Ratna Sagar

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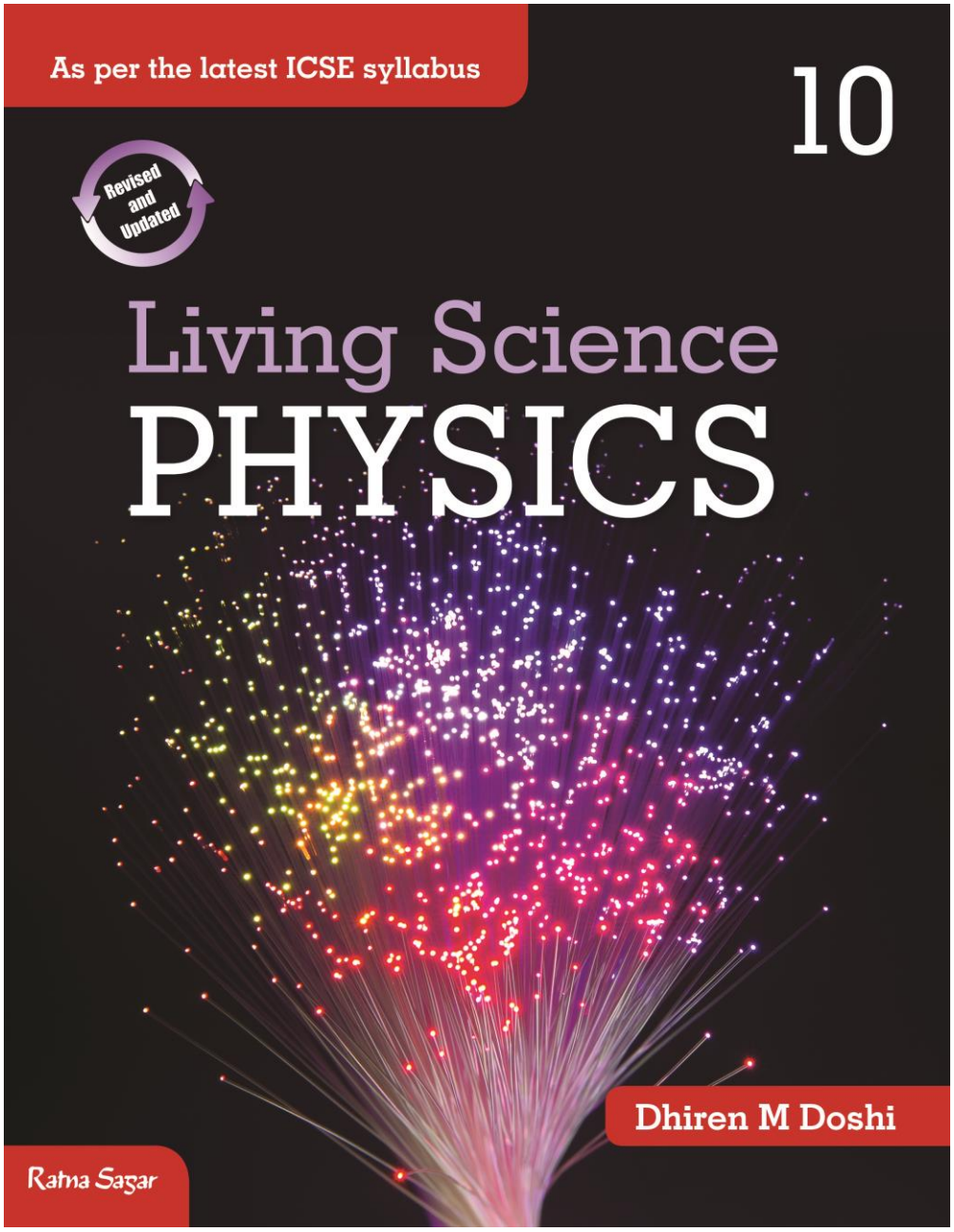
Education, Our Mission

ICSE
Living Science
Physics

Class 10

Chapter-9 Electrical Power and Household Circuits


As per the latest ICSE syllabus
10
Revised and Updated
Living Science
PHYSICS
Dhiren M Doshi
Ratna Sagar

LEARNING OBJECTIVES

Electrical Energy

- **Measurement of electrical energy**

Electric Power

- **Power rating of common electrical appliances**

Household Electrical Wiring System

Supply to the House

- **House wiring**

Fuses, Switches, Sockets and Plugs

- **Electrical fuse- a safety device**
- **Switches**
- **Pin and socket**

Earthing of Electrical Appliances

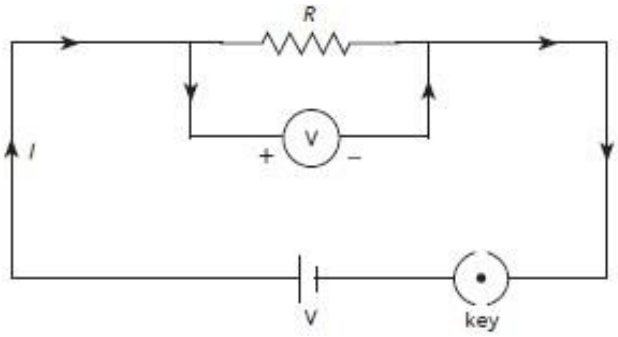
Safety precautions while using electricity

What are the various forms of energy?

Mechanical energy, chemical energy, heat energy, light energy, electrical energy, etc. are various **forms of energy** which can be converted from one form to other form of energy.

Measurement of Electrical Energy

If *V* is measured in volts, *I* in amperes and *t* in seconds, work done, *W* is in joules. This work done (*W*) by the current measures the electrical energy which is supplied by the battery or any other source of electrical energy. W = Vit



The SI unit of electrical energy is joule (J).

1 joule = 1 volt × 1 ampere × 1 second = 1 V As

Electric Power

The rate at which electrical energy is dissipated or consumed in an electric circuit is termed as electric power. This electrical energy is supplied by some source, say battery, to the electric circuit. So, electric power can also be defined as the rate at which electrical energy is supplied by the source.

i.e. Electric power (*P*) = Electrical work done /Time taken

or $P = W/T$

or $P = VI$ (Since $W = VIt$)

So, electric power is also defined as the product of the applied voltage and the current flowing through the circuit.

Unit of electric power

We know, $P = V I$

The SI unit of potential difference is 1 volt and that of current is 1 ampere. So, the SI unit of power = 1 V $\times$ 1 A = 1 V A or J s^{-1} or 1 watt (1 W).

$\therefore$ **SI unit of electric power is watt** (W).

Thus, electric power consumed is 1 watt if 1 ampere current flows through an electrical circuit when a potential difference of 1 volt is applied across it.

The commercial (practical) unit of power is horsepower (hp).

1 hp = 746 W

The commercial unit of electrical energy is kilowatt-hour (kWh), i.e.

1 kWh = 1000 Wh

One kilowatt-hour is the amount of electrical energy consumed when an electrical appliance having a power rating of 1 kilowatt is used for 1 hour.

1 kWh = 3.6 $\times$ 10^6 J

Power rating of common electrical appliances

All electrical appliances such as electric bulb, electric iron, geyser, toaster, room heater etc. are rated in terms of **voltage** and **electric power** (wattage).

1. Voltage: The voltage of an electrical appliance is the potential difference that can be safely applied across its input terminals. In our country, we get domestic electric supply at 220 V, so the voltage of the electrical appliances in our country is kept at 220 V.

2. Electric power (wattage): The electric power (wattage) of an electrical appliance is the rate at which it consumes electrical energy under the rated voltage.

Calculation of the cost of electrical energy consumed

The electric meter fixed at the main board in our house measures the electrical energy consumed in kWh.

The total electrical energy consumed in kilowatt-hour or number of 'units'. So,

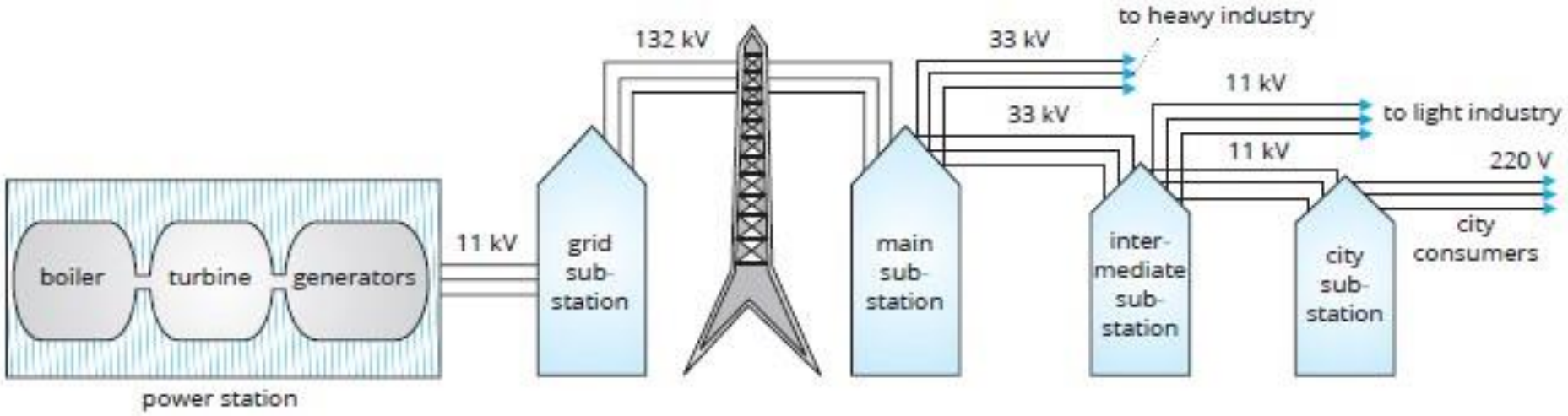
Electrical energy consumed (units) = Power (in watt) × Time (in hour)/ 1000

Now, knowing the cost of 1 unit of electricity, we can find the total cost.

Total cost (electricity bill) = Number of units consumed × Cost of 1 unit

Household Electrical Wiring System

Electric Power Station: Electric power is generated in power stations at 11,000 volts (11 kV) with an alternating frequency of 50 Hz. This is because the current becomes low at a high voltage and therefore the loss of energy due to heating in wires becomes less.



2.Grid Sub-station: This power is transmitted over long distances at a voltage greater than 11 kV to reduce transmission losses in the form of heat. So at generating station, also called grid sub-station, the voltage is stepped from 11 kV to 132 kV using step up transformer.

3. Main sub-station: From grid sub-station, the electric power is transmitted to the main sub-station. Here the alternating voltage is stepped down using step down transformer from 132 kV to 33 kV and further transmitted to city sub-station.

4. City sub-station: Here, the alternating voltage of electric power is further stepped down using step down transformer from 33 kV to 220 V for supply to the consumers for usage.

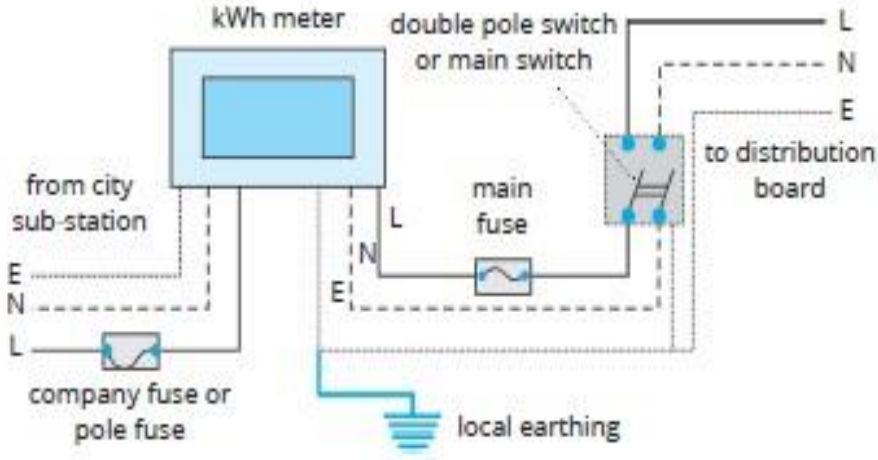
Supply to the House

The main supply of electric power is done to our homes using a three core cable. The three cables are: 1**.** Live wire (L) 2. Neutral wire (N) 3. Earth wire (E)

The live wire (L) is at a high voltage (220 V) and brings in the current. Neutral wire (N) provides a return path for the current and is kept at zero potential by connecting it to the earth at the power station itself

1.The live (L) and neutral (N) wires of the main line coming from the electric pole are brought to the main board fitted inside our house.

2.The two line wires are then connected to the electric meter. The electric meter measures the quantity of electricity consumed by us in units of kilowatt-hours.



Connections from electric pole to the distribution box through meter, main fuse and main switch

3.The two wires coming out of the electric meter are connected to the main switch. The main switch is a **double pole switch.** It has an iron covering which is earthed.

4. The wires from the main switch enter the **distribution box**. In the distribution box, the main line is divided into two main circuits: one of 5 A (domestic light) and another of 15 A (domestic power). The domestic light (5 A line) is used for running appliances of low power rating such as bulbs, tube lights, etc. The domestic power (15 A line) is used for running

House Wiring

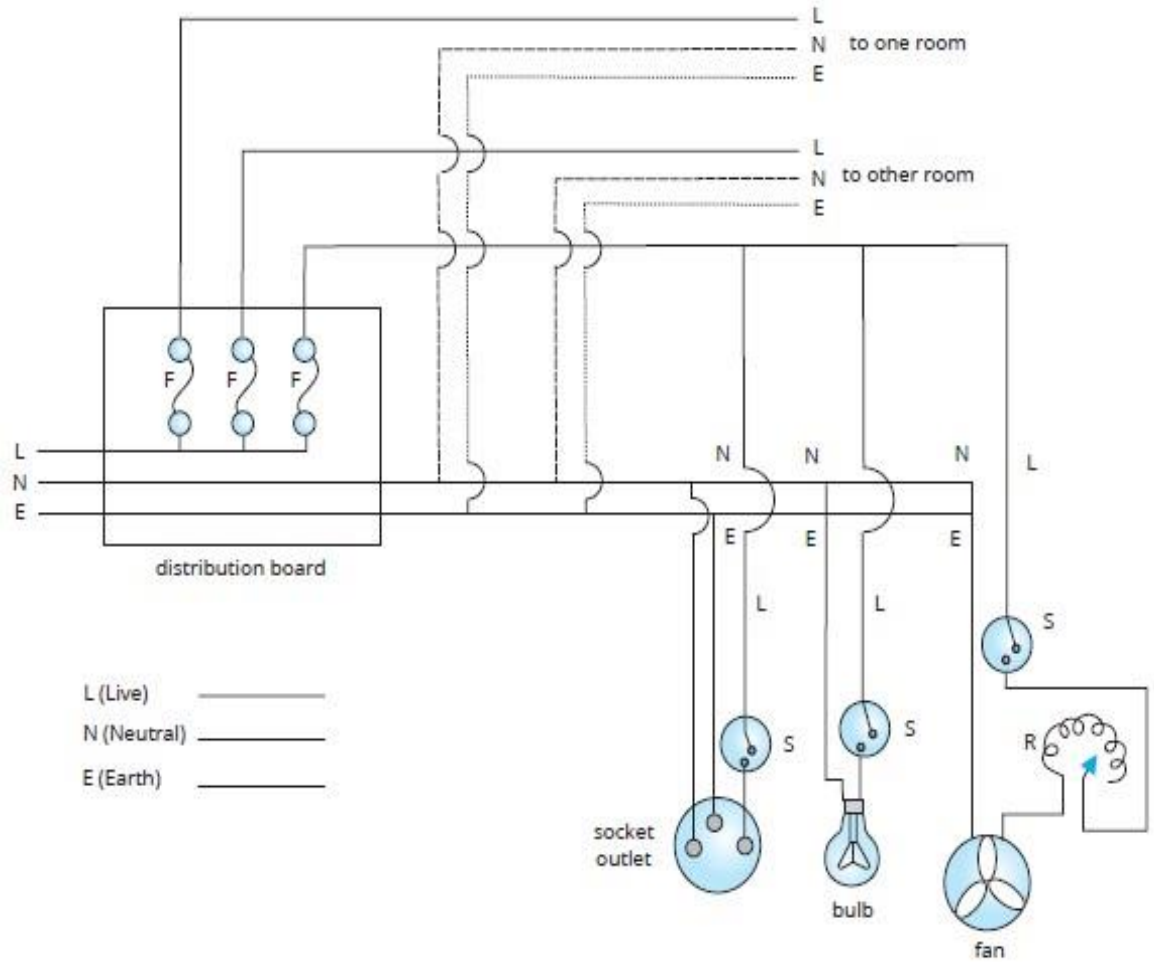
The power flowing out of the main switch can be distributed in house by two systems of wiring commonly called **a.** tree system and **b.** ring system.

Tree system of distribution of power

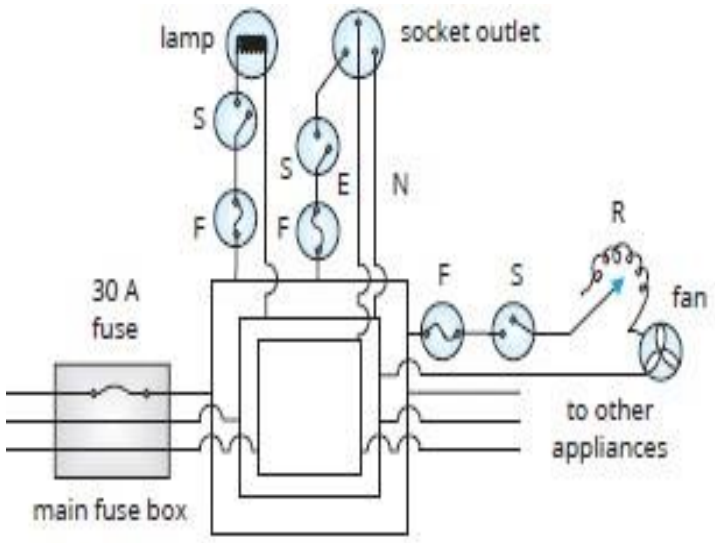
In this wiring system, various branch lines are taken from the distribution board. These lines are then connected to different parts of the house. This system of wiring is referred to as ‘tree system’ since the branch lines resemble the branches of a tree.

Ring system of distribution of power

Ring system of wiring is nowadays preferred than the tree system due to several disadvantages of the tree system as described above. In this system, the wiring is placed in the form of a ring, i.e. wires starting from the main fuse box, containing a fuse of 30 amperes run around all the rooms in the house and are brought back to the main fuse box.



Tree system of distribution of power



Ring system of distribution of power

Advantages of connecting the appliances in parallel

1. The same supply voltage is available for all electrical appliances. As a result, each electrical appliance works under constant voltage.

2. Each appliance works independently of other appliances. Even if one of the appliance is switched off or gets fused, it will not affect the working of other appliances in the circuit.

Disadvantages of connecting the appliances in series

1. If the appliances are connected in series, then the supply voltage gets divided between various appliances according to their resistances. Therefore, appliances do not operate at its rated voltage.

2. All the appliances will work simultaneously. If any one of the appliances is switched off, all the appliances will stop working.

Short-circuiting

Sometimes, the plastic coating on the live and neutral wires gets torn or melts which causes them to touch each other. The resistance of the so-formed circuit is very low and hence, allows a large current to pass through. This causes heating in the circuit and may start a fire. This is **short-circuiting**.

Some Essential Components of House Wiring System

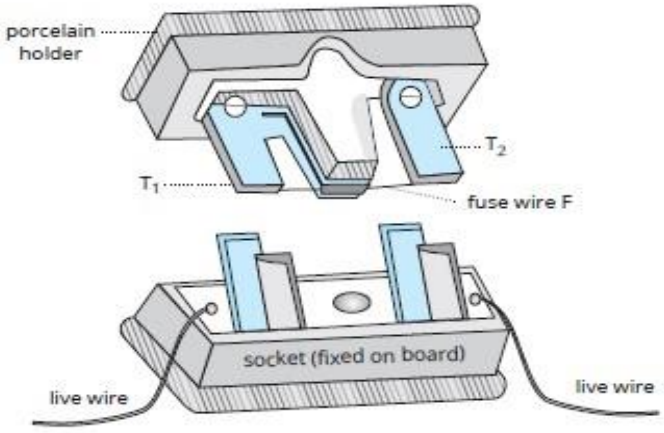
Electric fuse—a safety device

An electrical fuse is a safety device consisting of a short piece of metal or metal alloy, inserted in a circuit, which melts and breaks the circuit if the current exceeds a safe value, hence preventing the electrical appliances in the circuit from getting damaged. A fuse is always connected in the live wire and in series with the electrical circuit to protect it from overloading.

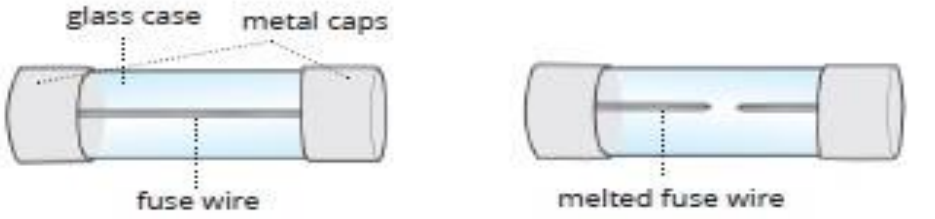
The two common types of fuses are as follows:

1. Cut-out type fuse– commonly used in domestic circuits.

2. Cartridge-type fuse– commonly used for additional safety in devices such as computers, music systems, TV and inverters.



Cut-out type fuse



a. The fuse is a thin wire placed inside the glass tube between two end caps

b. The wire has melted by the heat of too large a current

Cartridge-type fuse

Miniature circuit breakers (MCBs)

Miniature Circuit Breakers (MCBs) are used to protect the household wiring from overloading or short-circuit. They switch off the circuit within a very short duration of time (in a fraction of a second) in case of short-circuit or overloading. The MCB can be reset when the fault has been corrected.

Switches

A switch is a device that is used to allow current to flow in a circuit or in an electrical appliance and to cut it off when desired.
There are two types of switches.
A **single pole switch** used with an appliance starts or stops the flow of current through the appliance. It disconnects only the live wire from the appliance.

A **double pole switch** disconnects both the live and neutral wires. The main switch used at the distribution board to switch on or off the main supply is the double pole switch. Here, the two circuits, live and neutral are switched on and off simultaneously. The dual control switches used in staircases are special type of double pole switches.

Plug

The electrical appliances are provided with a cable having a plug at one end so that the appliance can be connected to the electric power supply. **A plug is a fixture provided with three metallic cylindrical pins usually made of brass embedded in ebonite casing.**

Three-pin Plug

In a plug, the top (longer and thicker) pin is for earthing, the live pin is on the right and neutral pin is on the left.

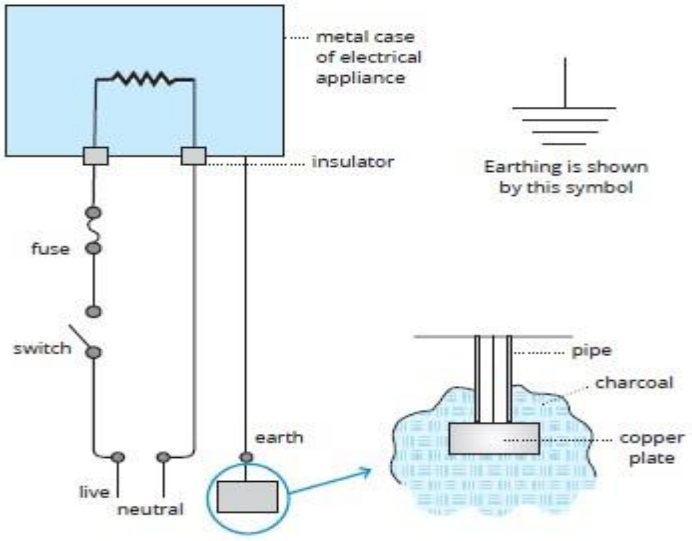
Socket

A socket is a fixture in an electric circuit. The plug is inserted into the socket. **A socket has three holes** with the inner walls in the form of metallic cylinders. **The sockets are provided with three brass cylinders embedded in ebonite at the back.** The upper bigger hole in the socket is for the earth connection, the right side hole of the socket is for connection to the live wire and the left side hole is for connection to the neutral wire of the electrical current supply.

Socket with switch

Earthing of Electrical Appliances

Sometimes if we touch any part of a defective electrical appliance, we may get an electric shock. Connecting the metallic body of an electrical appliance to the earth by a conducting wire to prevent electric shock is called the earthing of an appliance.



Earthing of an **electrical appliance is done to protect the user from any accidental electrical shock**. Earthing also saves the appliances from being damaged in case of short-circuit and overloading. **The earth can be regarded as an electric sink** since excess current flows through the earthing to the earth.

Colour Code for Electric Wires

Type of wire	Old convention	New convention
Live wire	Red	Brown
Neutral wire	Black	Light blue
Earth wire	Green	Green or yellow

Safety Precautions while Using Electricity

Electricity is a very convenient and useful form of energy. To avoid any accidental loss, the following precautions should be taken while working with any electrical appliance or circuit.

1. **Wiring:** Only good quality electrical wires should be used in electrical circuits.

2. **Fuse:** Each circuit should have a fuse of proper rating. Fuse should be connected to the live wire.

3. **Earthing:** All electrical appliances must be properly earthed.

4. **Electrical connections:** All electrical connections at switches, plugs, sockets, etc., must be tight. Fuse and switches must be connected with the live wire.

5. **Joints in wires:** All electrical joints should be properly covered with insulation tapes.

6. **Handling:** While using an electrical appliance, it should be held from its handles made of insulating material. Electrical appliances should never be operated (or touched) with wet hands.

SUMMARY

1. **Electrical energy:** The work done by a source to maintain a current in an electrical circuit is known as electrical energy.

2. **Electric power:** The rate at which electrical energy is dissipated or consumed in an electric circuit is termed as electric power.

3. **Power rating:** The power rating of an electrical device is the value of electrical power consumed by the device under standard condition.

4. **Cable wires:** Power is supplied through a cable consisting of three wires **a.** live or phase wire **b.** neutral wire **c.** earth wire.

5. **Ring system:** In this system, wires starting from the main fuse box run around all the rooms in the house and brought back to the main fuse box. All electrical appliances are connected directly to the ring with a separate fuse and a separate switch.

6. **Electric fuse:** It is a safety device consisting of a piece of thin wire of material having low melting point and high resistance, which melts and breaks the circuit if the current exceeds a safe value, hence preventing the electrical appliances in the circuit from getting damaged.

7. Switch: It is a device which is used to allow current to flow in a circuit or in an electrical appliance and to cut it off when desired. There are two types of switches **a.** Single pole switch **b.** Double pole switch.

8. Plug: It is a fixture provided with three cylindrical pins made of brass embedded in ebonite casing.

9. Earthing of an electric appliance: Connecting the metallic body of an electrical appliance to the earth by a conducting wire to prevent electric shock is called earthing of electric appliance.

10. Colour coding of wires: As per new convention live wire – brown, neutral wire – light blue, earth wire – green or yellow.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