example                                 |
|---|---|---|
| <b>Social Entrepreneurship</b>            | Focuses on solving social/environmental issues rather than profit.  | Nonprofit ventures, recycling programs. |
| <b>Innovative Entrepreneurship</b>        | Creates brand-new products, technologies, or processes.             | Tesla, Dyson, or local inventors.       |
| <b>Hustler/Imitative Entrepreneurship</b> | Improves or copies an existing idea with better service or quality. | Local delivery service, food vendor.    |
| <b>Research/Academic Entrepreneurship</b> | Converts research or inventions into business.                      | University spin-offs, biotech firms.    |

## Business Idea Generation

Generating a business idea means identifying **a gap, a need, or a problem** and finding a **profitable way to solve it**.

### 🗨 Sources of Ideas:

- **Personal skills or passions** (e.g., electrician starting a contracting business)
- **Customer pain points** (what frustrates people?)
- **Market trends** (new technologies, green energy, mobile apps)
- **Existing problems** in your community
- **Observation** — what can be improved?

### ✳ Techniques for Idea Generation:

1. **Brainstorming** – free flow of ideas without judgment.
2. **SCAMPER Method**: Substitute, Combine, Adapt, Modify, Put to another use, Eliminate, Reverse.
3. **SWOT Analysis**: Evaluate Strengths, Weaknesses, Opportunities, Threats.
4. **Market Research** – survey potential customers and analyze competitors.

✓ *Good ideas solve real problems, are feasible, and offer value.*

## Business Planning and Strategy

A **business plan** is a document that describes how your business will start, operate, and grow.

### 📋 Key Components of a Business Plan:

1. **Executive Summary** – overview of your business and goals.
2. **Business Description** – what you do and why it matters.
3. **Market Analysis** – target market, competitors, demand.
4. **Organization & Management** – team structure and skills.
5. **Product or Service Line** – details of what you sell.



6. **Marketing and Sales Strategy** – how you’ll attract and keep customers.
7. **Financial Plan** – startup costs, revenue, expenses, cash flow.
8. **Funding Request** (if needed) – how much money you need and why.

## 📌 Business Strategy

Your **strategy** defines *how* you’ll compete and succeed.

Common strategies include:

- **Cost Leadership:** Offer lowest prices.
- **Differentiation:** Offer unique or high-quality products.
- **Focus/Niche:** Serve a specific customer group.
- **Innovation:** Introduce new solutions regularly.

Financing a Business

## 💰 Sources of Startup Capital

| Source                                       | Description                                   | Pros                        | Cons                                |
|--|---|-----------------------------|-------------------------------------|
| <b>Personal Savings</b>                      | Using your own money                          | Full control                | Limited funds                       |
| <b>Family &amp; Friends</b>                  | Borrow or invest informally                   | Quick access                | Risk to relationships               |
| <b>Bank Loans</b>                            | Borrow from a bank with interest              | Larger amounts              | Requires collateral, credit history |
| <b>Microfinance Institutions</b>             | Small loans for startups                      | Easier for small businesses | Higher interest rates               |
| <b>Government Grants &amp; Programs</b>      | Public funds or support for entrepreneurs     | No repayment                | Competitive and limited             |
| <b>Angel Investors / Venture Capitalists</b> | Investors who take equity in your business    | Large funding & mentorship  | Share of ownership given up         |
| <b>Crowdfunding</b>                          | Raising small amounts online from many people | Public support              | Requires marketing effort           |

## 📊 Financial Management

- Track **income and expenses**.
- Maintain **cash flow** — always have enough for operations.
- Separate **personal and business finances**.
- Plan for **taxes, insurance, and contingencies**.

Entrepreneurship Challenges and Solutions

| Challenge              | Description                                  | Possible Solutions  |
|------------------------|--|---|
| <b>Lack of Capital</b> | Hard to find funds for startup or expansion. | Start small, reinvest profits, explore microloans, or partnerships. |



| Challenge                    | Description                                   | Possible Solutions                                  |
|------------------------------|---|---|
| <b>Competition</b>           | Other businesses offering similar products.   | Differentiate with quality, service, or pricing.    |
| <b>Limited Market Access</b> | Difficulty reaching customers.                | Use digital marketing, referrals, or partnerships.  |
| <b>Lack of Experience</b>    | New entrepreneurs may lack management skills. | Seek mentorship, training, and continuous learning. |
|                              |   |   |

## ENVIRONMENT STUDIES



### What is the Environment?

The **environment** refers to **everything that surrounds us** — living and nonliving things — that influence life on Earth.

It includes:

- **Natural components:** air, water, soil, plants, animals.





- **Human-made components:** buildings, roads, industries, technology.

## Importance of the Environment

- Provides **air, water, food, and shelter**.
- Supports **biodiversity** — all living species.
- Regulates **climate** and natural cycles.
- Offers **resources** for human development (energy, minerals, timber).

## Types of Environmental Hazards

Environmental hazards are **natural or human-made events** that harm people, animals, or ecosystems.

### A. Natural Hazards

Caused by natural processes of the Earth.

| Type                             | Examples                                    | Effects                               |
|----------------------------------|---|---------------------------------------|
| <b>Geological</b>                | Earthquakes, volcanic eruptions, landslides | Property destruction, loss of life    |
| <b>Climatic / Meteorological</b> | Floods, droughts, storms, hurricanes        | Crop loss, displacement, disease      |
| <b>Biological</b>                | Disease outbreaks, pests, invasive species  | Health problems, reduced biodiversity |

### B. Human-Made (Anthropogenic) Hazards

Caused by human activities and negligence.

| Type                        | Examples                                 | Effects                                  |
|-----------------------------|--|--|
| <b>Pollution</b>            | Air, water, soil, and noise pollution    | Health issues, environmental degradation |
| <b>Deforestation</b>        | Cutting down trees for land or timber    | Soil erosion, loss of habitat            |
| <b>Industrial Accidents</b> | Oil spills, chemical leaks               | Contamination, marine death              |
| <b>Waste Mismanagement</b>  | Improper disposal of solid/plastic waste | Pollution, visual blight                 |
| <b>Nuclear Hazards</b>      | Radiation leaks, weapon testing          | Long-term contamination                  |





## Impact of Human Activities on the Environment

Human activity has greatly changed natural systems. Major impacts include:

### 1. Pollution

- **Air Pollution:** from vehicles, factories, and burning fossil fuels → causes smog, asthma, global warming.
- **Water Pollution:** from industrial waste, sewage, oil spills → harms aquatic life.
- **Soil Pollution:** from pesticides, chemicals → affects crops and groundwater.
- **Noise Pollution:** from traffic, machinery → causes stress and hearing loss.

### 2. Deforestation

- Loss of forests for farming, housing, or logging.
- Leads to **loss of biodiversity, soil erosion**, and contributes to **climate change**.

### 3. Agricultural Practices

- Overuse of fertilizers and pesticides pollutes soil and water.
- Mono-cropping reduces soil fertility.

### 4. Urbanization and Industrialization

- Increases waste, pollution, and energy demand.
- Reduces natural green areas.

### 5. Resource Overuse

- Overfishing, over-mining, and overgrazing lead to **resource depletion**.

## Conservation and Sustainability

### Conservation

**Conservation** means the **careful management and protection of natural resources** to prevent depletion and ensure availability for future generations.

### Sustainability

**Sustainability** means meeting **today's needs** without **compromising future generations' ability** to meet theirs.

### Three Pillars of Sustainability:

1. **Environmental:** protect ecosystems and reduce pollution.
2. **Social:** promote equality, health, and education.



3. **Economic:** create jobs and income without harming the planet.

## Climate Change and Its Effects

**Climate change** is the long-term change in temperature, rainfall, and weather patterns — mainly due to increased **greenhouse gases** from human activities (burning fossil fuels, deforestation).

### Effects:

| Impact                         | Description  |
|--------------------------------|--|
| <b>Global Warming</b>          | Average global temperatures rising.                      |
| <b>Melting Ice Caps</b>        | Rising sea levels → coastal flooding.                    |
| <b>Extreme Weather</b>         | More droughts, storms, heatwaves, and floods.            |
| <b>Loss of Biodiversity</b>    | Species unable to adapt to changing climates.            |
| <b>Food and Water Scarcity</b> | Crop failure, drought, famine.                           |
| <b>Human Health Risks</b>      | Heat stress, respiratory diseases, spread of infections. |

## How to Contribute to Environmental Protection

- **Reduce, Reuse, Recycle** — manage waste responsibly.
- **Save energy and water** — switch off lights, repair leaks.
- **Plant trees** — they absorb CO<sub>2</sub> and provide oxygen.
- **Use eco-friendly products** — biodegradable materials, cloth bags.
- **Use public transport, cycle, or walk** to reduce pollution.

## As a Community or Workplace

- Start **environmental awareness campaigns**.
- Encourage **proper waste disposal** systems.
- Support **clean-up drives** and **tree-planting projects**.
- Promote **recycling programs** and **energy audits**.

## At Government or National Level

- Enforce **environmental laws and standards**.
- Support **renewable energy** projects.
- Invest in **public education and awareness**.
- Encourage **green industries** and **sustainable farming**.



## KP-RETP Component 2: Classroom SECAP Evaluation Checklist

### Purpose:

To ensure that classroom-based skills and entrepreneurship trainings under KP-RETP are conducted in an environmentally safe, socially inclusive, and climate-resilient manner, in line with the Social, Environmental, and Climate Assessment Procedures (SECAP).

**Evaluator:** \_\_\_\_\_

**Training Centre / Location:** \_\_\_\_\_

**Trainer:** \_\_\_\_\_

**Date:** \_\_\_\_\_



| Category                 | Evaluation Points  | Status |    | Remarks /Recommendation |
|--------------------------|--|--------|----|-------------------------|
|                          |  | Yes    | NO |                         |
| <b>Social Safeguards</b> | Is the training inclusive (equal access for women, youth, and vulnerable groups)?  |        |    |                         |
|                          | Does the classroom environment ensure safety and dignity for all participants (no harassment, discrimination, or child Labor)? |        |    |                         |

|  |  |  |  |  |
|--|--|--|--|--|
|  | Are Gender considerations integrated into examples, discussions, and materials?  |  |  |  |
|  | Is the Grievance Redress Mechanism (GRM) process, along with the relevant contact number, clearly displayed in the classroom |  |  |  |
|  | Are the Facilities and activities being accessible and inclusive for specially-abled (persons with disabilities)             |  |  |  |

|                                 |  |  |  |  |
|---------------------------------|--|--|--|--|
| <b>Environmental Safeguards</b> | Is the classroom clean, ventilated, and free from pollution or hazardous materials?                        |  |  |  |
|                                 | Is there proper waste management (bins, no littering)  |  |  |  |
|                                 | Are materials used in practical sessions environmentally safe (non-toxic paints, safe disposal of wastes)? |  |  |  |
|                                 | Are lights, fans, and equipment turned off when not in use   |  |  |  |



|                           |   |  |  |  |
|---------------------------|---|--|--|--|
|                           | (energy conservation)?  |  |  |  |
| <b>Climate Resilience</b> | Are trainees oriented on how their skills link with climate-friendly practices (e.g., renewable energy, efficient production, recycling)? |  |  |  |
|                           | Are trainers integrating climate-smart examples in teaching content?  |  |  |  |
|                           | Are basic health and safety measures available (first aid kit, safe exits, fire safety)?  |  |  |  |

|                              |   |  |  |  |
|------------------------------|---|--|--|--|
|                              | Is the trainer using protective gear or demonstrating safe tool use (where relevant)?   |  |  |  |
| <b>Institutional Aspects</b> | Is SECAP awareness shared with trainees (via short briefing, posters, or examples)?     |  |  |  |
|                              | Are trainees encouraged to report unsafe, unfair, or environmentally harmful practices? |  |  |  |
| <b>Overall Compliance</b>    | Overall SECAP compliance observed   | <input type="checkbox"/> High<br><input type="checkbox"/> Medium<br><input type="checkbox"/> Low |  |  |



## Overall remarks/ recommendations

| Name | Designation | Signature | Date |
|------|-------------|-----------|------|
|      |             |           |      |