Field Technician
Other Home Appliances

(Job Role)

Qualification Pack: Ref. Id. ELE/Q3104

Sector: Electronics

Textbook for Class IX

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

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Textbook for Class IX

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Foreword

The National Curriculum Framework–2005 (NCF–2005) recommends bringing work and education into the domain of the curricular, infusing it in all areas of learning while giving it an identity of its own at relevant stages. It explains that work transforms knowledge into experience and generates important personal and social values such as self-reliance, creativity and cooperation. Through work one learns to find one's place in the society. It is an educational activity with an inherent potential for inclusion. Therefore, an experience of involvement in productive work in an educational setting will make one appreciate the worth of social life and what is valued and appreciated in society. Work involves interaction with material or other people (mostly both), thus creating a deeper comprehension and increased practical knowledge of natural substances and social relationships.

Through work and education, school knowledge can be easily linked to learners' life outside the school. This also makes a departure from the legacy of bookish learning and bridges the gap between the school, home, community and the workplace. The NCF – 2005 also emphasises on Vocational Education and Training (VET) for all those children who wish to acquire additional skills and/or seek livelihood through vocational education after either discontinuing or completing their school education. VET is expected to provide a 'preferred and dignified' choice rather than a terminal or 'last-resort' option.

As a follow-up of this, NCERT has attempted to infuse work across the subject areas and also contributed in the development of the National Skill Qualification Framework (NSQF) for the country, which was notified on 27 December 2013. It is a quality assurance framework that organises all qualifications according to levels of knowledge, skills and attitude. These levels, graded from one to ten, are defined in terms of learning outcomes, which the learner must possess regardless of whether they are obtained through formal, non-formal or informal learning. The NSQF sets common principles and guidelines for a nationally recognised qualification system covering Schools, Vocational Education and Training Institutions, Technical Education Institutions, Colleges and Universities.

It is under this backdrop that Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE), Bhopal, a constituent of NCERT has developed learning outcomes based modular curricula for the vocational subjects from Classes IX to XII. This has been developed under the centrally sponsored scheme of Vocationalisation of Secondary and Higher Secondary Education of the Ministry of Education, erstwhile Ministry of Human Resource Development.

This textbook has been developed as per the learning outcomes based curriculum, keeping in view the National Occupational Standards (NOS) for the job role and to promote experiential learning related to the vocation. This will enable the students to acquire necessary skills, knowledge and attitude.

I acknowledge the contribution of the development team, reviewers and all the institutions and organisations, which have supported in the development of this textbook.

NCERT would welcome suggestions from students, teachers and parents, which would help us to further improve the quality of the material in subsequent editions.

Hrushikesh Senapaty
Director
National Council of Educational
Research and Training

New Delhi
September 2020

About the Textbook

The Consumer Electronics (CE) sub-sector has been one of the fastest growing industrial sectors during the past two or more decades. Consumer electronics refers to any device containing an electronic circuit board that is intended for everyday use by individuals.

The service industry in the CE sector is expected to be a major job creator in India. It is also the preferred choice as it offers good pay packages and an opportunity to climb up the corporate ladder fast. Latest CE products are now coming out with new and advanced features. So essentially, the entire service network, which has been addressing these products, need learning and skill development in new technologies used in the CE products.

In our day-to-day lives, we deal with many electrical and electronic appliances, which make our lives easy. These electronic appliances, such as, water purifier, mixer, geyser and microwave have become a part of every household. India's water purifier market is expected to reach USD 2.6 billion by the end of 2021 as compared to USD 1.3 billion in 2016. The market for mixer grinder stood at 9.5 million units in 2017 and it is expected to grow at a CAGR of 12 per cent by 2021. These appliances not only uplift the living and health standards of human beings, but also save time. Thus, creating huge opportunities in manufacturing, installation, maintenance and repair of these appliances.

The textbook for the job role of Field Technician—Other Home Appliances has been developed to impart knowledge and skills through hands-on learning, which forms a part of experimental learning. This will prepare students to install and maintain household appliances.

The textbook has been developed with the contribution of academic and industry experts for making it a useful and inspiring teaching-learning resource material. Adequate care has been taken to align the content of the textbook with the National Occupational Standards (NOSs) for the job role so that the students acquire necessary knowledge and skills as per the performance criteria mentioned in the NOSs of the Qualification Pack (QP).

The textbook has been reviewed by experts so as to make sure that the content is not only aligned with the NOSs, but is also of high quality. The NOSs for the job role of Field Technician—Other Home Appliances covered through this textbook are as follows:

1. ELE/N3101 Engage with customer for service
2. ELE/N3118 Install water purifier

3. ELE/N3119 Repair dysfunctional water purifier
4. ELE/N9901 Interact with colleagues

Chapter 1 of the textbook covers fundamentals of electricals and electronics. It gives a basic overview of electrical system and its terminologies including energy transformation. It explains electrical quantities, such as, current, voltage, resistance, concept of conductor, insulator, electric circuit, series and parallel circuit. The various laws used in circuit analysis, such as, Ohm's law, Kirchhoff's voltage law and Kirchhoff's current law are explained in this unit.

Chapter 2 of the textbook deals with electrical and electronic components. It covers basic electrical components, such as, resistor, inductor, capacitor, identifying the capacitors by reading their values and calculation of resistance value using various methods. The electronic components like diode, transistor and their types are also covered. This unit covers the identification and testing of various electrical and electronic components with hands-on practical activities.

Chapter 3 of the textbook covers the tools and equipment required for the installation and maintenance of water purifier. It also covers variuos practical activities, which will provide hands-on learning for handling and operating the tools and equipment.

Chapter 4 of the textbook covers the installation of RO water purifier. It covers basics of water-based appliances, water treatment method, water purification process and different layers of filter, water purification technologies, different features and function of purifier. It also covers the installation of water purifier, with hands-on learning and documentation of the installation procedure.

Chapter 5 of the textbook covers repair and maintenance of water purifier. It covers the symptoms of fault, maintenance of RO water purifier, fault repairing, checking functionality of repaired parts through hands-on learning of fault identification and repairing.

Chapter 6 of the textbook discusses health and safety at the workplace. It discusses the hazards related to handling water purifier, fire hazard, electrical hazard, electrical rescue techniques, and hazards occuring due to mishandling of tools.

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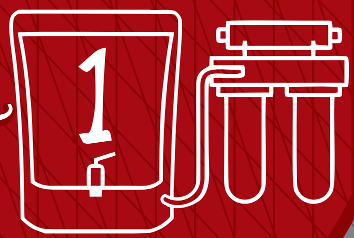
The Council is grateful to the Ministry of Education (MoE) for the financial support and cooperation in realising the objective of providing a quality textbook for the vocational students.

Contents

You have to grow from the inside out
None can teach you, none can make you spiritual.
There is no other teacher but your own soul.

— Swami Vivekananda

Chapter 1



Fundamentals of Electricals and Electronics

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Electricity has an important place in modern society. In this age, almost all the appliances we use, work on electricity. Even the automobile industry has started an electric car which will run on electricity instead of fuel. When power supply in a city breaks down, hospitals, hostels, office buildings, schools, food storage plants, banks and shops, etc., stop working.

Electricity makes no sound, does not have an odour, and cannot be seen. Learning the theory of electricity makes us cautious about the hazards associated with electric appliances. Therefore, it is very important to understand the concept of electricity for installation and troubleshooting electric appliances.

The electric elements in the appliance include controlled and uncontrolled sources of energy, resistors, capacitors, inductors, etc. The electric circuit should be designed correctly to perform a specific function. Analysis of electric circuits refers to computations required to determine the unknown quantities, such as, voltage, current and power associated with one or more elements in a circuit. To work in the area of electrical and electronics engineering, a person should have the basic knowledge of electrical electronic circuit analysis and laws. Systems, such as, mechanical, hydraulic, thermal, magnetic and power are easy to analyse and model by a circuit. To learn how to analyse the models of these systems, first, one needs to learn the techniques of circuit analysis. We shall briefly discuss some of the basic circuit elements and the laws that will help us to develop the background of this subject. In this chapter, students will understand the basic concepts of electricity and electric circuits. Students can apply their knowledge to design, build and demonstrate their own circuits.

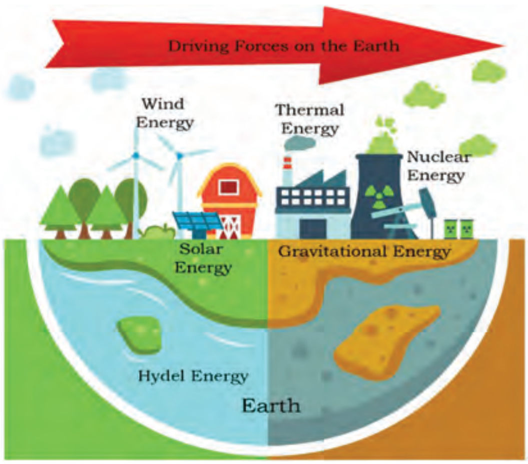


Fig. 1.1: Various driving forces on the earth

Electricity

Electricity is a set of physical phenomena associated with the presence and flow of electric charge. Electricity gives a wide variety of effects, such as, lightning, static electricity, electromagnetic induction and electric current. In addition, electricity permits the creation and reception of electromagnetic radiation, such as, radio waves. Electrical energy can be easily transferred from one location to another with minimum loss.

Fig. 1.2: Natural discharging of energy

Sources of electricity

Energy is the driving force for the universe, where energy is present in different forms as shown in Fig. 1.1. In our planet, energy is present in the form of hydel, wind, solar and thermal energy. These forms of energy can be used to generate electricity. Thunderstorm and lightning is an example of naturally generated electricity as shown in Fig. 1.2.

Energy transformation

According to the law of conservation of energy, "energy can neither be created nor destroyed. It can only change its form". One form of energy can be transformed to another form. Electrical energy can be generated by transforming several types of energy.

Nuclear Energy	→	Electrical Energy
Chemical Energy	→	Electrical Energy
Hydel Energy	→	Electrical Energy
Thermal Energy	→	Electrical Energy

Solar Energy → Electrical Energy
Wind Energy → Electrical Energy

For example, Fig.s 1.4(a) and 1.4(b) show how electrical energy can be generated from different sources. This generated electrical energy can be transferred from one place to another using a transmission tower. A typical transmission tower is shown in Fig. 1.3.

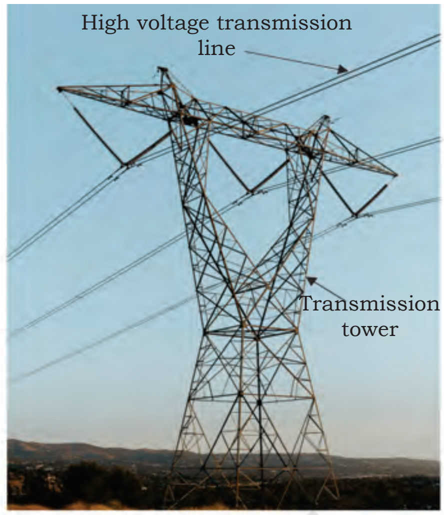


Fig.1.3: Transmission tower

Energy foundation

To understand electricity, we need to know about atoms. Everything in the universe— *solids, liquids* and *gases* are made up of atoms. Every star, tree, animal and even the human body are made up of atoms. Atoms are the building blocks of the universe. Atoms are so small that millions of them can fit on the head of a pin.

The centre of an atom is called the nucleus. Atoms consist of sub atomic particles— *protons, electrons and neutrons*. The protons and neutrons are very small, and electrons are much, much smaller. Protons carry positive (+) charge, electrons carry negative (-) charge and neutrons are neutral. The positive charge of protons is equal to the negative charge of electrons. Electrons move in their orbit around the nucleus. The positively charged protons attract negatively charged electrons and

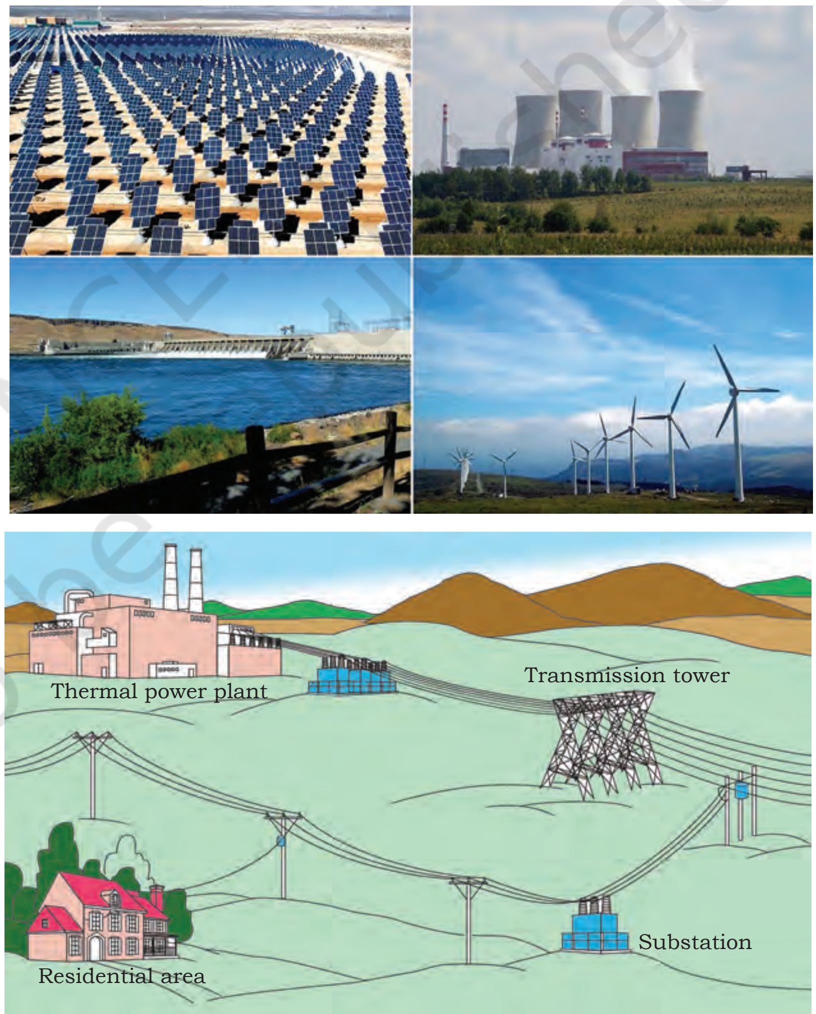


Fig.1.4 (a) and Fig.1.4 (b): Generation and transmission of electricity

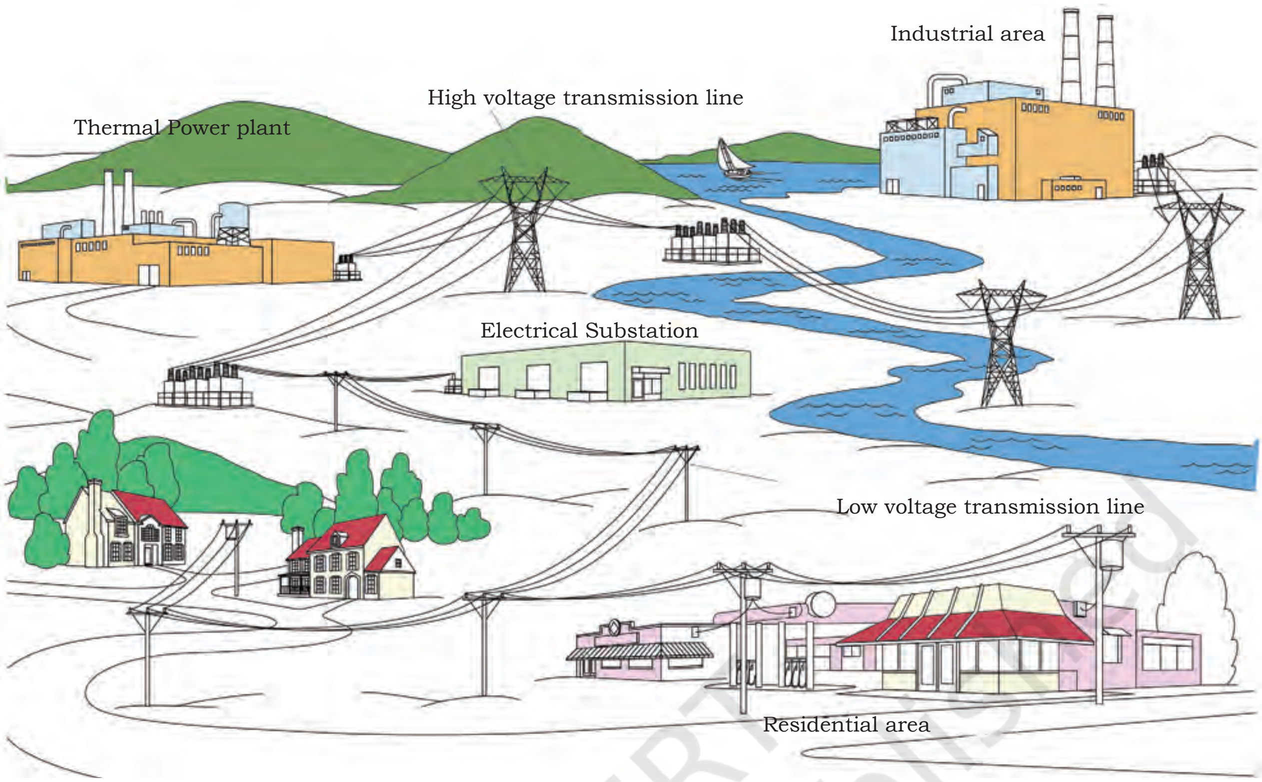


Fig. 1.5: Distribution of electricity

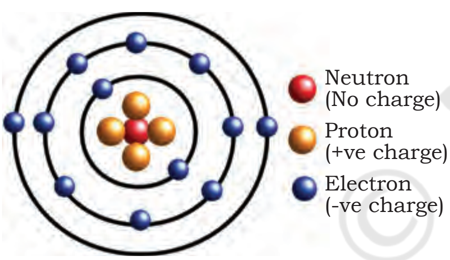


Fig.1.6: Atomic structure

hence hold the atomic structure as shown in Fig. 1.6.

Electric charge is a basic property of electrons, protons and other subatomic particles. Opposite charges attract each other and same charges repel each other. This makes electrons and protons stick together to form atoms. One foundational unit of electrical measurement is coulomb, which is a measure of electric charge proportional to the number of electrons in an imbalanced state. It was discovered by Charles Augustine de Coulomb.

One coulomb of charge is equal to the charge on 6.25×10^{18} (6,250,000,000,000,000,000) electrons. The symbol for electric charge quantity is the capital letter Q, while the symbol of coulomb is represented by the capital letter C.

Flow of charge inside a wire

Free electrons move randomly from one point to another inside a conductor. Due to this random flow, net electric charge of a conductor is zero. When an external power source is attached, net flow of electrons is in one direction. This movement of electrons generate a current. If there is a current of 1 ampere passing through a wire, it theoretically means that 6.25×10^{18} electrons are moving from one point to another in 1 second as shown in Fig. 1.7.

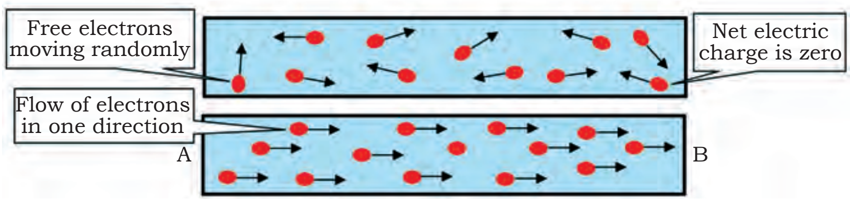


Fig.1.7: Flow of charge

Conductors and insulators

When electrons move among the atoms of matter, a current of electricity is created. As in the case of a piece of wire, the electrons are passed from atom to atom, creating an electrical current from one end to another.

Conductors

The material in which the electrons are loosely held and can move easily are called conductors. The metals like copper, aluminium or steel are good conductors of electricity.

Insulators

The materials which hold their electrons tightly, do not allow the electrons to move through them. These are called insulators. Rubber, plastic, cloth, glass and dry air are good insulators and have high resistance value.

Types of electricity

We have seen that electricity is a natural phenomenon as it is generated through lightning. This electricity is static in nature. Electricity that is generated in power plants is dynamic in nature. Thus electricity can be classified as:

- **Static electricity:** Materials are made up of atoms. Atoms are electrically neutral because they contain equal numbers of positive and negative charges. Static electricity requires a separation of positive and negative charges. When electrons do not move from one point to another, the electricity generated is called *static electricity*. Energy

NOTES

stored in electric cell or battery is an example of static electricity.

- **Dynamic or Current electricity:** Current electricity flows through wires or other conductors and transmits energy to devices. Flow of electricity is possible due to the flow of charged particles like electrons. When electrons are in motion, the generated electricity is called *dynamic or current electricity*. Dynamic electricity cannot be stored unless it is converted to static electricity. Current flowing through electric wire and electric appliances are examples of dynamic electricity.

Assignments

- Discuss the sources of electricity.
- Prepare a data sheet in which electric power generating capacity of the five hydel power generating stations are mentioned.
- List out the names of top five thermal power plants in India as per their electricity generating capacity.

ELECTRICAL QUANTITIES

Current, voltage and resistance are the three basic building blocks of electric and electronic circuit. These are called electrical quantities. The energy flowing through a wire or the voltage of a battery is not visible through the naked eye.

An electric circuit is formed when a conductive path is created to allow free electrons to move continuously. This continuous movement of free electrons through the conductors of a circuit is called **current**, and it is often referred to as 'flow', just like the flow of a liquid through a hollow pipe.

The force motivating electrons to flow in a circuit is called **voltage**. Voltage is a specific measure of potential energy that is relative between two points.

Free electrons tend to move through conductors with some degree of friction, or opposition to motion. This opposition to motion is called **resistance**. The amount of current in a circuit depends on the amount of voltage available to motivate the electrons, and also the amount of resistance in the circuit to oppose the flow of electons.

The standard units of measurement for electric current, voltage and resistance are given below.

Quantity	Symbol	Unit of Measurement
Current	I	Ampere (A)
Voltage	V	Volt (V)
Resistance	R	Ohm (Ω)

The symbol given for each quantity is the standard alphabetical letter used to represent that quantity in an algebraic equation. Each unit of measurement is named after a famous experimenter in electricity— the 'amp' after the Frenchman Andre M. Ampere, the 'volt' after the Italian Alessandro Volta, and the 'ohm' after the German Georg Simon Ohm.


Alessandro Volta (1745–1827)

Voltage

Voltage is the potential difference between two points. Voltage is also the amount of work required to move one coulomb charge from one point to another.
Mathematically, it can be written as:

$V=W/Q$

where,
'V' is the voltage,
'W' is the work in joule and
'Q' is the charge in coulomb.

In an electric circuit, the battery is used as an electric potential. Battery is one of the sources of voltage in an electric circuit. Inside a battery, chemical reactions provide the energy needed to flow electrons from the negative to positive terminal.

When voltage is applied in an electric circuit, negatively charged particles are pulled towards higher voltages, while positively charged particles are pulled towards lower voltages. Therefore, the current in a wire or resistor always flows from higher to lower voltage.

A voltmeter can be used to measure the voltage (or potential difference) between

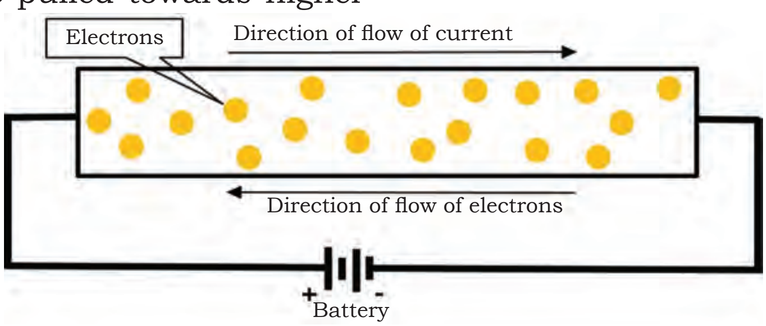


Fig.1.8: Flow of electrons on application of DC supply

two points in a system. Value of voltage is measured in volt or joules per coulomb. Symbolic representation of voltage is 'V' or 'v'.

When one joule of work is done to move one coulomb charge from one point to another, the potential difference between the two points is said to be 1 volt.

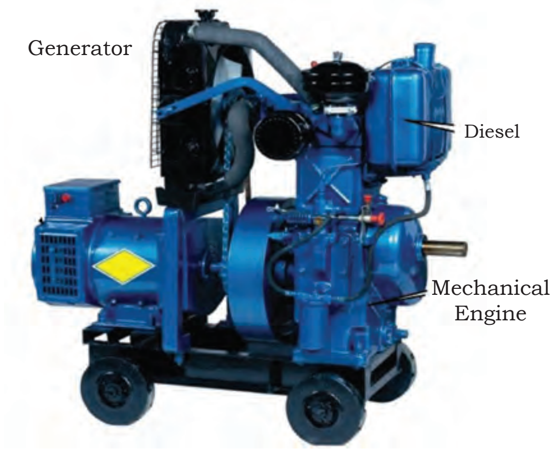


Fig. 1.9: Diesel AC voltage generator

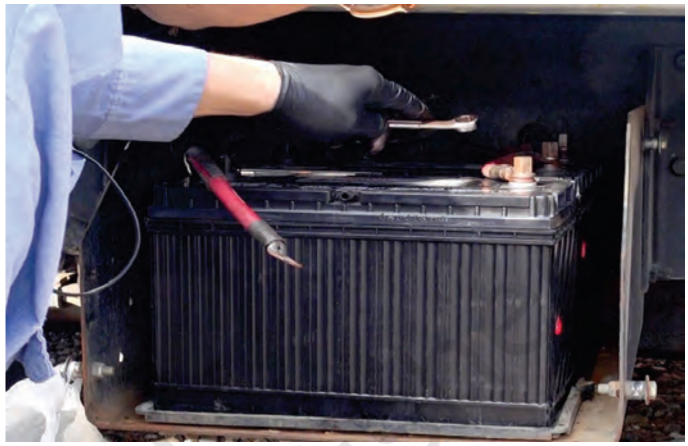


Fig. 1.10: DC voltage source in truck

Example: How much work is done in moving a charge of 2 C across two points having a potential difference of 12 V?

Solution: Given, amount of charge Q, that flows between two points at potential difference V (= 12 V) is 2 C. Thus, the amount of work done (W) in moving the charge is:

$$W = VQ$$
$$= 12\ V \times 2\ C$$
$$= 24\ J$$

More to Know

When electrons move, they create vacancy for other electrons. In this way, the movement is repeated resulting in electric current.

Assignments

- Calculate the amount of work required to move a 10C charge between the two points having a potential difference 24V.
- Calculate the amount of charge required when 12J of work is performed to move the charge in potential difference of 10V.

Current

The flow of electric charge is called *electric current.* The electrons carry charge and flow from one place to another. More moving electrons generate more charge.

The amount of current flowing from one place to another is determined by the amount of charge flowing through it per unit of time as shown in Fig. 1.11. The unit of current is ampere (A). Symbolic representation of current is 'I'. Mathematically, it can be written as;

I = Q/t

Where,

'I' is the current,

'Q' is the amount of charge in coulombs,

't' is the time in seconds.

Note: Coulomb is the unit of charge.

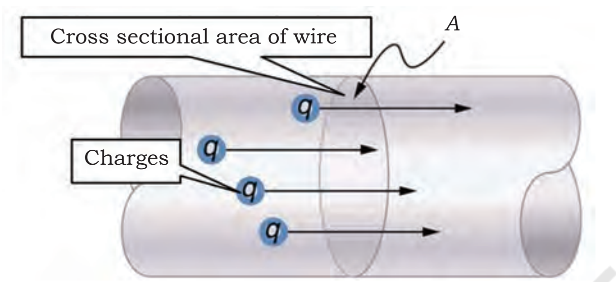


Fig. 1.11: Flow of charge through a cross section 'A'

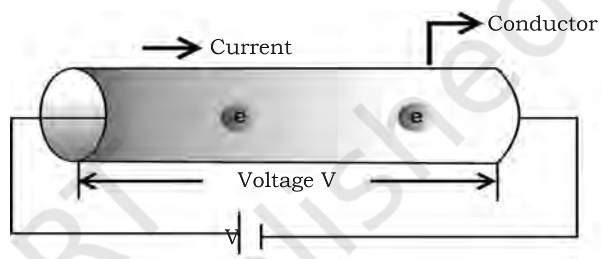


Fig.1.12 Flow of electrons in the conductor

If 1 coulomb charge passes through a point in 1 second, it will produce 1 ampere current. Conventionally, the direction of current flow is taken as opposite to the flow of electrons.

Example: Calculate the amount of current flowing through a wire when the amount of charge is 5 coulombs and the time is 10 seconds.

Solution: We will use the relation between the current, charge and time.

I= Q/t

5/10

0.5 Ampere

Assignments

- Calculate the amount of current consumed by radio when the amount of charge is 120 coulombs in 1 minute.
- Consider an electric circuit in which LED is used for indication. While observing, it was found that the rate of charge used by the LED is 180 coulombs in 2.5 minutes. Calculate the current drawn by the LED.

NOTES

- What does an electric circuit mean?
- Define the unit of current.
- Calculate the number of electrons constituting 1 coulomb of charge.

Classification of current

Depending upon the movement of electrons in an electric circuit, current can be classified as:

Direct Current (DC)

Direct current is unidirectional in nature, i.e., movement of electrons takes place only in one direction. This means that current flows only in one direction. DC voltage sources (like batteries and cells) produce direct current. Direct current is used in wall clock, remote control, vehicles, automobiles, cell phones, etc.

Alternating Current (AC)

Alternating current is bi-directional in nature, i.e., movement of electrons takes place in two directions. This means that current flows in two directions. AC voltage source (like AC generator) produces alternating current. Hydel power plants, thermal power plants, etc., are the examples of alternating voltage sources. Alternating current is used in ceiling fans, coolers, washing machines, etc. In India, standard AC generating frequency (f) of alternating current is 50 hertz.

Frequency can be defined as 'the number of cycles in one second'. Movement from point A to point B represents one cycle. Hertz (Hz) is the unit of frequency.
Example: 50 Hz represents 50 cycles in 1 second.

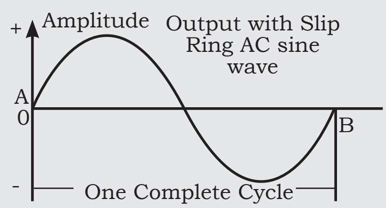


Fig. 1.13: Cycle of AC Signal

The main difference between AC and DC current is the direction of the flow of electrons. In alternating current, the movement of electric charge periodically reverses direction. In direct current, the flow of electric charge is only in one direction.

The usual waveform of an AC power circuit is a sine wave. In certain applications, different waveforms are used, such as, triangular or square waves. Audio and radio signals carried on electrical wires are examples of alternating current.

Assignment

Prepare a list of gadgets in tabular form, having two columns. In the first column, list out the gadgets, which work on the alternating current and in the second column, list out the gadgets which work on the direct current.

Resistance

We know that in conducting materials, electrons are loosely held and can move easily. In insulators, electrons are tightly bound to their atoms and they do not move easily. A high voltage is required to move the electrons in an insulating material. On the other hand, low voltage is required to move the electrons in any conductor. In conductors, the resistance is low, while in insulators the resistance is high.

Resistance resists the flow of electrons and hence the flow of electric current in the circuit. Conceptually resistance controls the flow of electric current. Resistance is represented by the symbol R. The SI unit of electrical resistance is ohm (Ω).

Georg Simon Ohm (1789–1854)

Example: We use various appliances for our daily use at home. To control the amount of current flowing into the appliance, resistors are used. If a resistor is not used in the circuit, then it will cause damage to the appliance.

Electric power

Electric power is the rate at which electric energy is transferred by an electric circuit. Electric power is the rate of doing work, which means amount of work done in one second. Power is represented by symbol P. The SI unit of power is watt (W) which is equal to one joule per second. It is named after Scottish inventor James Watt (1736–1819).

Electric horsepower (HP) is another unit of measurement of power. It is equal to 746 watts. It is slightly higher than mechanical horsepower, which is 745.7 joules per second.

James Watt
(1336–1819)

The electric power in watts produced by an electric current I consisting of a charge of Q coulombs every t seconds passing through an electric potential (voltage) difference of V is—

QV/t = V × I

where,

'Q' is electric charge in coulombs

't' is time in seconds

'I' is electric current in amperes

'V' is electric potential or voltage in volts

P = Work done per unit time

P = W/t or P=I2R

Where,

'W' is the work done in joules

t is the time in seconds

Power can also be defined in terms of current and voltage i.e., the product of voltage and current results in power. Watt is a measure of energy flow. Since, watt is a very small unit of power, in actual practice we need a much larger unit—the kilowatt, which is equal to 1000 watts. Since, the product of power and time gives electrical energy; therefore, unit of electrical energy is watt hour or kilowatt hour. One watt hour of energy is consumed when 1 watt of power is used for 1 hour. The commercial unit of electric energy is kilowatt hour (kWh).

1kWh = 1000 watt × 3600 seconds

= 3.6×10^6 watt second or $3.6 \times 10^6 \times 2$ joule

Example: Suppose, power of LED is 9 watts, which means that it will do 9 joules of work in 1 second.

Fig. 1.14: LED Bulb by Government of India

Assignments

1. Calculate the electric power, when the voltage across an electric motor is 440V and current drawn by the motor is 2A.
2. Calculate the amount of charge flowing through the machine in 10 seconds, when the applied voltage to the 1000 watt machine is 220V.
3. Calculate the applied voltage to the machine, when the current and power are 10A and 1500 watt respectively.
4. A 100 watt electric bulb glows for two hours daily, and four 40 watt bulbs glow for four hours daily. Calculate the energy consumed (in kWh) in 30 days.

More to know: Government of India has launched National Programme for LED-based Home and Street Lighting in New Delhi for energy conservation by reducing energy consumption. Government of India has also launched a scheme for Light Emitting Diode (LED) bulb distribution under the Domestic Efficient Lighting Programme (DELP).

Fig. 1.15: Domestic Efficiency Lighting Programme (DELP) 9 Watt LED

Power factor

In AC circuit, various components are connected such as, resistor, inductor and capacitor. These components consume power. When voltage is applied to an inductor, it opposes the change in current. The current is built up more slowly than the voltage, lagging in time and phase. In this way, it can be stated that current lags voltage. In case of capacitor, voltage depends on the charge. In this case, flow of current transfers the charged electron to the plates of the capacitor, after which, a voltage gets established across the plates. When inductor or capacitor is involved in an AC circuit, the current and voltage do not peak at the same time. The fraction-of-a-period difference between the peaks are expressed in degrees and is known as *phase difference*. The phase difference is < = 90 degrees. Because of this phase difference in voltage and current, power in capacitor and inductor will be minimum or, it can be said that the circuit will lose this power. This power is called as *reactive power*. In case of resistor, both current and voltage are in the same phase. Therefore, power applied to the resistor will get utilised. This power is called *real or true power*. Combination of true power and reactive power is called apparent power.

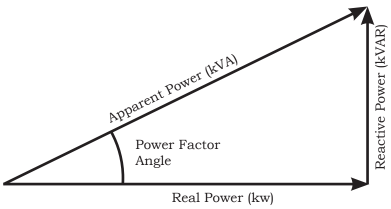


Fig. 1.16: Power factor triangle

Power factor is the ratio of real power to the apparent power. Value of power factor varies from 0 to 1. It is denoted by cos Ø.

Power factor = Real power / Apparent power

Referring to Fig. 1.16, it is observed that as the reactive power starts reducing, the real power and apparent power become equal. When real power and apparent power become equal it means that the AC circuit is resistive in nature i.e. it will only have a resistive component in the circuit. At this time, it can be summarised that the reactive power due to capacitor and inductor will not get utilised by the circuit.

Apparent power is the total power given to the circuit, reactive power is the unutilised power, and real power is power utilised by the circuit.

Assignment 1

Form an electric circuit as shown in Fig. 1.17 and find out the parameters showing voltage, current, resistance and power.

Material required: Battery of 9V, fixed resistor of 3 Ohm, bulb or LED of 5 watt.

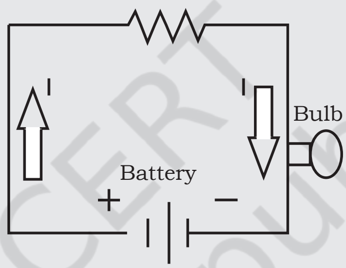


Fig.1.17: Electric circuit

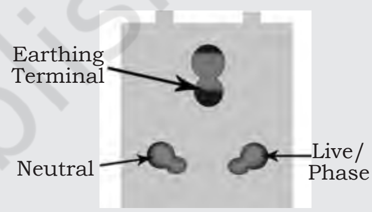


Fig.1.18: Power socket

Assignment 2

Analyse the live, neutral and earth ports of the power socket which is shown in Fig. 1.18.

Note: Perform the above assignments in the presence of an elder or teacher.

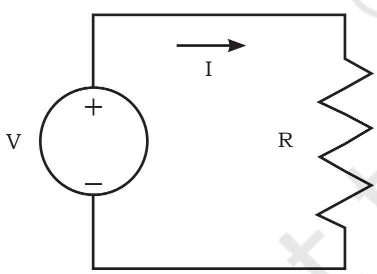
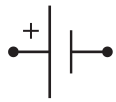
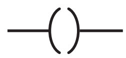
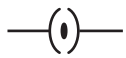
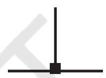
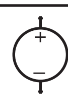


Fig.1.19: Basic electric circuit

Basic Electric Circuit

An electric circuit supplies electricity to the electric device. These devices are called loads. Before the load will operate, electricity must have a complete path from the source to the load and back to the source. This path for electricity is called a *circuit*. An electric circuit is an interconnection of electric components in such a way that electric charge is made to flow along a closed path (a circuit), usually to perform some useful task. In Fig. 1.19, the voltage source V on the left drives a current I around the circuit, delivering electrical energy into the resistor R. From the resistor, the current returns to the source, completing the circuit. The components in an electric circuit includes elements, such as, resistors, capacitors, switches, transformers and electronic. The components in the circuit can be active or passive.

Symbols of some commonly used components in circuit diagrams are—

S. No.	Components	Symbol
1.	An electric cell	
2.	A battery or a combination of cells	
3.	Plug key or switch (open)	
4.	Plug key or switch (closed)	
5.	A wire joint	
6.	Wires crossing without joining	
7.	A resistor of resistance R	
8.	Variable resistance or rheostat or	
9.	AC Voltage Source	
10.	DC Voltage source	

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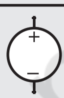
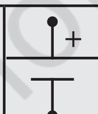
Assignment

Identify and name the following symbols.

						**Ω**	**V**	**I**

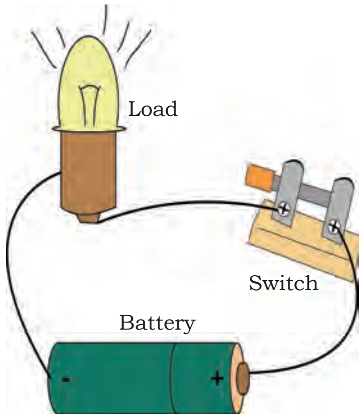


Fig. 1.20 (a): Closed circuit

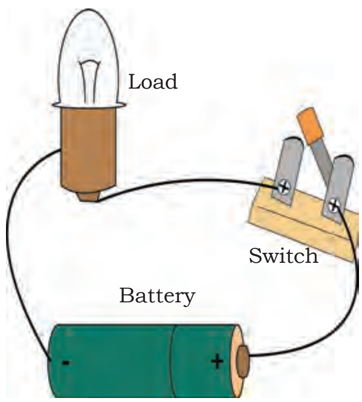


Fig. 1.20 (b): Open circuit

Active and passive components

There are two classes of electronic components—active and passive. Both these electronic components are different from each other.

Active components: Active components produce energy in the form of voltage or current. These components require external source for their operation. Some of the common examples of active components are diode, transistors, etc. If we connect a diode in a circuit and then connect this circuit to the supply voltage, then the diode will not conduct the current until the supply voltage reaches 0.3V (in case of germanium) or 0.7V (in case of silicon).

Passive components: Passive components do not produce energy in the form of voltage or current. These components do not require external source for their operation. Some of the common examples of passive components are resistor, capacitor, inductor, etc.

Like a diode, resistor does not require 0.3V or 0.7V. i.e., when we connect a resistor to the supply voltage, it starts working automatically without using a specific voltage. In simple words, active components are energy donors, and passive components are energy acceptors.

Open and closed circuit

A circuit is a closed path or loop around which an electric current flows. If the circuit is complete, it is called *closed* and the device will receive power and work properly. If this path is broken, the circuit is *open* and the device will not work as explained in Fig. 1.20 (a) and 1.20 (b).

Practical Exercises

Activity 1

Analysis of open and close circuit. Prepare the circuit to power the lamp as shown in Figs. 1.21 and 1.22.

Apparatus required

9 volts battery, connecting wire, resistor, lamp, wire stripper, wire cutter and switch.

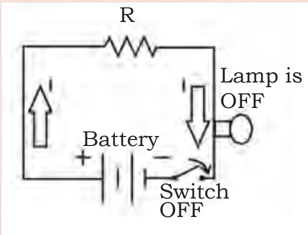


Fig. 1.21: Open circuit

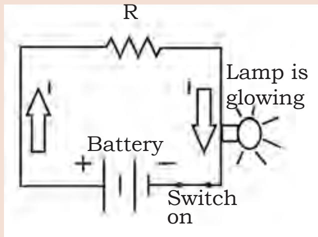


Fig. 1.22: Close circuit

Procedure

Following steps are used to form a circuit:

1. Take a battery; identify the positive and negative terminals of the battery.
2. Cut the wire using wire cutter and strip the insulation using a wire stripper.
3. Connect the wire to the positive and negative terminals of the battery.
4. Connect the resistor to the wire which is connected to the positive terminal of the battery.
5. Connect the other terminal of the resistor to one of the terminals of the lamp.
6. Connect the other terminal of the lamp to one of the terminals of switch.
7. Connect the other terminal of switch to the wire which is connected to the negative terminal of the battery.

Result

When the switch is turned 'ON', the lamp will start glowing.

Activity 2

Construct a test lamp and connect it to mains.

Apparatus required

1 bulb, 1 bulb holder, wire, wire cutter, wire stripper, plug

Circuit diagram

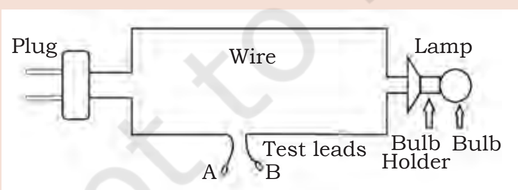


Fig.1.23: Circuit diagram for test lamp

Procedure

1. Using wire cutter, cut the wire into two pieces each of one metre length.
2. Now, you have two pieces of wire. Strip the insulation of the wire terminals.

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3. Fix the bulb holder using one end of the two pieces of wires and install a light bulb on to the holder.
4. You have other two ends of the wire free.
5. Fix a two-pin plug on those free pairs of wires. It means you can light up the bulb if you put a two-pin plug in a live two-pin socket.
6. Check the continuity of the test lamp to ensure that bulb turns on when the plug is inserted in a live two-pin socket.
7. Now, pull out the plug from the socket.
8. Finally, you need to slice one of the wires in the middle and remove insulation from each of the cut-ends for half an inch so that the bare copper is clearly visible.
9. Your test lamp is ready for experimental test. Always use a cap to cover the bare copper wire to avoid any accidental electrification.

Series and parallel circuits

The electrical and electronic circuits are arranged in many ways. The circuit can be named based on the way components are connected. There are two types of connection circuits known as Series and Parallel.

Series circuit

In a series circuit, electric load is connected along a single path in the circuit. So, the current flowing through each of them will remain the same. Since, there is only one path for the electric current to flow through, if a wire is cut or switch is opened, all electric loads in the circuit will stop working. If a battery has insufficient charge or energy, there is insufficient current through the circuit to make the lights glow. In this case, battery may be replaced or putting two batteries in a series may solve this problem. In the series circuit, as shown in Fig. 1.24, the arrows show the direction of the flow of current.

A series circuit or series-connected circuit is a circuit having just one current path. Thus, Fig. 1.24 is an example of a series circuit in which a battery of constant potential difference V, and three resistances, are all connected in series.

Since a series circuit has just one current path, it follows that all the components in a series circuit carry the same current I, a fact evident from Fig. 1.24.

In a series circuit, the total resistance, R_T is equal to the sum of the individual resistances. Thus, in case of Fig. 1.24, the total resistance, $R_T = R_1 + R_2 + R_3$, while in the general case of n resistances connected in series, the total resistance is as follows:

R_T = Total Resistance

R_1 = 1st Resistance connected in Series

R_2 = 2nd Resistance connected in Series

R_3 = 3rd Resistance connected in Series

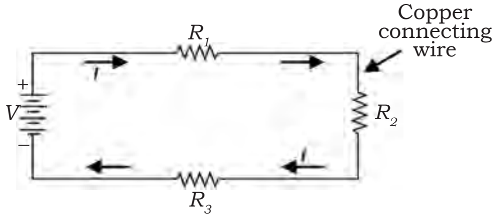


Fig. 1.24: Series circuit

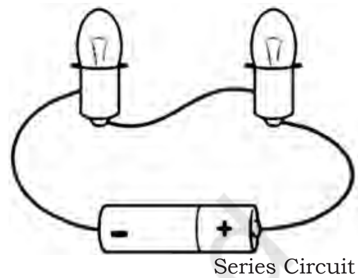


Fig.1.25: Bulbs connected in series

Parallel circuit

In a parallel circuit, electric load in the circuit forms multiple paths. Since, there are a number of paths, even if one electric load stops working, the other loads in the circuit will still work. The current from the source divides, so some of the current flows through one path and the rest through other paths. This means that the power source must supply more current to power a parallel circuit than a series circuit which may run down the battery faster. In a parallel circuit shown in Fig. 1.26, the arrows represent the direction of flow of current.

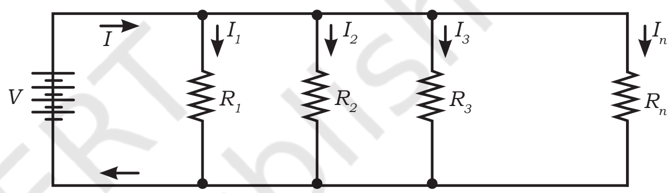


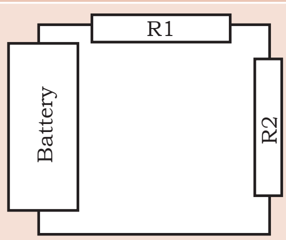
Fig.1.26: Parallel circuit

Parallel circuit is one in which the battery current is divided into a number of parallel paths.

Total resistance of the parallel circuit is as follows:

$R_T = (R_1 \times R_2 \times R_3 \times ... R_n)/(R_1 + R_2 + R_3 + ...+ R_n)$

R_T = Total Resistance of Circuit
R_1 = 1st Resistance in Parellel Circuit
R_2 = 2nd Resistance in Parellel Circuit
R_3 = 3rd Resistance in Parellel Circuit

Key Concept	Diagram
For a series circuit, R1 is said to be in series with R2. For these circuits, the current flowing through each device in series is the same. Adding the voltages across each element in series is equal to the total (battery) voltage.	 *Fig.1.28(a)*

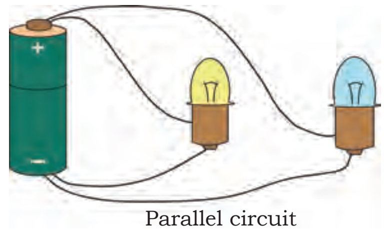


Fig.1.27: Bulbs connected in parallel

For a parallel circuit, R1 is said to be in parallel with R2. For these circuits, the voltage across each device in parallel is the same. Adding the current through each element in parallel is equal to the total (battery) current.

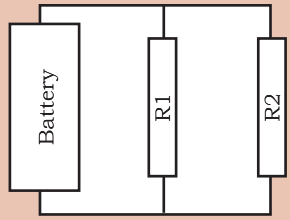


Fig. 1.28(b)

Example 1: Calculate the total resistance when three resistors of values R_1= 20 ohms, R_2 = 30 ohms, R_3 = 50 ohms are connected in series.

Solution: Given, R_1 = 20 ohms, R_2 = 30 ohms, R_3 = 50 ohms.

Using series resistors relation,

$R_T = R_1 + R_2 + R_3 = 20 + 30 + 50$

$= 100$ Ohms

Example 2: Calculate the total resistance when three resistors R_1 = 10 ohms, R_2 = 20 ohms, R_3 = 40 ohms are connected in parallel.

Using parallel resistors relation

$R_T = 1/R_1 + 1/R_2 + 1/(R_3)$

$= (10 \times 20 \times 40)/ (20 \times 40 + 40 \times 10 + 10 \times 20)$

$= 8000/1400$

$= 5.31$ ohms

Assignments

1. Build the series and parallel connections of resistors and calculate the resistance. Set up a circuit in which three resistors of different values are connected in series and in parallel. Then manually calculate the value of total resistance in both series and parallel connections. Verify the values using ohmmeter.
2. Calculate the total resistance of R_1 =15 ohm, R_2 =30 ohm, R_3 = 40 when connected serially.
3. Calculate the total resistance when, R_1=10 ohm, R_2=40 ohm, R_3=50 ohm are connected parallelly.

Practical Exercises

Activity 3

Build a simple electric bulb holder.

Material required

Thin cardboard (15 cm × 6 cm), aluminium foil (6 cm × 4 cm), scissors, glue stick, pushpin, pen, light bulb, electrical tape

Procedure

1. Cut out the shape as shown in Fig. 1.29.

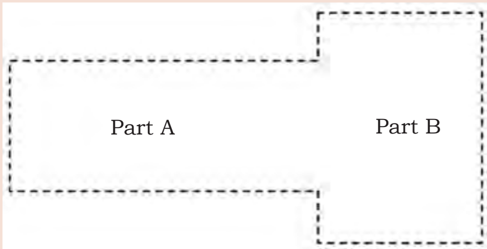


Fig. 1.29

2. Lay the shape on top of the cardboard, use a pen to trace around it, and then cut out the piece of cardboard as shown in Fig. 1.30.

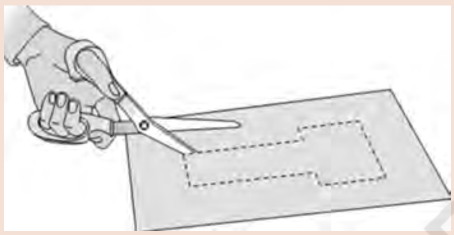


Fig. 1.30

3. Glue the piece of aluminium foil onto part B of the bulb holder as shown in Fig. 1.31.

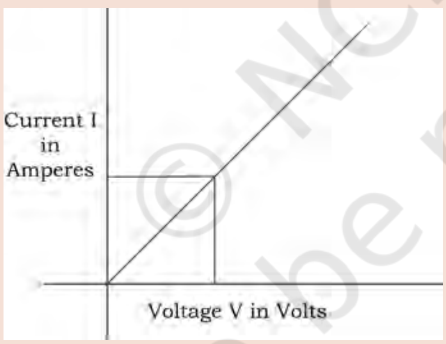


Fig. 1.31

4. Use a pushpin to poke a hole near the middle of part A as shown in Fig. 1.32. Use a pen to widen the hole.

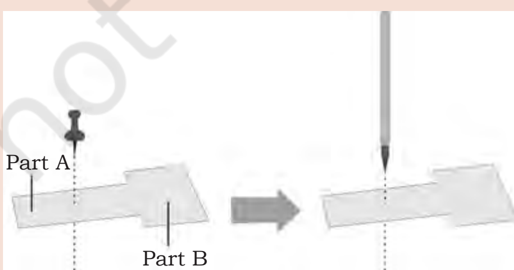


Fig. 1.32

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5. Make sure the hole is large enough for a bulb to fit into it. Then loop part A around the backside of part B. Tape it into place using electrical insulation tape as shown in Fig. 1.33.

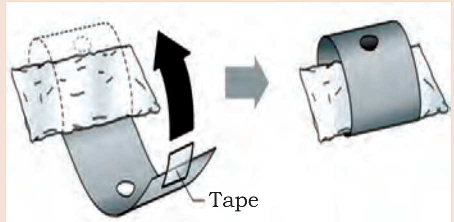


Fig. 1.33

Activity 4

Make a simple electric circuit using a bulb holder.

Material required

Bulb holder, light bulb, cardboard (20 cm × 15 cm), battery, C or D cell, 2 brads, push pin, pen, two connecting wires (stripped on each end), 15 cm long, electrical tape.

Procedure

1. Attach the battery to the cardboard circuit board by moving it down towards the narrow side of the cardboard.
2. Prepare to attach the bulbholder to the cardboard circuit board by using a pushpin to poke holes in the bulb holder and the cardboard circuit board.
3. Use the tip of a pen to widen the holes and then use brads to lock the bulb holder in place on the circuit board as shown in Fig. 1.34.

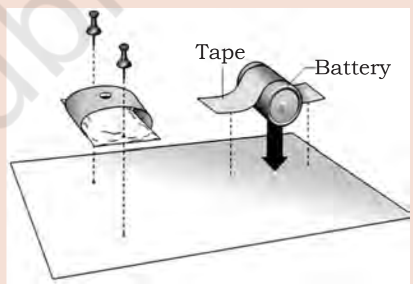


Fig. 1.34

4. Tape one end of a connecting wire to the terminal of the battery. Wrap the other end around a bulbholder brad.

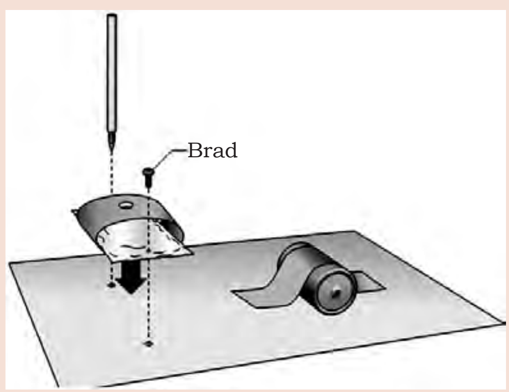


Fig. 1.35

5. Tape one end of the other connecting wire to the other terminal of the battery. Lay the other end into the bulb holder as shown in Fig. 1.35.
6. Place the bulb into the bulb holder. Make sure the bottom of the bulb is touching the aluminium foil as shown in Fig. 1.36.

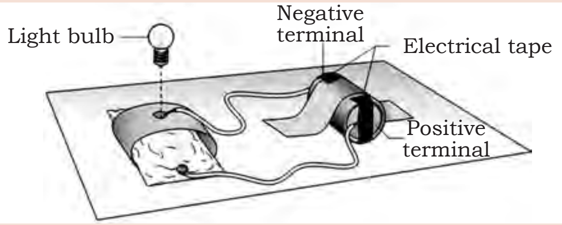


Fig. 1.36

Ohm's Law

Is there a relationship between the potential difference across a conductor and the current through it? Let us explore it with an activity.

Practical Exercises

Activity 5

To prove Ohm's law.

Material required

A resistor of about 5 Ω, an ammeter (0 – 3 A), a voltmeter (0 – 10 V), four dry cells of 1.5 V each with a cell holder (or a battery), a plug key, connecting wires and a piece of sandpaper.

Procedure

1. Draw the circuit diagram as shown in Fig. 1.37.
2. Arrange the apparatus as per the circuit diagram.
3. Clean the ends of the connecting wires with sand paper.
4. Make the connections as per the circuit diagram. All the connections must be neat and tight. Take care to connect the ammeter and voltmeter with their correct polarity (+ve to +ve and -ve to -ve).

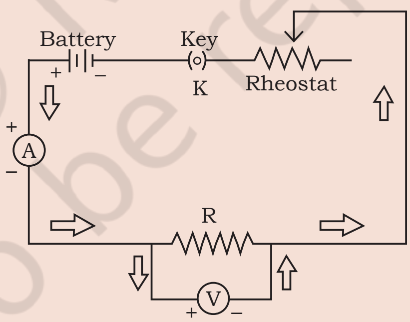


Fig. 1.37

Circuit set up to verify Ohm's Law

Notes

Notes

5. Determine the zero error and least count of the ammeter and voltmeter and record them.
6. Adjust the rheostat to pass a low current.
7. Insert the key K and slide the rheostat contact to see whether the ammeter and voltmeter are showing deflections properly.
8. Adjust the rheostat to get a small deflection in ammeter and voltmeter.
9. Record the readings of the ammeter and voltmeter.
10. Take atleast six sets of readings by adjusting the rheostat gradually.
11. Plot a graph with V along x-axis and I along y-axis.
12. The graph will be a straight line which verifies Ohm's law.
13. Determine the slope of the V-I graph. The reciprocal of the slope gives resistance of the wire.

Observations

- Range of the given ammeter = ... A
- Least count of the given ammeter = ... A
- Range of the given voltmeter = ...V
- Least count of the given voltmeter = ...V
- Mean value of V/I from observations, R = ... Ω

Observations from the graph

- Slope of I vs V graph = ...
- R from graph = 1/ slope = ... Ω

Observation table

Voltage across (V)	Current through (A)
0	0
2	.5
4	1
6	1.5
8	2
10	2.5
12	3

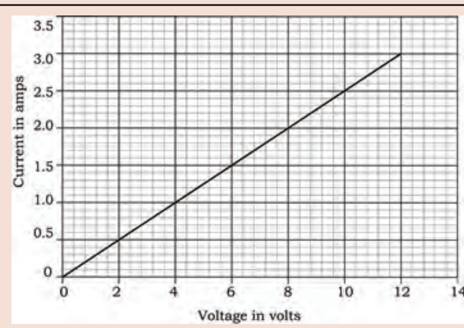


Fig.1.38

Graph between voltage and current

Precautions

- All the circuit connections must be neat and tight.
- Voltmeter and ammeter must be of proper range.
- The key should be inserted only while taking readings.

Georg Simon Ohm (16 March 1389–6 July 1854) was a German physicist and mathematician. As a school teacher, Ohm began his research with the new electrochemical cell. He investigated the relation between current and voltage in a resistor and published his experimental results in 1823. Ohm's Law can be used to understand the behaviour of electricity in individual components as well as in the entire circuit.

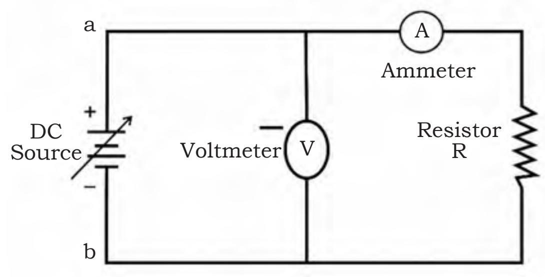


Fig.1.39: Circuit setup for Ohm's law

Ohm's experiment

A DC variable supply voltage is connected with positive terminal at point 'a' and negative terminal at 'b' as shown in Fig. 1.39. As voltage is increased, the current recorded by the ammeter increases. For every voltage value, the current is recorded and the corresponding point is plotted on the graph. With this, a straight line graph passing through origin is obtained in the first quadrant.

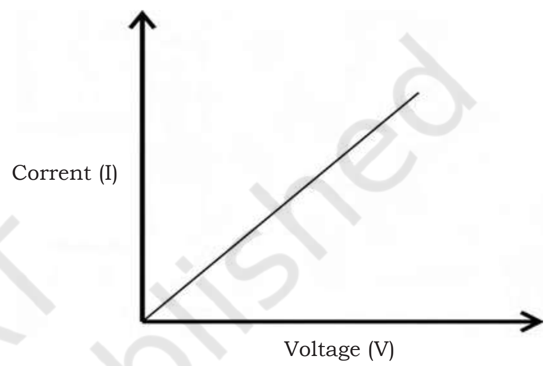


Fig.1.40: Ohm's Law Graphical Analysis

Combining the two proportionalities, we have,

$V \alpha IR$

Or, $V = k (I \times R)$

where, k is a constant of proportionality. However, the units of voltage, current and resistance are defined, so that k = 1. When the current is 1 ampere, voltage is 1 volt, the resistance is 1Ω.

$1 = k.\ 1.\ 1$

Thus, the equation becomes

$V = IR$

Thus, Ohm's law states, "Current in a conductor is directly proportional to the potential difference between the terminals of the conductor and inversely proportional to the resistance of the conductor."

It means that, if the resistance is kept constant, as the voltage increases, the current increases and if the voltage decreases, then the current decreases. Also, if the voltage remains constant as the resistance increases, the current decreases and vice versa.

NOTES

It means, keeping the voltage constant, the resistance is inversely proportional to the current.

Thus, from Ohm's law, we have;

$V = I R$

where,

'V' = voltage applied to the conductor

'I' = current flowing through the conductor

'R' = resistance of the conductor

Problems on Ohm's Law

Below are some solved examples to better understand Ohm's law.

Example 1: A 10 V battery is connected to the electric bulb of resistance of 20 Ω. Find the current flowing through the electric bulb.

Solution: Given,

V= 10 V

R = 20 Ω

The current flowing through the electric bulb is given as:

$V = I R$

$I = V/R$

$I = 10/20$

$I = 0.5$ A

So, the current flowing through the bulb is 0.5 A.

Example 2: An electric iron of resistance 40 Ω is connected to a supply voltage. The current flowing through the electric iron is 6 A. Find the voltage applied to the electric iron.

Solution: Here, I = 6 A, R = 40 Ω

$V = I R$

So, voltage is expressed as $V = 6 \times 40$,

$V = 240$

Example 3: A 110 V source supplies power to a halogen light. The current flowing through the halogen light is 5 A. Find the resistance of the halogen light.

Solution: Here, V=110, I=5A

$R = V / I$

$= 110/5$

$= 22$ Ω

So, the resistance of halogen light is 22 Ω.

Assignments

A. Solve the problems based on Ohm's law

1. 9 V is applied across a 3 Ω resistor. What is the current flowing?
2. A 6 Ω resistor passes a current of 2 A. What is the voltage?
3. What is the voltage of a circuit with a resistance of 255 Ω and a current of 3 A?
4. A small electrical pump is labeled with a rating of 5 A and a resistance of 30 Ω. At what voltage is it designed to operate?
5. A 9 V battery is hooked up to a light bulb with a rating of 2 Ω. How much current passes through the light?
6. A lamp is plugged into the wall outlet, which is providing 110 V. An ammeter attached to the lamp shows 2 A flowing through the circuit. How many ohms of resistance is the lamp providing?
7. If your skin has a resistance of 9000 Ω and you touch a 9 V battery, how much current will flow through you?
8. What is the amount of current flowing through your body with a skin resistance of 12,000 Ω is given, if you touch a 120 V house potential?
9. When you are soaked in sea water, your resistance is lowered to 1000 Ω. Now how much current will flow through you if you touch a 9 V battery?
10. When you are soaked in sea water, what current will flow through you if you touch a 120 V house potential?

B. Write the electrical symbols and units. Complete the following table of electrical symbols and units.

	Current	Voltage	Resistance
Symbol			
Unit			

C. In the following table, from the given values, calculate the unknown quantities. The unit 'k' stands for kilowatt (kW), which means 1000 W.

Voltage	Current	Resistance	Power
100 V	5A		
12 V		1 Ω	
	5A	8 Ω	

Notes

NOTES

230 V	13A		
	3A	150 Ω	
50 V		20 Ω	
		40 Ω	1 kW
	0.5 A		2.5 W
250 V			62.5 W

D. Find the electrical quantities in the circuit shown in Fig. 1.41.

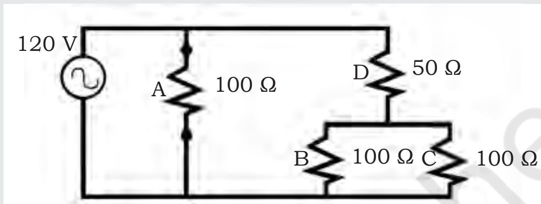


Fig. 1.41

1. Calculate the equivalent resistance of this circuit.
2. Calculate the total current drawn.
3. Calculate the voltage across the following:
   Resistor A ____________________
   Resistor B ____________________
   Resistor C ____________________
   Resistor D ____________________
4. Calculate the amount of power consumed by the circuit.

E. Find the following quantities for the circuit shown in Fig. 1.42.

1. Calculate the voltage across each load when the switch is open.
2. Calculate the current drawn from the battery.
3. Calculate the voltage drop across each resistor.
4. Calculate the equivalent resistance in the circuit.

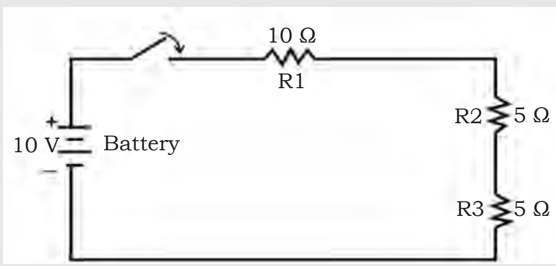


Fig. 1.42

Kirchhoff's Law

Kirchhoff's law is named after Gustav Kirchhoff, a German physicist. Kirchhoff defined the basic relationship between voltage (V) and current (I). These laws are used for circuit analysis. Kirchhoff's laws relate to the conservation of energy, which states that energy cannot be created or destroyed, only changed into different forms. This can be expanded to the laws of conservation of voltage and current. In any circuit, the voltage across each series component (carrying the same current) can be added to find the total voltage. Similarly, the total current entering a junction in a circuit must equal the sum of current leaving the junction. Kirchhoff's laws are classified as:

1. Kirchhoff's Current Law
2. Kirchhoff's Voltage Law

Kirchhoff's Current Law (KCL)

Kirchhoff's current law states that, "Total incoming currents at a point are equal to the total outgoing currents". It can be understood by an example. Consider that I_1 and I_2 are coming towards a point. Current I_1 and I_2 are incoming as they are coming towards a point P as shown in Fig. 1.43. Current I_3 is outgoing from the point. The sum of incoming currents I_1 and I_2 are equal to the sum of outgoing current I_3.

Mathematically, at P, $I_1 + I_2 = I_3$

Fig. 1.43: Kirchhoff's Current Law

In a series circuit, total current flowing in the circuit remains same at any point in the circuit.

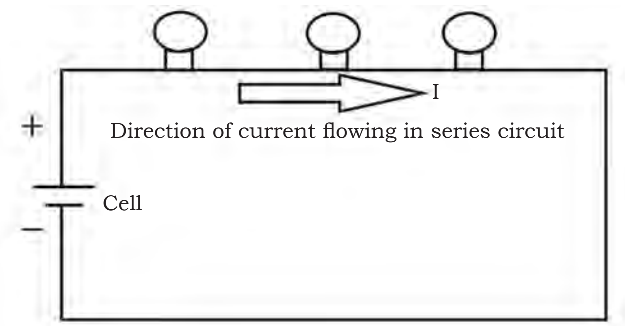


Fig. 1.44: Loads connected in series circuit

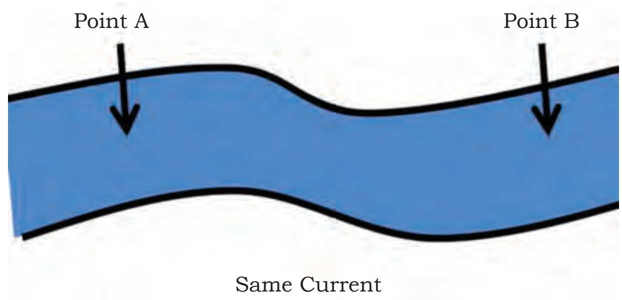


Fig.1.45: Analogy of current in series circuit

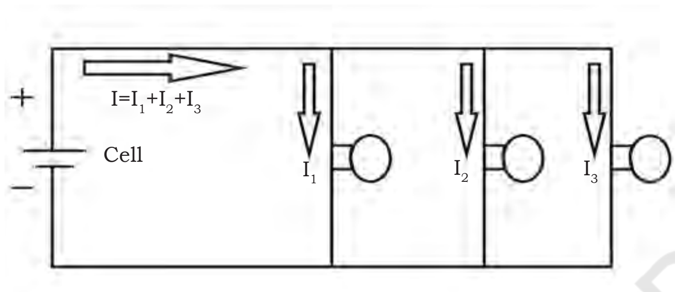


Fig.1.46: Loads connected in a parallel circuit

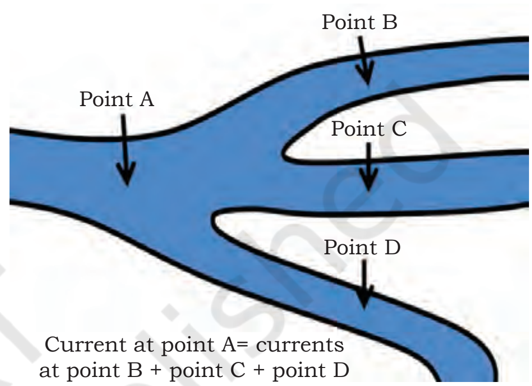


Fig.1.47: Analogy of current in parallel circuit

In a parallel circuit, total current flowing in the circuit is divided in parallel branches.

Kirchhoff's Voltage Law (KVL)

Kirchhoff's voltage law states, "Total voltage drop across the loads in the circuit is equal to the total voltage applied to the circuit" or "the algebraic sum of the products of currents and resistance in each of the conductors in any closed path (or mesh) in a network plus the algebraic sum of the E.M.F. (electromotive force) in that path is zero".

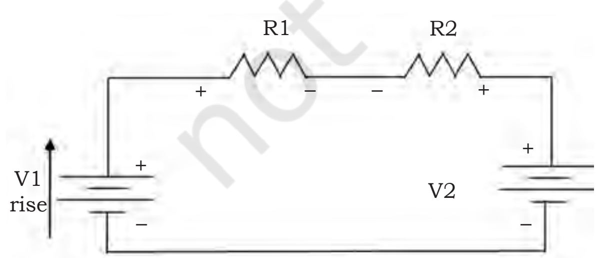


Fig.1.48: Circuit diagram for Kirchhoff's voltage law analysis

In other words, $\sum IR + \sum E.M.F. = 0$

EMF is the force exerted on the electrons to enable them to move from one place to another.

Let us now write the equation for Fig. 1.48 in accordance with Kirchhoff's voltage law. To do this, we start at any point and move around the circuit, listing the voltage drops and the voltage rises as we go. (In doing this, remember that we have defined that going from minus to plus constitutes a rise in voltage and going from plus to minus constitutes a drop in voltage.) Thus, if we agree to list all voltage drops on the left-hand sides of our equations and all the voltage rises on the right-hand sides, the Kirchhoff voltage equation for Fig. 1.48:

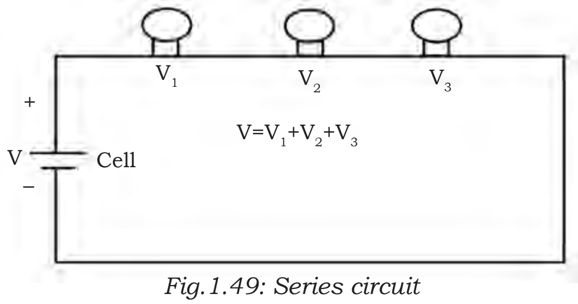


Fig.1.49: Series circuit

R1I + V2 + R2I = V1

Note that V2 appears as a voltage drop, because we go through that battery from plus to minus (+ to -). Alternatively, putting all the battery voltages on the right hand side, the above equation becomes

Fig.1.50: Representation of series circuit

R1I + R2I = V1 – V2

Hence, I = (V1 – V2) / (R1+R2)

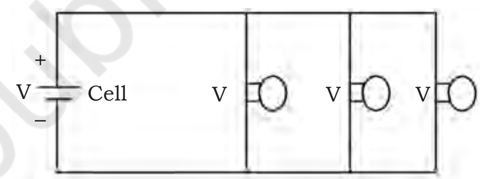


Fig.1.51 Parallel circuit

It can be understood by an example. Consider a circuit in which three loads are used, i.e., R_1, R_2 and R_3. Total applied voltage to the circuit is V. Voltage drop across the loads are V_1, V_2 and V_3. Therefore, according to Kirchhoff's voltage law, total applied voltage (V) is equal to the sum of individual voltage drop (V_1, V_2, V_3) across the loads.

V_1 = 1st Voltage drop across the parallel circuit
V_2 = 2nd Voltage drop across the parallel circuit
V_3 = 3rd Voltage drop across the parallel circuit

Mathematically,

$V = V_1 + V_2 + V_3$

As shown in Fig. 1.49, voltage drop across the loads are 5V, 2V and 3V. Total applied voltage is 10V.

10V = 5V + 2V + 3V

In a parallel circuit, the total voltage provided by the source is equal to the voltage across each parallel branch.

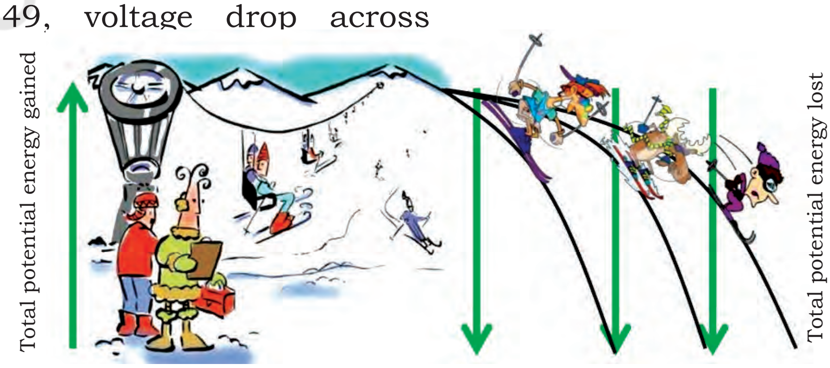


Fig.1.52: Representation of parallel circuit

NOTES

Assignment A

Analysis of Kirchhoff's Law

The circuit in Fig. 1.53, with 3 A of current running through the 4 Ω resistor indicated in Fig. 1.53.

1. Determine the current through each of the other resistors.
2. Determine the voltage of the battery on the left.
3. Determine the power delivered to the circuit by the battery on the right.
4. Identify the currents through the resistors by the value of the resistor (I_1, I_2, I_3, I_4) and the currents flowing through the batteries are I_{Left} (current flowing from battery at the left side) and I_{Right} (current flowing from battery at the right side).

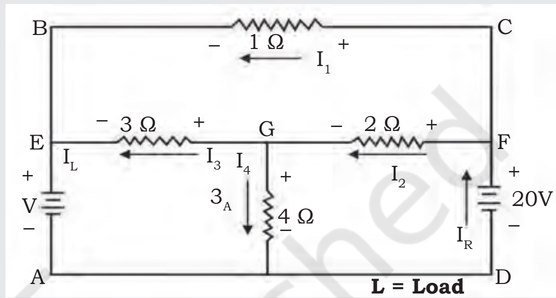


Fig. 1.53

5. Start with the 2 Ω resistors, apply the loop rule to the circuit on the lower right.
   $20\text{ V} = I_2(2\Omega) + (3A)(4\Omega)$
   $I_2 = 4A$
6. Start the circuit analysis from 3 Ω resistors. Apply the junction rule at point A in the center of the circuit.
   $I_2 = I_3 + I_4$
   $4A = I_3 + 3\text{ A}$
   $I_3 = 1\text{ A}$
7. The current through the 1 Ω resistor certainly runs from right to left. If we apply the loop rule to the top circuit, we will have to run against that current. This changes what is normally considered a potential drop into a potential increase.
   $I_1(1\Omega) = (4A)(2\Omega) + (1A)(3\Omega)$
   $I_1 = 5A$
8. Apply the loop rule to the outer circuit i.e. ABCD to get the voltage of the battery on the left (continuing with the assumption that the current is running anti-clockwise). We find the current running through the left battery backwards.
   $20V = (5A)(1\Omega) + V_L$
   $V_L = 9V$

Notes

9. Let us verify this result by repeating the procedure for the bottom circuit, i.e., AEFD

   $20\ V = (4A)(2\Omega) + (1A)(3\Omega) + V_L$

   $V_L = 9\ V$

10. The power delivered to the circuit by the battery can be calculated by multiplying voltage and current in the circuit. We already have the voltage (it's given in the problem) and we have to determine the current. Apply the junction rule to the junction on the left.

    $I_L = I_1 + I_3$

    $I_L = 5A + 1_A$

    $I_L = 12A$

    and again to the junction at the bottom

    $I_R = I_L + I_4$

    $I_R = 12A + 3A$

    $I_R = 15A$

11. To find the power of the battery on the right

    $P = VI$

    $P = (20V)(15A)$

    $P = 300W$

Assignment B

Determine the current through each resistor in the circuit shown below.

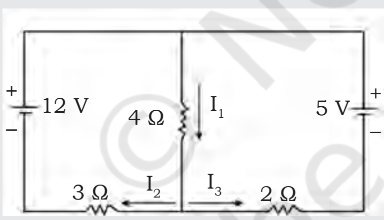


Fig. 1.54

Practical Exercises

Activity 6

Verify Kirchhoff's law by observing the reading in ammeter and voltmeter as shown in Fig. 1.55.

Material required

Resistances of 30Ω, 50Ω, 82Ω and 100Ω, connecting cords, power supply.

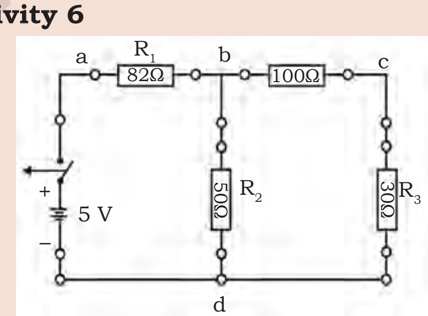


Fig. 1.55

NOTES

Procedure

1. Using the DC circuit trainer, connect the circuit shown in Fig. 1.55.
2. Measure the values of voltage and current of each resistor in the circuit and record it in the table below.

	R_1(Ohm)	R_2(Ohm)	R_3(Ohm)	R_4(Ohm)
I (mA)				
V (Volt)				

3. Measure the voltage and current values across the resistors.
4. Measure the voltage and current values across the resistors R_1, R_2, R_3, and R_4 and note the reading in the table. Observe the total voltage applied in the circuit and the voltage drop across the individual resistor.
5. If total applied voltage in the circuit and the voltage drop across the individual resistor are equal, then we can say that Kirchhoff's voltage law is verified.

Activity 7

Calculate the amount of energy consumption in home appliances.

Material required

Household appliances such as refrigerator, fan, television, tubelight.

Procedure

Follow the given steps to calculate the energy consumption in home appliances.

Calculation of energy

To calculate the energy consumption in home appliances, the following technique is used. We know that:
Power = Energy/Time
or
Energy = Power × Duration of Usage (Time)
By modifying this formula slightly, we can determine the energy consumption per day:
Energy consumption/day = Power Consumption × Hours Used/Day
where,

1. Energy consumption will be measured in kilowatt hour (kWh), like on your electricity bills.
2. Power consumption will be measured in Watt.
3. Hours used per day will be the actual time you use the appliance.

Since we want to measure energy consumption in Kilowatt hour, we must change the way power consumption is measured from Watt to Kilowatt (kWh). We know that 1 kilowatt hour (kWh) = 1,000 Watts hour, so we can adjust the formula above to:

Energy consumption/Day (kWh) = Power consumption (Watt/1000) × hours used/day

Example: Calculate the amount of energy consumed by a ceiling fan. If you use a ceiling fan (200 watt) for four hours per day, and for 120 days per year, what would be the annual energy consumption?

Solution: Given, ceiling fan = 200 watt and the fan works for 4 hours per day; 120 days per year.

Formula used: Energy consumption/day (kWh) = Power consumption (Watt/1000) × hours used/Day

Energy consumption per day (kWh) = (200/1000) × 4 (hours used/day).

Energy consumption per day (kWh) = (1/5) × 4 energy consumption per day (kWh) =4/5 or 0.8. So the energy consumption per day is 0.8 kWh.

To find out the energy for 120 days, do simple multiplication— 0.8 × 120 = 96 kWh

Assignment

1. Calculate the amount of energy consumed by a tubelight. If you use a tubelight of 40 watts for eight hours per day and for 365 days, what would be the annual energy consumption?
2. Calculate the amount of energy consumed by a television. If you use a television consuming 100 watt for six hours per day, and for 200 days per year, what would be the annual energy consumption?

Check Your Progress

A. Multiple Choice Questions

1. Which of the following components is used to close or break the circuit?
   (a) Bulb (b) Switch
   (c) Wire (d) Electric cell
2. Which of the following components is used to provide resistance?
   (a) Heat (b) Energy
   (c) Product (d) Resistor

Notes

NOTES

3. Frequency (f) of alternating current is____________ hertz in India.
(a) 45 (b) 60
(c) 50 (d) 55

4. In a series circuit, current remains ____________and voltage is ____________.
(a) divided, same (b) same, same
(c) divided, divided (d) same, divided

5. In a parallel circuit, current remains____________ and voltage is ____________.
(a) divided, same (b) same, same
(c) divided, divided (d) same, divided

6. Amount of work in one second is known as ____________.
(a) power (b) current
(c) voltage (d) charge

7. Ohm's law states that ____________.
(a) voltage is directly proportional to the applied voltage
(b) voltage is directly proportional to the applied current
(c) current is directly proportional to the applied voltage
(d) current is directly proportional to the applied current

8. The amount of charge flowing through a point in one second is called ____________.
(a) voltage (b) current
(c) power (d) charge

9. The amount of work required to move a unit coulomb charge from point A to point B is called ____________.
(a) current (b) charge
(c) voltage (d) power

10. What are the basic components of all matter?
(a) Electrons, neutrons, and protons
(b) Electrons, proton and ions
(c) Neutrons, protons and ions
(d) Electrons, neutrons and charged ions

11. Electric charge can be produced by ____________.
(a) sticking (b) rubbing
(c) oiling (d) passing AC current

12. An electron has ____________ charge.
(a) positive (b) negative
(c) zero (d) both (a) and (b)

13. A proton has ____________ charge.
(a) positive (b) negative
(c) zero (d) both (a) and (b)

14. A neutron has ____________ charge.
(a) positive (b) negative
(c) zero (d) both (a) and (b)

15. Unit of electric current is ____________.
(a) Ampere (b) Volt
(c) Watt (d) Joule

16. The unit of electrical power is ____________.

(a) Volt (b) Watt
(c) Joule (d) Ampere

17. The term used to designate electrical pressure is ____________.

(a) Voltage (b) Watt
(c) Joule (d) Ampere

18. The statement which correctly represents Ohm's law is ____________.

(a) V = IR (b) V = R/I
(c) R = VI (d) I = R/V

19 If V = 50 V and I = 5 A, then R = ____________.

(a) 50 Ω (b) 5 Ω
(c) 10 Ω (d) 2 Ω

20. If P = 50 watt and R = 2 Ω, then I = ____________.

(a) 50 A (b) 5 A
(c) 10 A (d) 2 A

21. A current of 3A flows through a conductor whose ends are at a potential difference of 6V. Calculate the resistance of the conductor.

(a) 4 Ω (b) 5 Ω
(c) 1 Ω (d) 2 Ω

22. Combination of three resistances in a series is given as ____________.

(a) $R_1 + R_2 + R_3$ (b) $1/R_1 + 1/R_2 + 1/R_3$
(c) $R_1 \times R_2 \times R_3$ (d) $R_1 + R_2 \times R_3$

23. A current of 2A flows through a 12V bulb. Calculate the resistance.

(a) 6 Ω (b) 16 Ω
(c) 24 Ω (d) 20 Ω

24. Conductors which do not obey the Ohm's law are called ____________.

(a) un-ohmic conductor (b) non-ohmic conductor
(c) low-ohmic conductor (d) less-ohmic conductor

25. A complete electric circuit is called ____________ circuit.

(a) open (b) close
(c) incomplete (d) complete

26. Copper wires are used as connecting wires because of ____________.

(a) low resistivity (b) low conductivity
(c) high resistivity (d) none of the above

27. Electrical conductors are materials which contain ____________.

(a) only positive charge (b) movable electric charge
(c) only negative charge (d) None of the above

28. How many terminals do an electric cell consist of?

(a) One (b) Three
(c) Two (d) Four

NOTES

Notes

29. Electric cell converts ____________________ energy into ____________________ energy.
    (a) electrical, mechanical (b) Mechanical, electrical
    (c) chemical, electrical (d) electrical, chemical

30. Battery is used in the circuit to ____________________.
    (a) measure current
    (b) maintain potential difference
    (c) oppose the current
    (d) measure potential

B. Fill in the Blanks

1. In _____________ circuit, current remains same and voltage divides.
2. In _____________ circuit, current divides and voltage remains same.
3. Amount of _____________ in one second is known as power.
4. A component which is used to close or break a circuit is _____________.
5. Proton has _____________ charge.
6. Unit of electrical _____________ is watt.
7. Current is directly proportional to the applied voltage is a law given by _____________.
8. 1kWh = _____________ watt × _____________ second
9. Switch is used for _____________ and _____________ of circuit.
10. Electrons have _____________ charge.

C. State whether True or False

1. Frequency (f) of alternating current is 60 hertz in India.
2. Electrons are electrically neutral.
3. Due to rubbing of two bodies, electric charge is produced.
4. Kirchhoff's law states the relation between voltage, current and resistances.
5. Unit of current is ampere.
6. A resistor easily passes current.
7. Unit of voltage is watt.
8. Unit of power is joule/second.
9. Current in a circuit is instantly established.
10. 1kWh = 1000 watt × 3600 seconds.

D. Short Answer Questions

1. What is the supply of voltage at residential homes?
2. What is one volt?
3. What is the supply frequency of supply voltage?

4. What is electric current?
5. What does 10 A mean?
6. Explain diagrammatically, how the components are connected in series circuits?
7. Explain diagrammatically, how the components are connected in parallel circuits?
8. Explain diagrammatically, how the components are connected in complex circuits?
9. What will happen to the series circuit if a bulb is fused? Will the circuit be closed in this case?
10. List the appliances where resistors are used.
11. What are the different variable resistors?
12. How AC and DC currents are different from each other?
13. List the appliances which use DC power.
14. Calculate the current 'I' flowing through the circuit in Fig. 1.56.

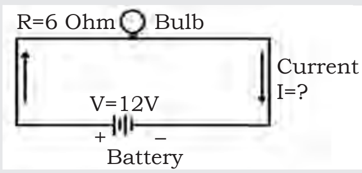


Fig.1.56

15. Calculate the Resistance 'R' in the circuit in Fig. 1.57.

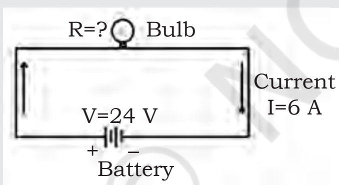


Fig. 1.57

16. Calculate the voltage 'V' in the circuit in Fig. 1.58.

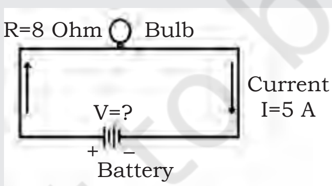


Fig. 1.58

17. Verify the KCL and KVL and find I1, I2, I3 for Fig.1.59.

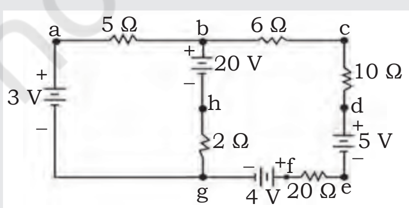


Fig. 1.59

Chapter 2

Electrical and Electronic Components

17976CH02

There are several basic electrical components that are commonly found in the circuits. These components are the fundamental building blocks of electrical and electronic circuits, and can be found in great numbers on control panels, printed circuit boards, etc. They can be used and combined with each other in many different ways to form a new circuit. It is useful to know a bit about how they work, and this chapter will help you in recognising some of what you see on those boards, and understanding the fundamentals of circuit schematics.

Electrical control system includes the components that are assembled to form a circuit as shown in Fig. 2.1. Components which are assembled in the control panel must have a specific rating. Each component has its data sheet on which details of a component are mentioned.

Fig. 2.1 Basic circuit components

Before assembling the electrical circuit, the technician should have detailed knowledge of each component and its identification. Technicians should be able to distinguish the components physically. There are some common components which are used in almost every control system, such as, resistor, capacitor, integrated circuit, light emitting diode, etc. Technicians must know the characteristics of each component, dependence of each component on different parameters, basic construction of each component,etc.


Fig. 2.2 Resistor

Resistor

Resistor is a fundamental component of an electrical and electronic device as shown in Fig. 2.2. In simple words, a resistor opposes the movement of electric charge. This opposition is called resistance. It has two-ends. Resistor controls the current flow, and it also drops the voltage across it, thus lowers the voltage levels within circuits. High-power resistors are used to dissipate electrical power. Resistors can have fixed resistance value. This fixed resistance value can change slightly, only when there is change in temperature, time or operating voltage. Resistors whose values can be changed are called variable resistors. These variable resistors can be used to control different parameters. For example, in a radio circuit, variable resistor is used as a volume control component.

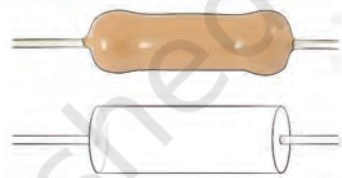


Fig. 2.3(a): Basic structure of an axial resistor

Colour Coded Resistors (Axial Resistors)

Axial resistors are cylindrical in shape with leads extending at each end. Axial resistor is colour coded. The basic shape of axial resistor is shown in Fig. 2.3(a). Whereas, axial resistor in colour coded form with 4 or 5 bands is shown in Fig. 2.3(b).

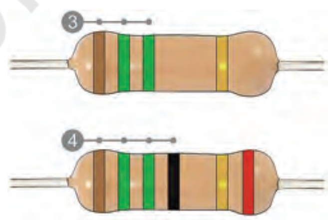


Fig. 2.3(b): Colour code band of an axial resistor

In Fig. 2.3 (b), in case of 4-band resistor, first two bands represent significant digit, third band represents multiplier and the fourth band represents tolerance. In case of 5-band resistor, first three bands represent significant digit, fourth band represents multiplier and the fifth band represents tolerance.

Resistors are colour coded, mainly because of the difficulties of writing a value on the side of the resistor and the many errors that would occur.

Each colour represents a number according to the scheme in Fig. 2.4.

Colour	Number
black	0
brown	1
red	2
orange	3
yellow	4
green	5
blue	6
violet	7
grey	8
white	9

Fig. 2.4: Colour code

Specification of four-band resistor

1. The resistor is read in a way that the three colour bands are on the left of the resistor and the single band is to the right.
2. The first band on a resistor is interpreted as the first number of the resistor value. For the resistor shown in Fig. 2.5, the first band is yellow, so the first number is 4.
3. The second band gives the second number. This is a violet band, making the second digit 7.
4. The third band is called the multiplier and denotes the number of zeros, in this case 0 range which is 3.
5. So the value of the resistor is 47000Ω or 47kΩ.
6. The fourth colour gives the tolerance.
7. The tolerance gives the upper and lower value of the resistor, take the example in Fig. 2.7 for a 100Ω resistor:

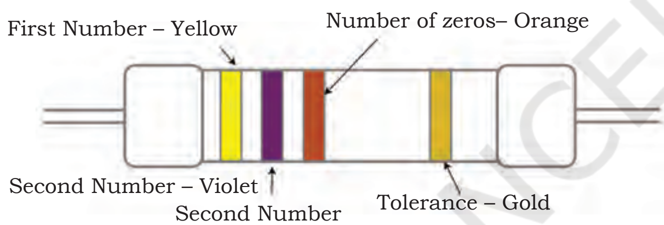


Fig. 2.5: Four-band resistor specification

Fig. 2.6: Four-band resistor

Tolerance	***Colour***	***Stated***	***Allowed upper value***	***Allowed lower value***
+/-1%	Brown	100 Ω	101 Ω	99 Ω
+/-2%	Red	100 Ω	102 Ω	98 Ω
+/-5%	Gold	100 Ω	105 Ω	95 Ω
+/-10%	Silver	100 Ω	50 Ω	90 Ω

Fig. 2.7: Tolerance value

Calculation of resistor value

Read the colour bands from left to right. The colours on the first 2 or 3 bands correspond to numbers from 0 to 9, which represent the significant digits of the resistor's ohmic value, the last band gives the multiplier (as shown in Fig. 2.8). For example, a 4-band resistor with brown,

brown, yellow and gold bands is rated at 11 × 104 or 110 kilo-ohms with 0.1 tolerances. The code is as follows:

(a) Brown: 1 significant digit

(b) Brown: 1 significant digit

(c) Yellow: Multiplier of 104

(d) Gold: Tolerance of 1/10

(e) Silver: Tolerance of 1/100

The last colour band represents the tolerance value of resistor. To calculate the tolerance value of the resistor, read the colour on the last colour band, which is on the farthest right. This represents the tolerance of the resistor. If there is no colour band, the tolerance is 20 per cent as shown in Fig. 2.8. Most resistors have either no band, a silver band or a gold band, but you may find resistors with other colours.

Colour	Significant figures			Multiplier
black	0	0	0	1Ω
brown	1	1	1	10Ω
red	2	2	2	100Ω
orange	3	3	3	1KΩ
yellow	4	4	4	10KΩ
green	5	5	5	100KΩ
blue	6	6	6	1MΩ
violet	7	7	7	10MΩ
grey	8	8	8	
white	9	9	9	
gold				
silver				

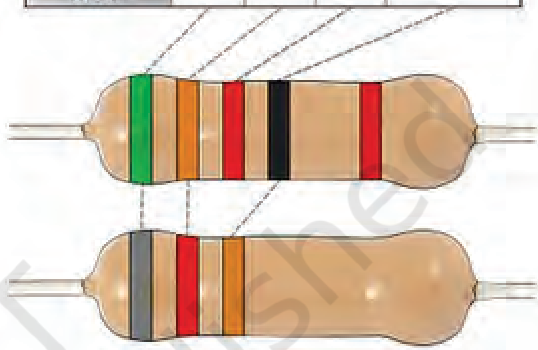


Fig. 2.8: Colour coding chart of resistor

Practical Exercises

Activity 1

Calculation of resistance value of a resistor

Material required

Colour coded resistors, alphanumerically coded resistors.

Procedure

Step 1: Calculation of resistance for the colour coded resistor. The following procedure can be used for reading the resistance value of colour-coded resistor.

Resistors are the fundamental components of electrical and electronics industry. A resistor opposes the flow of current in the circuit. The amount of opposition is measured in ohm. Ohmic value is mostly printed on the resistor in the form of code. In surface mount resistors, ohmic value is printed on the surface, whereas, in carbon film resistors, ohmic value is printed in the form of bands of colour code. By learning the codes, along with using a helpful mnemonic device, one can identify the resistors easily.

There are two methods for manually reading and identifying the value of a resistor. These are:

(a) colour coded resistors (axial resistors).

(b) alphanumerically coded resistors (surface mounted resistors).

Notes

Step 2: Calculation of resistance for alphanumeric coded resistor.

Follow the given procedure for reading the resistance value of surface mount resistor using alphanumeric code:

Surface mounted resistors are rectangular in shape as shown in Fig. 2.9(a). Surface mounted resistors have leads, which are coming out from the resistor, these leads are used for mounting the resistor on the printed circuit board. Some surface mounted resistors use plates on the bottom of the resistor.

The first two or three numbers printed on the surface mounted resistor represents significant digits and the last digit represents the number of zeroes that should follow. For example, as shown in Fig. 2.9 (b), a resistor reading 1252 indicates a value 125200 ohm. For determining the tolerance value, use the letter at the end of the code.

Compare the letter at the end of the code with the tolerance it represents.

Fig. 2.9(a): Surface mounted resistor

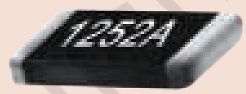


Fig. 2.9(b): Alphanumeric code of surface mounted resistor

Assignment

Calculate the value of resistors by using colour code.

Fig. 2.10(a): Brown-black-yellow-yellow

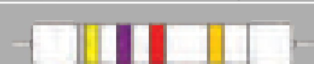


Fig. 2.10(b): Yellow-violet-red-yellow

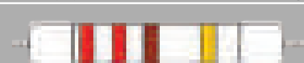


Fig. 2.10(c): Red-red-brown-yellow

Fig. 2.10(d): Orange-white-orange-yellow

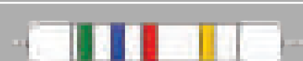


Fig. 2.10(e): Green-blue-red-yellow

Note: When numbers of resistors are combined together to connect in series or parallel or both, relation between voltage, current and resistance can be derived using ohm's law, Kirchhoff's voltage law and Kirchhoff's current law.

Practical Exercises

Activity 2

By analysing series circuit, calculate the resistance, current, power dissipation and power in the circuit.

Material required

Battery 12V, resistor of R_1 = 1.00 Ω, R_2 = 6.00 Ω, and R_3 = 13.0 Ω, connecting wires, two multimeters (voltage and current measurement).

Procedure

- Suppose the voltage output of the battery in Fig. 2.11 is 12.0 V, and the resistances are connected in series.
- The total resistance is simply the sum of the individual resistances, as given by the equation:
- $R_S=R_1+R_2+R_3=1.00\ \Omega+6.00\ \Omega+13.0\ \Omega=20.0\ \Omega$
- The current is found using Ohm's law, V = IR. Entering the value of the applied voltage and the total resistance yields the current for the circuit:

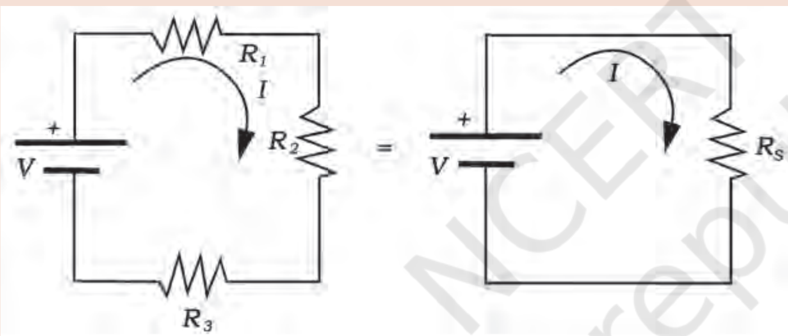


Fig. 2.11: Series circuit

$I=V/R_S=12.0\ V/20.0\ \Omega=0.60\ A$

The voltage or IR drop in a resistor is given by Ohm's law. Entering the current and the value of the first resistance yields

$V_1 = IR_1 = (0.600A)\ (1.0\ \Omega) = 0.600\ V.$

Similarly,

$V_2 = IR_2 = (0.600A)\ (6.0\ \Omega) = 3.60\ V$

and

$V_3 = IR_3 = (0.600A)\ (13.0\ \Omega) = 7.80\ V.$

The three IR drops add to 12.0 V, as predicted:

$V_1 + V_2 + V_3 = (0.600 + 3.60 + 7.80)\ V = 12.0\ V.$

The easiest way to calculate power in watts (W) dissipated by a resistor in a DC circuit is to use **Joule's law**, P = IV, where P is electric power. In this case, each resistor has the same full current flowing through it. By substituting Ohm's law V = IR into Joule's law, we get the power dissipated by the first resistor as

$P_1 = I2_{R1} = (0.600\ A)^2(1.00\ \Omega) = 0.360\ W.$

More to Know

Series connection of resistors:
R equivalent = R1 + R2 + R3+.....
Series key idea: Current is the same in each resistor by current law.

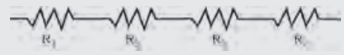


Fig. 2.12(a): Series connection of resistors

Parallel connection of resistors:
$1/R$ equivalent $=1/\ R_1 + 1/R_2 + 1/\ R_3+.....$
Parallel key idea: Voltage is the same in each resistor by voltage law.

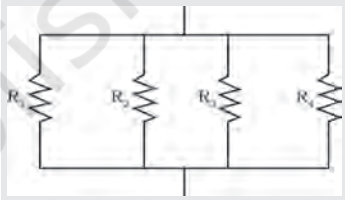


Fig. 2.12(b): Parallel connection of resistors

More to Know

Joule's law states that the heat produced by an electric current 'I' flowing through a resistance 'R' for a time 't' is proportional to I^2Rt.

Notes

Similarly,

$P_2 = I2_{R2} = (0.600\ \text{A})^2(6.00\ \Omega) = 2.16\ \text{W}.$

and

$P_3 = I2_{R3} = (0.600\ \text{A})^2(13.0\ \Omega) = 4.68\ \text{W}.$

- Power can also be calculated using either P = IV or $P=V_2R$, where V is the voltage drop across the resistor (not the full voltage of the source). The same values will be obtained.
- The easiest way to calculate power output of the source is to use P = IV, where V is the source voltage. This gives

$P = (0.600\ \text{A})(12.0\ \text{V}) = 7.20\ \text{W}.$

Note, coincidentally, that the total power dissipated by the resistors is also 7.20 W, the same as the power put out by the source. That is,

$P_1 + P_2 + P_3 = (0.360 + 2.16 + 4.68)\ \text{W} = 7.20\ \text{W}.$

Power is energy per unit time (watts), and so conservation of energy requires the power output of the source to be equal to the total power dissipated by the resistors.

Activity 3

By analysing parallel circuit, calculate the resistance, current, power dissipation and power in the circuit.

Material required

Battery 12V, resistor of R_1 = 1.00 Ω, R_2 = 6.00 Ω, and R_3 = 13.0 Ω, connecting wires, two multimeters (voltage and current measurement).

Procedure

Let the voltage output of the battery and resistances in the parallel connection in Fig. 2.13 are V = 12.0 V, R_1 = 1.00 Ω, R_2 = 6.00 Ω, and R_3 = 13.0 Ω.

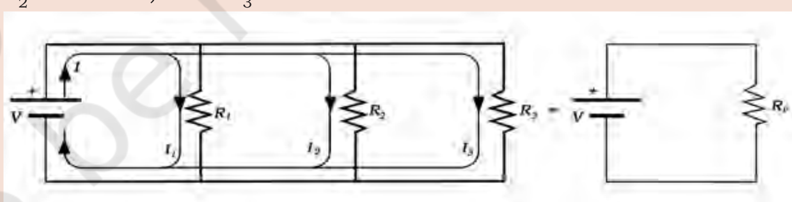


Fig. 2.13: Parallel circuit

The total resistance for a parallel combination of resistors is found using the equation below. Entering known values gives

$1/R_P=1/R_1+1/R_2+1/R_3=1/1\ \Omega+1/6\Omega+1/13\Omega$

Thus,

$1/R_P=1\Omega+0.1667\ \Omega+0.07692\ \Omega=1.2436\ \Omega$

We must invert this to find the total resistance R_P. This will yield:

$R_P=1/1.2436 = 0.8041\ \Omega$

The total resistance with the correct number of significant digits is R_P= 0.804 Ω

R_P is, as predicted, less than the smallest individual resistance.

The total current can be found from Ohm's law, substituting Rp for the total resistance. This gives:

$I=V/Rp=12.0\ V/0.8041\ \Omega=14.92\ A$

Current I for each device is much larger than that for the same devices connected in series (see the previous example). A circuit with parallel connections has a smaller total resistance than the resistors connected in series.

The individual currents are easily calculated using Ohm's law, since each resistor gets the full voltage. Thus,

$I_1=V/R_1=12.0\ V1.00\ \Omega=12.0\ A$

Similarly,

$I_2=V/R_2=12.0\ V6.00\ \Omega=2.00\ A$

and

$I = V/R_3=12.0\ V13.0\ \Omega=0.92\ A$

The total current is the sum of the individual currents:

$I_1 + I_2 + I_3 = 14.92\ A.$

This is consistent with conservation of charge.

The power dissipated by each resistor can be found using any of the equations relating power to current, voltage, and resistance, since all three are known. Let us use $P=V^2R$, since each resistor gets full voltage. Thus,

$P_1= V^2/R_1= (12.0\ V)\ (21.00\ \Omega) = 144\ W$

Similarly,

$P_2 = V^2/R_2 = (12.0\ V)\ 26.00\ \Omega = 24.0\ W$

and

$P_3 = V^2/R_3 = (12.0\ V)\ 213.0\ \Omega = 11.1\ W$

The power dissipated by each resistor is considerably higher in parallel than when connected in a series to the same voltage source.

The total power can also be calculated in several ways. Choosing P = IV, and entering the total current, yields:

$P = IV = (14.92\ A)\ (12.0\ V) = 179\ W.$

Total power dissipated by the resistors is also 179 W.

$P_1 + P_2 + P_3 = 144\ W + 24.0\ W + 11.1\ W = 179\ W.$

This is consistent with the law of conservation of energy.

P = Power
V = Voltage
R = Resistance
I = Current

$P = \frac{V^2}{R}$

Or

$\text{Power} = \frac{(\text{Voltage})^2}{\text{Resistance}}$

Assignment

Calculate the value of equivalent resistance in parallel and series, where value of resistors are R_1= 10 and R_2 = 20 ohms.

Capacitor

The word capacitor specifies the capacity. It represents the capacity to store energy. In a capacitor, energy is stored in the form of electric field. Capacitors have two parallel sections, between which energy is stored.

Factors affecting the resistance values of a wire

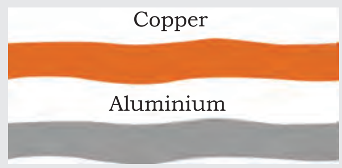


Fig.2.14: Material used for wire

Fig.2.15: Thickness of wire

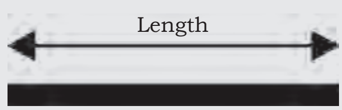


Fig.2.16: Length of wire

Fig.2.17: Temperature of wire

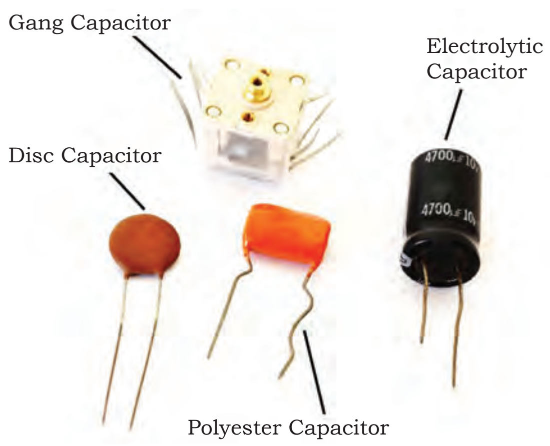


Fig. 2.18: Types of Capacitor

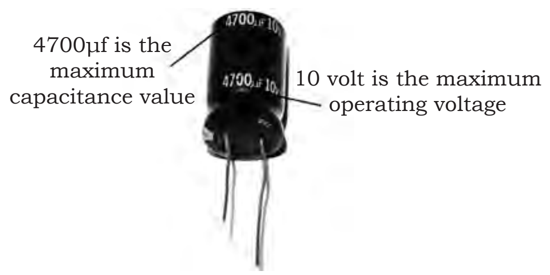


Fig. 2.19: Electrolytic capacitor representing parameters such as maximum operating voltage

It consists of two metallic conducting sections (plates) separated by an insulator (dielectric material) as shown in Fig. 2.18. Metallic conductors can be made up of aluminium, copper, etc. A dielectric can be ceramic, mica, electrolyte, air, paper, gang capacitor, etc. It stores the charges on its metallic plates, this will generate the electric field between the plates. In this way it stores energy in the form of electric field.

Capacitor is one of the fundamental components of electrical and electronic devices. The parameters of capacitor are the maximum voltage it can withstand without damage, charge storage capacity, polarity of terminals, i.e., positive and negative terminals, as shown in Fig. 2.19.

Mathematically,

$$Q = C \times V$$

Where, Q= Charge in coulomb

C= Capacitance in farad

V= Voltage in volt

Smaller units of capacitance are mili farad (mF), Micro farad (µF), Nano farad (nF), Pico farad (pF).

Example: When 250V is applied across the capacitor of capacitance value 10 µF, the amount of charge stored by it is given as:

$$Q = C \times V$$

$$Q = 10 \times 10^{-6} \times 250$$

$$Q = 2.5 \text{ mC}$$

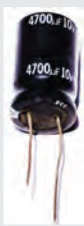
Assignments

A. Calculate the following for a capacitor.

1. Determine the voltage across a 1000 pF capacitor to charge it with 2C.
2. The charge on the plates of a capacitor is 6 mC when the potential between them is 2.4 kV. Determine the capacitance of the capacitor.
3. For how long must a charging current of 2 A be fed to a 5 F capacitor to raise the potential difference between its plates by 500 V? (Hint: I=Q/t)

4. A direct current of 10 A flows into a previously uncharged 5 µF capacitor for 1 mS. Determine the potential difference between the plates.(Hint: I=Q/t)

B. Browse the internet for the different types of capacitors and fill the specifications of each.

Capacitor Picture	Capacitor Name
 *Fig. 2.20*	Name................................ Voltage range..................... Capacitance value...............
 *Fig. 2.21*	Name............................... Voltage range..................... Capacitance value...............
 *Fig. 2.22*	Name................................ Voltage range..................... Capacitance value...............
 *Fig. 2.23*	Name................................ Voltage range..................... Capacitance value...............

Inductor

Inductor is an electrical component in an electric circuit which possesses inductance. Inductor is constructed, when a (conductor) material is wound on the magnetic material. Inductor is like a coil as shown in Fig. 2.24. When current flows through the coil, a magnetic field is created around the wire. This way we can say that the inductor stores the energy in the form of a magnetic field along the coil. If the current flowing through an

Fig. 2.24: Inductor

Notes

inductor changes, a changing magnetic field appears across wires. This changing magnetic field develops (induces) a voltage across the two ends of the wires. Inductor opposes the change in the electric current passing through it. This property of opposition is known as inductance.

Inductor Picture	Name of inductor
 *Fig. 2.25:* Air gap inductor	
 *Fig. 2.26* Ferrite core inductor	
 *Fig.2.27:* SMT inductor	

Semiconductor

Semiconductor is a solid substance that exhibits conductivity between insulators and metals. Electronic devices are made up of semiconductor material. Silicon and germanium are widely used semiconductors in the industry. Semiconductor materials are of the following two types.

Intrinsic (pure)

It is a pure form of semiconductor. The word pure specifies that this semiconductor does not contain any other impure atom. For example, pure form of silicon contains only the atoms of silicon; no other impure atom is present in the silicon. Absence of any impure atom results in less conductivity of semiconducting material. To improve the conductivity of intrinsic semiconductor, impure atom needs to be added.

Extrinsic (impure)

When impure atoms are added in the intrinsic semiconductor, then that is called an extrinsic semiconductor. Extrinsic semiconductors are classified as N-type and P-type semiconductor. For example, presence of impure atoms (e.g., Arsenic (As)) in the pure silicon semiconductor. The process of adding an impure atom in a semiconductor is called *doping*. Doping increases the conductivity of a semiconductor.

Since, the atomic number of silicon is 14; electronic configuration of silicon is 2, 8 and 4. Thus, silicon has 4 electrons in the outermost shell. In order to increase the conductivity, free carriers are added. As silicon has 4 electrons in its outermost shell, it is better to add an impure atom having valence (number of atoms in the outermost shell) of either 5 (penta) or 3 (tri). The atoms which have five electrons in their outermost shell are known as *pentavalent*. The atoms which have three electrons in their outermost shell are known as *trivalent*.

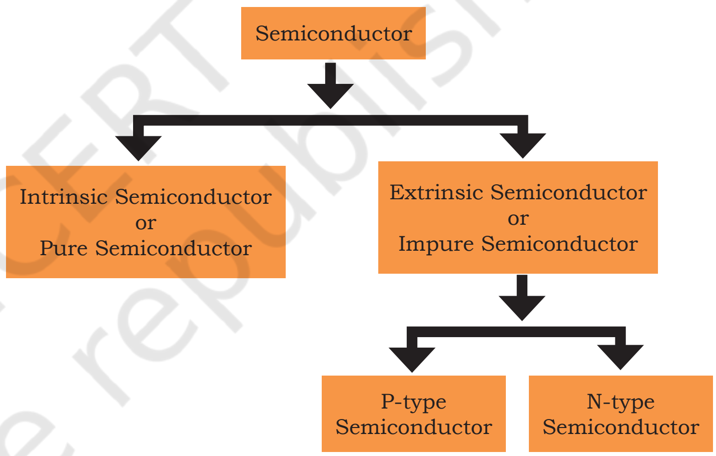


Fig. 2.28: Classification of semiconductor

- When pentavalent impurity atom is added, an extrinsic semiconductor is formed which is known as N-type semiconductor.
- When trivalent impurity atom is added, an extrinsic semiconductor is formed which is known as P-type semiconductor.

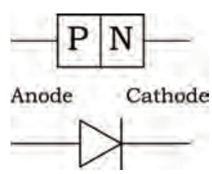


Fig. 2.29: Diode symbol

Fig. 2.30: Diode

Diode

When two semiconductors, i.e., P-type semiconductor and N-type semiconductor are combined to form a new component, it is known as diode. 'Di' means two, thus

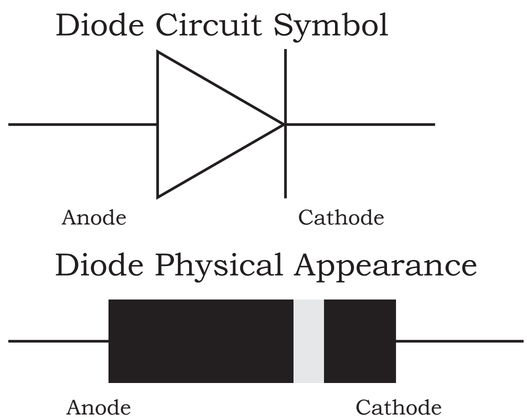


Fig. 2.31: Terminals of diode

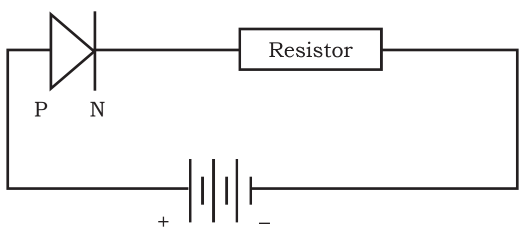


Fig. 2.32: Current will flow in this circuit

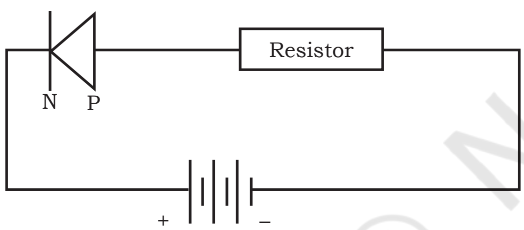


Fig. 2.33: Current will not flow in this circuit

diode has two terminals as shown in Figures 2.29, 2.30 and 2.31.

Diode can be used in switching application. Diode passes current only in one direction. The P-side is called anode and the N-side is called cathode. When the anode and cathode of a PN-junction diode are connected to external voltage source, such that the positive end of a battery is connected to the anode and negative end of the battery is connected to the cathode, diode is said to be forward biased. We can also say that diode will act as a closed switch (it will be turned "ON"). In a forward biased condition, diode will pass the current through it.

When the P-side of diode is connected to the negative terminal of the battery and N-side of the diode is connected to the positive terminal of the battery, the diode is said to be reverse biased or we can say that the diode will act as an open switch (it will be turned "OFF"). In reverse biased condition, diode will not pass the current through it.

If the anode of PN diode is connected to the positive terminal of a battery and the cathode of the diode is connected to the negative terminal of a battery, the diode is said to be in forward bias and current will flow through the diode.

If the anode of PN diode is connected to the negative terminal of the battery and the cathode of the diode is connected to the positive terminal of the battery, the diode is said to be in reverse bias and current will not flow through the diode.

Transistor

Transistor is a three layered semiconducting device. These three layers have three terminals — emitter, base and collector. The place where the two layers touch each other is called a *junction*. The junction where the emitter and base touch each other is called *emitter base junction*. The junction where the collector and base touch each other is called *collector base junction*.

More to Know

A hole is the absence of an electron in a particular place in an atom. Although, it is not a physical particle in the same sense as an electron.

Transistor will act as a switch or can be used for amplification. It is controlled by an electrical signal. Transistor can also be used for enhancing the applied signal strength.

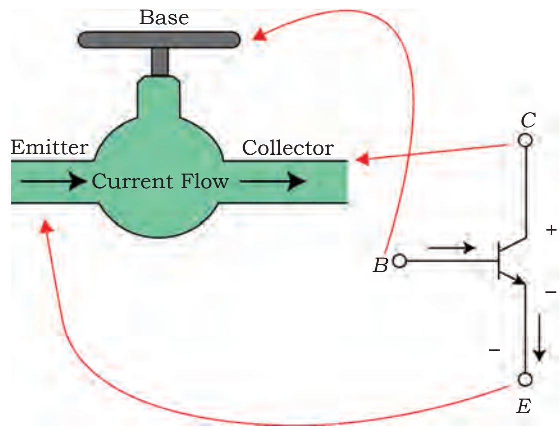


Fig. 2.34: Analogy of transistor

To understand the functioning of a transistor, we can relate it to the water supply system in our home. A storage tank which is kept at the roof of the building is similar to an emitter in transistor which acts as the source of charge carrier (i.e. electrons and holes in semiconductor). The tap at the ground is similar to the base of transistor; this tap controls the flow of water, likewise, base controls the flow of charge carrier. The bucket on the ground collects the water, coming from the storage tank. Similarly, the collector of the transistor collects the charge carriers coming from the emitter.

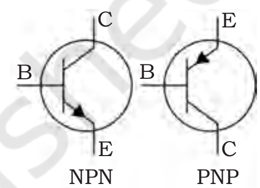


Fig. 2.35: BJT symbol

Identifying Bipolar Junction Transistor (BJT) terminals

Keep the transistor in such a way that the flat surface faces towards you.

We know that the bipolar junction transistor (BJT) has three terminals [Fig. 2.36(a) and (b)] —


Fig. 2.36(a): and Fig. 2.36(b): Terminals of transistor

1. Emitter (E)
2. Base (B)
3. Collector(C)

The schematic symbol of BJT is given in Fig. 2.35

Practical Exercises

Activity 4

Identification of BJT terminal using multimeter.

Material required

Bipolar transistor NPN and PNP, multimeter.

Procedure

The following procedure is used to identify the BJT terminals. NPN and PNP are the two types of BJT. Both are similar in

Notes

physical appearance. Physically, they cannot be differentiated. Multimeter is used to identify the type of BJT.

Following points illustrate the steps for the identification of BJT types:

- If we see the transistor internally, BJT has two junctions (NPN ≡ N - P - N ≡ NP Junction + PN Junction and PNP ≡ P - N - P ≡ PN Junction + NP Junction).

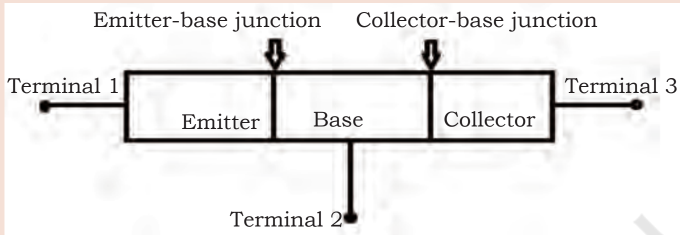


Fig. 2.37: Layers and junctions in BJT

- Emitter to base is one PN junction (diode) and base to collector is another PN junction (diode).
- When multimeter is set to diode mode, then the multimeter will show the voltage when we keep the positive probe of the multimeter to the anode of the diode and negative probe to the cathode.

Fig. 2.38: Multimeter in diode mode

- When multimeter is set to diode mode, then it will not show the voltage when we keep the positive probe of the multimeter to the anode of the diode and negative probe to the cathode.

Steps to identify the NPN type transistor

(a) Connect the red cord to the voltage measuring point as shown in Fig. 2.39.

Fig. 2.39 Connecting terminals of multimeter

(b) Connect the black cord to the common point.

(c) Turn the multimeter in the diode mode as shown in Fig. 2.40.

Fig. 2.40: Circulating knob of multimeter

(d) Touch the red probe to the centre pin (base) of the transistor, black probe to either of the two pin-1 (emitter) or pin- 3 (collector) of BJT as shown in Fig. 2.41.

Fig. 2.41: Testing the transistor

(e) Look at the display of multimeter.

(f) It will show NPN transistor. The logic behind this is, in NPN transistor:

- Emitter (E) – N type material – Equivalent to cathode of the diode
- Base (B) – P type material – Equivalent to anode of the diode
- Collector (C) – N type material – Equivalent to cathode of the diode

(g) If the multimeter positive probe is connected to anode and negative probe is connected to cathode, then it will show voltage. If the connections are interchanged, it will not show any value as shown in Fig. 2.42.

Fig. 2.42: Observing the voltage value

Notes

NOTES

Steps to identify the PNP type transistor

(a) Connect the red cord to the voltage measuring point as shown in Fig. 2.43.

Fig. 2.43

(b) Connect the black cord to the common point.

(c) Turn the multimeter in the diode mode as shown in Fig. 2.40.

(d) Touch the black probe to the centre pin (base) of the transistor, red probe to the either of the two pins – 1 (emitter) or pin- 3 (collector) of BJT as shown in Fig. 2.44.

Fig. 2.44

(e) Look at the display of multimeter.

(f) It is a PNP transistor. The logic behind this is, in PNP transistor:

- Emitter (E) – P type material – Equivalent to anode of the diode,
- Base (B) – N type material – Equivalent to cathode of the diode,
- Collector (C) – P type material – Equivalent to anode of the diode.

(g) If the multimeter positive probe is connected to anode and negative probe is connected to cathode, then it will show voltage. If the connections are interchanged, it will not show any value as shown in Fig. 2.42.

TRANSFORMER

A transformer is a static unit. It simply transforms the voltage level of an AC signal. It either steps up or steps down the AC voltage. It works on the principle of electromagnetic induction. A transformer does not change the frequency of applied AC signal. Transformers play an important role in the electrical systems.

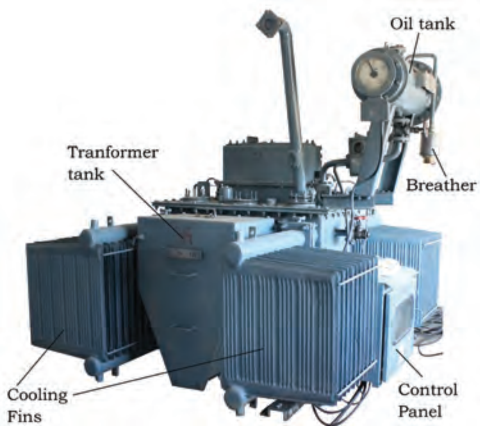


Fig. 2.45: Parts of a transformer

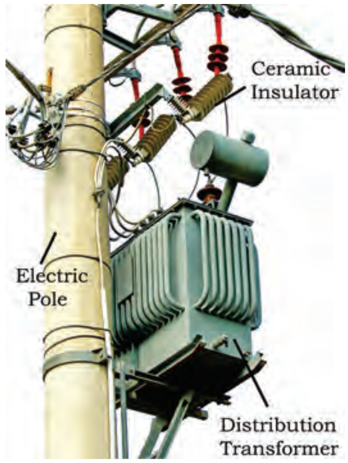


Fig. 2.46: Input-output terminals of a transformer

1. Transformers are available in a number of sizes. For example, a transformer used in a mobile charger is very small, whereas transformers used in the substation of an electricity board are big.
2. High voltage is used for transmission and low voltage is used in office and at home.
3. Transformers are used to increase or decrease AC voltage in transmission and distribution of electricity.
4. Basic construction of transformer includes two coils wound on the magnetic frame or core.
5. Both the coils are magnetically coupled, whereas they are electrically insulated from each other.
6. The primary or input coil is connected to the energy source, while secondary or output coil supplies power to load.
7. Electromagnetic induction is used in a transformer. In power grids, large transformers are used. These transformers are used in the generation, distribution and transmission in the electrical systems. Transformers are placed in every location from the generator to the user.

More to Know

Switch is a device which has two operations ON and OFF. When switch is closed (ON) current flows in the circuit. In this case circuit is said to be complete. When switch is open (OFF), current will not flow in the circuit. In this case circuit is said to be incomplete.

Amplification is the process of increasing the level of voltage and current. Transistor is used in such a way that it will increase the voltage and current level of the input signal which is given to the transistor. Transistors have three terminals. In transistors major current flows between any two terminals while the third terminal is used for controlling the flow of current between terminals.

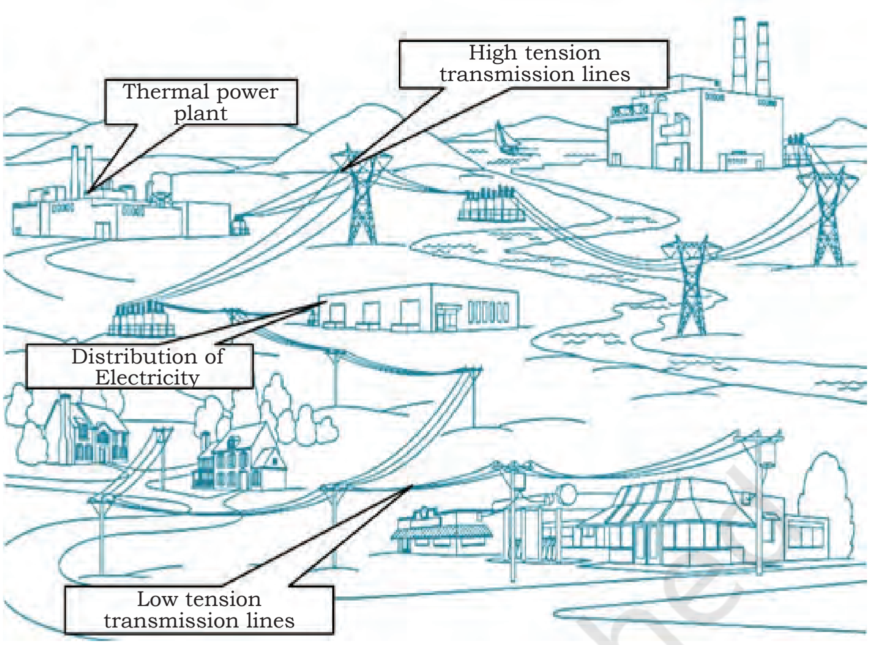
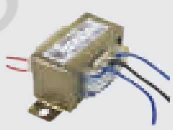


Fig. 2.47: Electrical network

Assignment

A. Search the internet for different types of transformers and fill their specifications.

Transformer	Type of transformer	Specification mentioned on the transformer
 *Fig. 2.48*	Simple step-down transformer	Input voltage: ________ Output voltage: ________ Operating Frequency: ________
 *Fig. 2.49*	Centre-tape transformer	Input voltage: ________ Output voltage: ________ Operating Frequency: ________
 *Fig. 2.50*	High frequency transformer	Input voltage: ________ Output voltage: ________ Operating Frequency: ________

B. Visit the nearest power distributing substation and identify the different parts of high voltage transformer.

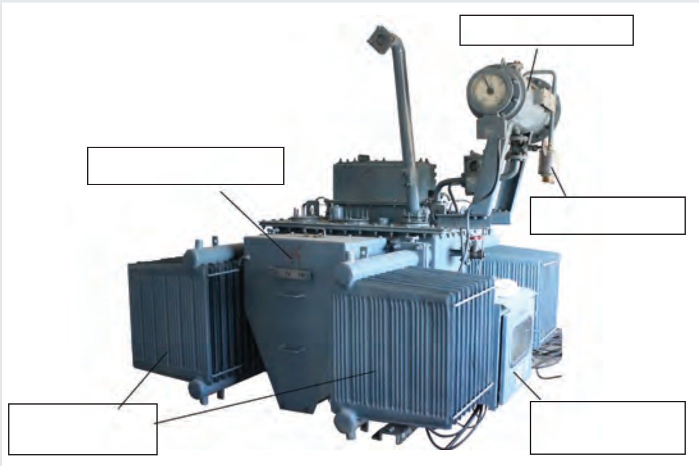


Fig. 2.51

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Practical Exercises

Activity 5

Perform an experiment to identify the primary and secondary winding of a transformer.

Material required

Transformer (230V to 12V), multimeter, input supply, bulb of 200 watt, wire, wire stripper, wire cutter, insulation tape

Procedure

Follow the given steps to identify the primary and secondary winding of transformer.

(a) Connect the wire to the primary winding of the transformer.

(b) Connect the wire to the secondary winding of the transformer.

(c) Connect the primary winding wire to the input supply carefully.

(d) Connect the wire of secondary winding to the load.

(e) Turn ON the power supply.

(f) Measure the voltage using multimeter at primary and secondary winding.

(g) Note down the reading displayed on the screen of the multimeter.

(h) Note the observed reading in the following table:

S. No.	Reading at primary winding	Reading at secondary winding
1.		
2.		
3.		
4.		
5.		

Fig. 2.52: Integrated Circuit

INTEGRATED CIRCUIT (IC)

An integrated circuit is a combination of electronic components on a single piece (or 'chip') of semiconductor material as shown in Fig. 2.52. Integrated circuit has a large number of tiny transistors in a small chip and results in circuits that are smaller, cheaper and faster.

The internal structure of an IC is shown in Fig. 2.53.

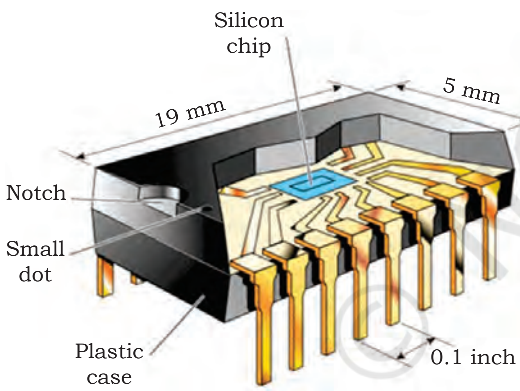


Fig. 2.53: Internal structure of IC

Integrated circuit has a number of pins. Each pin defines an input or output. Datasheet is required when working with an integrated circuit chip. Datasheet gives complete information about a particular integrated circuit.

LIGHT EMITTING DIODE (LED)

Fig. 2.54: Light emitting diode

Light Emitting Diode (LED) comprises of several layers of semiconducting material. When the diode is being utilised with DC, the active layer produces light. The LED emits light in a particular colour and this colour is dependent on the type of semiconductor material used in it. LEDs are made of semiconductor crystals. Typical LEDs are shown in Fig. 2.54..

When current flows through the crystals, they emit light in red, green, yellow or blue colours depending on the composition of the crystal compounds. Blue LEDs also emit white light by using a yellowish fluorescent layer or by creating a mix of red, green and blue (RGB) LEDs.

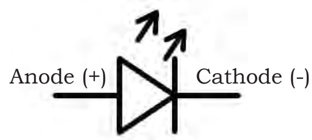


Fig. 2.55: LED Symbol

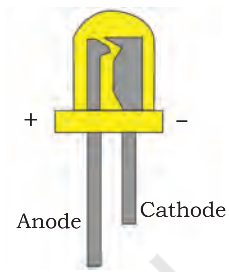


Fig. 2.56: LED Light

Check Your Progress

A. Multiple Choice Questions

1. A diode ________.
   (a) is the simplest of semiconductor devices
   (b) has characteristics that closely match with those of a simple switch
   (c) is a two-terminal device
   (d) All of the above
2. Which of the following is a semiconductor material?
   (a) Silicon
   (b) Germanium
   (c) Both A and B
   (d) None of these
3. An LED produces light when it is ____________.
   (a) forward biased
   (b) reverse biased
   (c) unbiased
   (d) None of the above
4. A semiconductor device consisting of two terminals is a ____________.
   (a) diode
   (b) triode
   (c) transistor
   (d) integrated circuit
5. Resistance of variable resistors can be changed and hence they are called ____________.
   (a) rheostat
   (b) fixed resistor
   (c) variable resistor
   (d) thermistor
6. ____________ consists of a coil or a wire loop.
   (a) Inductor
   (b) Capacitor
   (c) Resistor
   (d) Diode
7. A semiconductor device consisting of three terminals is ____________.
   (a) diode
   (b) transistor
   (c) IC
   (d) All of the above

NOTES

8. The different colours emitted by LED is a result of _____________.
   (a) applied voltage
   (b) forward or reverse bias
   (c) different compounds formation
   (d) None of these
9. LED requires _____________ supply.
   (a) AC
   (b) DC
   (c) AC or DC
   (d) None of these
10. A transformer is used to _____________.
    (a) step up the voltage
    (b) step down the voltage
    (c) Both A and B
    (d) None of These
11. A transformer works on _____________.
    (a) AC
    (b) DC
    (c) both AC and DC
    (d) None of these
12. Transistor has _____________ layers and _____________ junctions.
    (a) two, three
    (b) three, two
    (c) three, three
    (d) two, two
13. A diode is forward biased when _____________.
    (a) the cathode is connected to the positive and anode is connected to the negative terminal of a battery
    (b) the cathode is connected to the negative and anode is connected to the positive terminal of a battery
    (c) no specific polarity is required
    (d) None of these
14. A diode is reverse biased when _____________.
    (a) the cathode is connected to the positive and anode is connected to the negative terminal of a battery.
    (b) the cathode is connected to the negative and anode is connected to the positive terminal of a battery.
    (c) no specific polarity is required.
    (d) None of these
15. Devices which store energy in the form of electric field are known as _____________.
    (a) capacitors
    (b) inductors
    (c) resistors
    (d) diode

16. Devices which store energy in the form of magnetic field are known as _____________.
    (a) capacitors
    (b) inductors
    (c) resistors
    (d) diode
17. Resistance of material is affected by _____________.
    (a) length
    (b) temperature
    (c) thickness
    (d) All of the above
18. Pentavalent impurities in extrinsic semiconductors have _____________ electrons in their outermost orbits.
    (a) 3
    (b) 5
    (c) 4
    (d) 2
19. Trivalent impurities in extrinsic semiconductors have _____________ electrons in their outermost orbits.
    (a) 3
    (b) 5
    (c) 4
    (d) 2
20. Pure form of semiconductor is known as _____________.
    (a) intrinsic semiconductors
    (b) extrinsic semiconductors
    (c) both A and B
    (d) None of these
21. Impure form of semiconductor is known as _____________.
    (a) intrinsic semiconductors
    (b) extrinsic semiconductors
    (c) both A and B
    (d) None of these
22. What are the two major categories for resistors?
    (a) Low and high power value
    (b) Commercial and industrial
    (c) Low and high ohmic value
    (d) Fixed and variable
23. What is the ohmic value for the colour code of orange, orange, orange?
    (a) 22 kΩ
    (b) 33 kΩ
    (c) 3300 Ω
    (d) 44000 Ω
24. Which of the following is true for resistance?
    (a) Symbolised by R, measured in ohms, and directly proportional to conductance.
    (b) Represented by the flow of fluid in the fluid circuit.

Notes

NOTES

(c) Directly proportional to current and voltage.
(d) The opposition to current flow is accompanied by the dissipation of heat.

25. Resistor tolerance is either printed on the component, or provided by the ____________.
(a) company
(b) keyed containers
(c) colour code
(d) size

26. For a fixed voltage, if resistance decreases, then current will ____________.
(a) decrease
(b) double
(c) increase
(d) remain the same

27 Resistance in a circuit is ____________.
(a) the same as current
(b) opposite to current
(c) the same as voltage
(d) opposite to voltage

28. A colour code of Brown, Brown, Red, Gold stands for what ohmic value?
(a) 1.2k Ω 5%
(b) 1.1k Ω 5%
(c) 1.3k Ω5%
(d) 1.5k Ω 5%

29. A colour code of Black, Brown, Green, Gold stands for what ohmic value?
(a) 1×10^5Ω5%
(b) 1×10^4Ω5%
(c) 1×10^5Ω10%
(d) 1×10^4Ω10%

30. A colour code of Brown, Red, Orange, Silver is for what ohmic value?
(a) 12×10^3 10%
(b) 21×10^3 10%
(c) 14×10^3 5%
(d) 12×10^2 5%

31. A colour code of Red, Yellow, Grey, Gold is for what ohmic value?
(a) 23×10^8Ω5%
(b) 24×10^8Ω5%
(c) 25×10^7Ω 5%
(d) 22×10^7Ω5%

B. Fill in the Blanks

1. Transformer works on ____________ voltage.

2. Extrinsic semiconductor is ____________ form of semiconductor.
3. Intrinsic semiconductor is ____________ form of semiconductor.
4. A capacitor stores energy in the form of ____________ field.
5. Inductor stores energy in the form of ____________ field.
6. Diode has ____________ terminals.
7. Silicon is ____________ material.
8. Transistor has ____________ terminals.
9. When LED is forward biased, it will turn ____________.
10. A three terminal semiconducting device is ____________.
11. Green, Orange, Violet colour coded resistor is ____________.
12. Violet, Brown, Orange, Silver colour coded resistor is ____________.
13. Red, Red, Orange, Gold colour coded resistor is ____________.
14. Yellow, Orange, Yellow, Gold colour coded resistor is ____________.
15. Red, Black, Yellow, Gold colour coded resistor is ____________.

C. State whether True or False

1. Transformer is used to step up the voltage.
2. LED emits light in a particular colour and this colour is dependent on the type of semiconductor material used in it.
3. Transistor is used as an amplifier and switch.
4. The electromagnetism in a transformer is the energy source for the transformer.
5. Low voltage is used for transmission and high voltage is used in office and home.
6. Transformer changes the frequency of the applied signal.
7. The junction where emitter layer and base layer touch each other is named as emitter base junction.
8. Amplification is the process of increasing the level of voltage and current.
9. The base unit of capacitance is farad.
10. Green, Orange, Orange, Violet colour coded resistor is 62kΩ 5%.
11. Violet, Green, Orange, Silver colour coded resistor is 75kΩ 10%.

NOTES

NOTES

12. Blue, Red, Orange, Gold colour coded resistor is 62kΩ 5%.
13. Orange, Orange, Yellow, Gold colour coded resistor is 330kΩ 5%.
14. Red, Orange, Yellow, Gold colour coded resistor is 330kΩ 5%.
15. Black, Red, Green, Silver colour coded resistor is 300kΩ 5%.
16. Brown, Green, Orange, Silver colour coded resistor is 15kΩ10%.
17. Orange, Orange, Yellow, Gold colour coded resistor is 330kΩ 5%.
18. Orange, Orange, Yellow, Gold colour coded resistor is 330kΩ 5%.
19. Semiconductors are materials whose conductivity lie between conductors and insulators.
20. Inductors store energy in the form of electric field.

D. Short Answer Questions

1. Write short notes on: Diode, Transistor, LED, Capacitor and Inductor
2. What is an extrinsic semiconductor?
3. What is an intrinsic semiconductor?
4. What are the applications of transistor?
5. Write down the specification of a capacitor.
6. Why LEDs are good choice?
7. What is an inductance?
8. What is a capacitor?

E. Label the following Figures

1. Identify and name the P type and N type terminal of diode in Fig. 2.57. Also specify the anode and cathode terminals of diode.

Fig. 2.57

2. Identify the parts of Light Emitting Diode (LED) in Fig. 2.58.

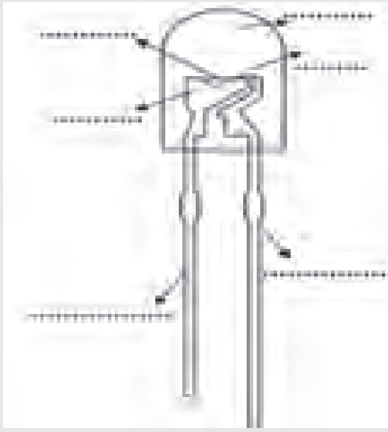
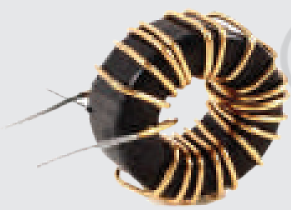


Fig. 2.58

3. Identify and name different types of inductors listed in the following table.

Types of inductor	Name
	
	
	

Notes

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F. Match the Columns

Name of component	Related terms
Semiconductor	Magnetic field
Capacitor	Opposition in the flow of current
Resistor	Unidirectional device
Inductor	Electric field
Diode	Three-terminal device
Transistor	Trivalent and pentavalent

Chapter 3

Tools and Equipment

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In the modern age humans use various appliances at home, like, water purifier. To install and maintain water purifier, various hand tools and equipment are required. Some of the hand tools are, screwdriver, phase tester, stripper, plier, etc. In this chapter, we will discuss the basic tools and equipment used by a field technician.

Multimeter

Electrical quantities, such as, voltage, current, resistance and others can be accurately measured with electrical and electronic measuring instrument called meter. A meter can be of different kinds, such as, ammeter which measures current, a voltmeter which measures the potential difference (voltage) between two points, and an ohmmeter, which measures resistance. A multimeter combines all these functions and possibly some additional ones as well, into a single instrument.

Multimeters are very useful test instruments. By operating a multi-position switch on the meter, they can be quickly and easily set to be a voltmeter, an ammeter or an ohmmeter. They have several settings (called 'ranges') for each type of meter and the choice of alternating current (AC) or direct current (DC). Some multimeters have additional features, such as,

Notes

transistor testing and ranges for measuring capacitance and frequency. Multimeters are available in digital and analogue types.

Practical Exercises

Activity 1

Use multimeter to measure the various electrical quantities.

Material required

Digital multimeter, resistor, AC and DC power source, connecting cords.

Procedure

(a) Measuring the resistance using digital multimeter

1. Digital multimeter has two probes which can be used to measure resistance. Insert the black probe into the common terminal and the red probe into the terminal marked for measuring volts and ohms. The terminal may also be marked for testing diodes.

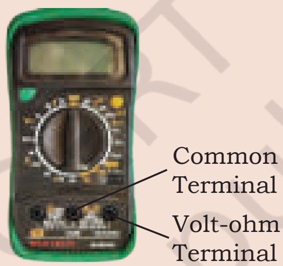

Fig. 3.1(a): Volt-ohm and common terminals

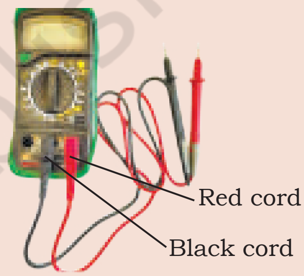

Fig. 3.1(b): Red and black cord connected to the volt-ohm and common terminals respectively

2. Twist the selector knob to set the multimeter to measure resistance. This may be represented by the Greek letter Omega, which stands for ohms, the unit of resistance.
3. Touch the tips of the probes to each side of the resistor.

Fig. 3.2: Multimeter knob switched to measure the resistance value

Fig. 3.3: Measuring the resistance of resistor by touching the resistor terminal to the red and black probes

4. Read the display, and note the units. A reading of 10 may indicate 10 ohms, 10 kilo-ohms or 10 mega-ohms.

Fig. 3.4: Resistance value in Kilo-ohm

(b) Measuring AC and DC voltage using digital multimeter

1. Digital multimeter has two probes which can be used to measure voltage. Put the black probe in the common terminal and the red probe in the terminal marked for measuring volts and ohms.

Fig. 3.5: Connecting the red probe to the volt terminal and black probe to the common terminal

2. Set the multimeter for the voltage you are measuring. You can measure volts DC, milli volts DC or volts AC. If your multimeter has an auto-range function, it is not necessary to select the voltage you are measuring.

Fig. 3.6 Turning the knob to measure voltage

3. Measure AC voltage by placing the probes across the component. In case of AC, it is not necessary to observe polarity.

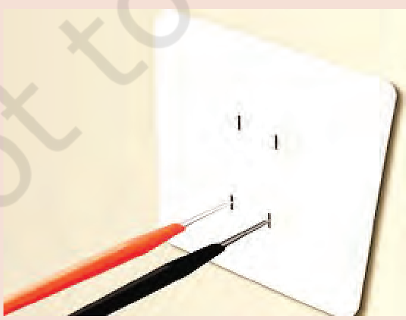

Fig. 3.7: Measuring AC voltage using multimeter

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4. Observe the polarity while measuring DC voltage or milli voltage. Place the black probe on the negative side of the DC source and the red probe on the positive side of the DC source.

Fig. 3.8: Measuring DC voltage using multimeter

5. Read the display, taking care to note the units. If you prefer, you can use the touch-hold feature to keep the reading on the display after you remove the probes. The multimeter will beep each time a new voltage is detected.

Fig. 3.9: Holding the value in the display using hold button

c) Measuring AC and DC current using multimeter

1. Choose either the terminal marked for measuring 10 amps or the one marked for measuring 300 milliampere (mA). If you are not sure of the current, start from the 10 ampere(A) terminal until you are sure the current is less than 300 milliampere (mA). Set the multimeter to measure current.

Fig. 3.10: Choose either the terminal marked for measuring 10a or the one marked for measuring 200 mA

2. Turn off the power to the circuit.

Fig. 3.11: Turn off the circuit

3. Break the circuit. To measure current, you must place the multimeter in series with the circuit. Place the probes on either side of the break, observing polarity (black probe on negative side, red probe on positive side.)

Fig. 3.12: Break the connect in order to connect the ammeter in series with the components

4. Turn ON the power. The current will flow through the circuit. Current will first enter through the red probe of the multimeter and then it will pass through the

Fig. 3.13: Turning ON the circuit

NOTES

NOTES

multimeter. After that it will enter into the circuit then it will return through the black probe. This path will be followed by the current.

5. Read the display, while keeping in mind whether you are measuring amps or milliamps. You can use the touch-hold feature if required.

Fig. 3.14: Hold button can be used to stabilise the value

Activity 2

To study and verify the functionality of diode.

Material required

Diode, resistor, breadboard, digital multimeter as a voltmeter, digital multimeter as an ammeter, DC power supply, connecting wires.

Circuit diagram

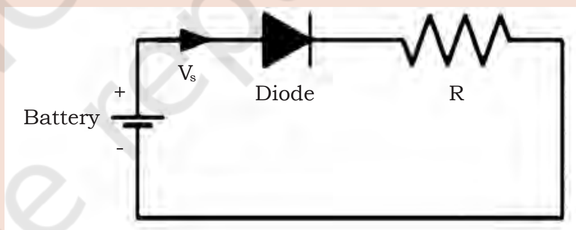
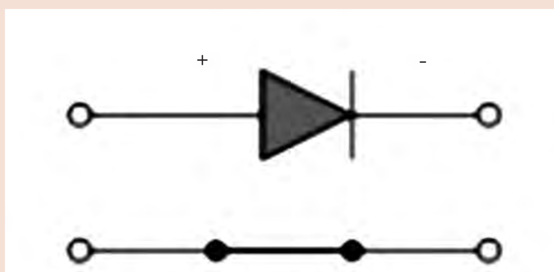
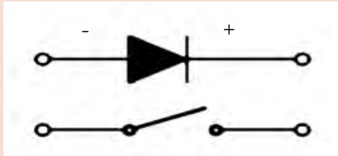


Fig. 3.15 Diode is in forward bias mode



Equivalent of circuit of diode

Fig. 3.16: Diode in forward bias acts as a closed switch



Equivalent of circut of diode

Fig. 3.17: Diode in reverse bias acts as an open switch

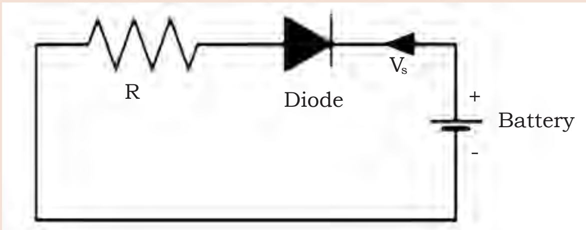


Fig. 3.18: Diode is in reverse bias mode

Procedure

(a) Forward Bias Condition

1. Connect the circuit as shown in Fig. 3.15 (PN Junction diode with milli-ammeter in series with the diode).
2. Vary regulated power supply (RPS) voltage V_s in steps of 0.1 V. Once the current starts increasing, vary V_s in steps of 0.02V and note down the corresponding readings — forward voltage of diode (Vf) and forward current of diode If.
3. Note down the different forward currents obtained for different forward voltages.
4. Plot the voltage-current characteristics.
5. Compare the theoretical and practical values.

(b) Reverse Bias Condition

1. Connect the circuit as shown in Fig. 3.17.
2. Vary V_s in the regulated power supply (RPS) gradually in steps of 1V from 0V to 12V and note down the corresponding readings of reverse voltage of diode (V_r) and reverse current of diode (I_r).
3. Note down different reverse currents obtained for different reverse voltages in a table.
4. Plot the voltage-current characteristics.
5. Compare the theoretical and practical values.

Forward bias		**Reverse bias**	
VD (Volts)	ID (mA)	VD (Volts)	ID (μA)

Notes

Notes

Using the observed reading, draw the characteristic graph of forward and reverse bias in a diode.

Result

Volt-Ampere characteristics of P-N Diode are studied.

Activity 3

Identification of Bipolar junction transistor terminal using multimeter.

Material required

Multimeter, NPN transistor, PNP transistor, connecting cords.

Procedure

NPN and PNP are two types of BJT. Both are similar in physical appearance. Physically, they cannot be differentiated. Multimeter is used to identify the type of BJT.
The following points illustrate the steps for the identification of BJT types:

- If we see the transistor internally, BJT has two junctions (NPN ≡ N - P - N ≡ NP Junction + PN Junction and PNP ≡ P - N - P ≡ PN Junction + NP Junction).
- Emitter to base is one PN junction (diode) and base to collector is another PN junction (diode).
- When multimeter is set to diode mode, then the multimeter will show the voltage when we keep the positive probe of the multimeter to the anode of the diode and negative probe to the cathode.
- When multimeter is set to diode mode, then the multimeter will not show the voltage when we keep the positive probe of the multimeter to the cathode of the diode and negative probe to the anode.

Steps to identify the NPN type transistor

1. Connect the red cord to the voltage measuring point.
2. Connect the black cord to the common point.
3. Turn the multimeter in the diode mode.
4. Touch the red probe to the centre pin (base) of the transistor, black probe to either of pin-1 (Emitter) or pin- 3 (collector) of BJT.
5. Look at the display of multimeter.
6. It will point to NPN transistor. The logic behind this is, in NPN transistor.
   - Emitter (E) - N type material - Equivalent to cathode of the diode
   - Base (B) - P type material - Equivalent to anode of the diode
   - Collector (C) - N type material - Equivalent to cathode of the diode.

7. If positive probe of the multimeter is connected to anode and negative probe is connected to cathode, then it will show voltage. If the connections are interchanged, it will not show any value.

Steps to identify the PNP type transistor

1. Connect the red cord to the voltage measuring point.
2. Connect the black cord to the common point.
3. Turn the multimeter in the diode mode.
4. Touch the black probe to the centre pin (base) of the transistor, red probe to either of pin–1 (emitter) or pin- 3 (collector) of BJT.
5. Look at the display of multimeter.
6. It will point to PNP transistor. The logic behind this is, in PNP transistor.
   - Emitter (E) - P type material - Equivalent to anode of the diode
   - Base (B) - N type material - Equivalent to cathode of the diode
   - Collector (C) - P type material - Equivalent to anode of the diode
7. If positive probe of the multimeter is connected to anode and negative probe is connected to cathode, then it will show voltage. If the connections are interchanged, it will not show any value.

Line Tester or Phase Tester

Line or phase tester is a tool which is used to identify or test the phase, live, hot or positive wire or conductor. Phase or Line Tester is also called Neon Screw Driver or Test Pin (phase, line, hot, live and positive are the same terms).

Construction of Phase or Line Tester

The main parts of a typical phase or line tester are:
Metallic Rod and Mouth: It is a cylindrical metal rod. It has one flat end which is used to test the phase or live wire in power supply. The other end of the metal rod is connected in series with resistance and neon bulb. The flat end of cylindrical metal rod is also covered with the transparent insulated plastic for insulation purposes except around the mouth.

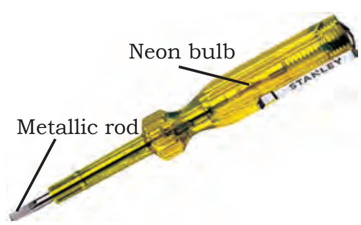


Fig. 3.19: Phase tester

Body and Insulation: All these components (resistance, neon bulb, element or metallic spring, and metallic cap screw) are covered in a transparent insulated body made of plastic. The flat end of cylindrical metal rod except the mouth is also covered with transparent insulated plastic for insulation purpose.

Resistor: It is an element which opposes the flow of current through it. In a phase or line tester, the resistor is connected between cylindrical metal rod and neon bulb to prevent high current and reduces it to a safe value for neon bulb. In absence of a resistor, high current may damage the neon bulb. Moreover, it would not be safe to use this tool without a resistor.

Neon Bulb: It is connected between Resistance and Element (metallic spring). It is used as a phase indicator bulb. When a small current flows through it, it glows. Due to neon bulb, a phase or line tester is also called a neon screw driver.

Element (Metallic Spring): It is used to connect neon bulb and metallic cap screw.

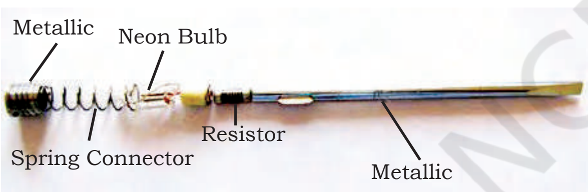


Fig. 3.20: Internal parts of phase tester

Metallic Cap Screw and Clip: Metallic cap screw is used to tighten all the components inside the phase tester slot. In addition, metallic cap screw is connected with spring (element) to neon bulb. Moreover, clip is used for holding the phase tester in pocket.

Screwdriver

A screwdriver is a basic tool used in an electrical panel installation. It is manual or powered, for inserting and removing screws. A typical simple screwdriver has a handle and a shaft. The ending tip of the driver is put into the screw head by the user before turning the handle. The shaft is usually made of tough steel. It is used to resist bending or twisting. The tip may be hardened to resist wear. Handles are made up of wood, metal or plastic. A handle is usually hexagonal, square, or oval in cross-section to improve grip. This will be helpful while twisting the screwdriver and will prevent the tool from rolling on the head of the screw. Some

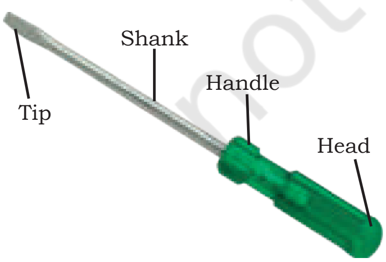


Fig. 3.21: Parts of screwdriver

manual screwdrivers have interchangeable tips that fit into a socket at the end of the shaft and are held in mechanically or magnetically. These often have a hollow handle that contains various types and sizes of tips.

Combination Plier

Combination pliers, as the name suggests, perform various operations. It enables the user to perform the combined operation of cutting and gripping. Some combination pliers have other additions, especially if they are designed for use in particular industries or for specific tasks.

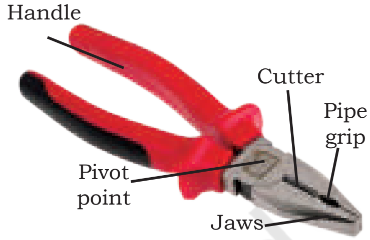


Fig. 3.22: Combination plier

Handles: The handles of combination pliers will usually have a plastic coating, for added comfort and grip. The size and length of the handles will depend on the size of the pliers. Pliers designed for use by technicians have insulated handles.
Jaws: The jaws of combination pliers open and close along with the handles. They have flat edges for general gripping, which are often serrated for extra grip, although sometimes they are smooth. They usually have squared tips.
Cutter: The cutters built into the jaws of combination pliers are usually designed to cut cables and wires.
Pipe grip: The pipe grip is rounded, cut-out in the jaws. It is primarily used for gripping rounded stock, like pipes and cables.
Pivot point: The pivot point is a kind of hinge that allows the handles and tips to open and close so that the jaws can grip or cut, and then be opened again.

Drill Bits

Drill bits are cutting tools used to remove material to create holes. Drill bits come in many sizes and shapes. Different sizes of holes can be made by using different sizes of bits. In order to create holes, drill bits are usually attached to a drill machine, which powers them to cut through the workpiece, typically by rotation.
Step 1. Insert the chuck key. If your drill came with a chuck key, you will need to use this in order to loosen the chuck. To insert the chuck key, line up the teeth

Fig. 3.23: Insert the chuck to loosen the bit

Fig. 3.24: Counter clockwise rotate the chuck to loosen the bit

so that they match the teeth on the chuck and insert the tip into one of the holes on the side of the chuck. (Fig. 3.23)

Step 2. Turn the chuck key counter clockwise. As you turn the key, the jaws on the chuck will begin to open. Continue turning until the chuck opens enough to easily slide the drill bit out. The jaws are the three or four pieces in the mouth of the chuck that extend to hold the bit in place. (Fig. 3.24)

Step 3. Remove the bit. Pull the bit out using your thumb and index finger once the chuck is loosened. If the chuck is opened wide and you turn the drill face down, it may just fall out. (Fig. 3.25)

Fig. 3.25: Pull out the bit

Step 4. Inspect the bit. Check for damage. If the bit is dull, bent or showing signs of cracking, replace it.

Step 5. Insert a bit. While the jaw on the chuck is opened wide, insert a new bit. Hold the bit with your thumb and index finger so that the smooth part of the bit (the shank) is facing the jaws of the chuck and insert it.

Step 6. Keep your fingers on the bit and the chuck since the bit is not secured and could fall out. (Fig. 3.26 (a) and (b))

Fig. 3.26(a): Again tighten the bit using chuck

Fig. 3.26(b): Replace the bit

Wire Lugs

Wire lugs are connecting terminals used to connect the conductor wire to the external world. Wire lugs are a class of electrical connectors which are used to transfer electrical current from a power or grounding source to a user. Terminals are joined by using crimping or soldering technique in which conductor of wire is connected to lug.

Fig. 3.27: Wire lug

Wire Stripper

A wire stripper is a portable handheld tool used by workers, especially electricians, for removing the protective coating of an electric wire in order to replace or repair the wire. It is also capable of stripping the end portions of an electric wire in order to connect them to other wires or to terminals. A wire stripper is often considered an important tool for professional electricians and other related personnel.

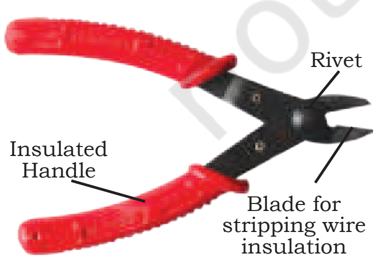


Fig. 3.28: Wire stripper

Wire strippers are available in various shapes and sizes and are usually made of steel. They usually have serrated teeth, which comes handy while stripping wires. The handles can be either straight or curved and, in most cases, are covered with rubber coating to provide a secure grip. Wire strippers often have a wire cutter as well.

Wire strippers can be categorised into two types — manual wire strippers and automatic wire strippers. A manual wire stripper is considered the most versatile; to use it, the user needs to manually rotate it while applying pressure around the insulation in order to cut or adjust the wires. In case of an automatic wire stripper, one side is held tight and, simultaneously, the other side is cut and removed. An automatic wire stripper can help to cut and strip most wires quickly. However, it only works for certain size ranges of wires.

Wrench

The pipe wrench is an adjustable wrench or spanner used for turning soft iron pipes and fittings with a rounded surface. The design of the adjustable jaw allows it to lock in the frame, such that any forward pressure on the handle tends to pull the jaws tighter together. Teeth angled in the direction of the turn, dig into the soft pipe. They are not intended for use on hardened steel hex nuts or other fittings because they would ruin the head; however, if a hex nut is soft enough that it becomes rounded beyond use with standard wrenches, a pipe wrench is sometimes used to break the bolt or nut free. Pipe wrenches are classified by the length of the handle; they can be available in any size from as small as 3 inches up to 48 inches or larger. They are usually made of cast steel.

A present, aluminium is also used to construct the body of the wrench, while the teeth and jaw remain of steel. Teeth and jaw kits (which also contain adjustment rings and springs) can be bought to repair broken wrenches, as this is cheaper than buying a new wrench.

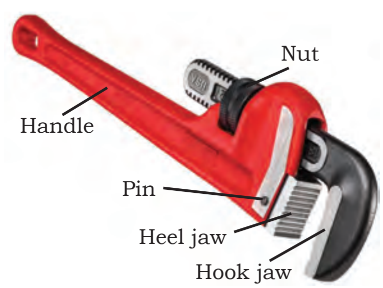


Fig. 3.29: Pipe wrench

Hammer

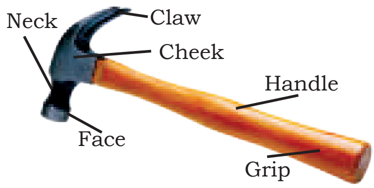


Fig. 3.30: Claw hammer

A tool consisting of a piece of metal with a flat end that is fixed onto the end of a long, thin, usually wooden handle, used for hitting things, shaping of metal sheets, etc., is called a hammer.

Ladder

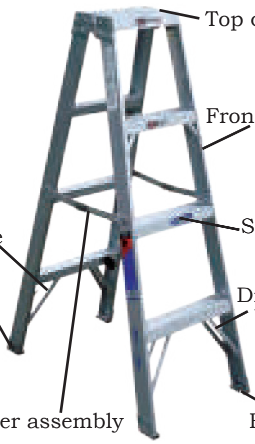
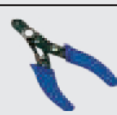


Fig. 3.31: Ladder

A ladder is a vertical or inclined set of steps. There are two types: rigid ladders that are self-supporting or that may be leaned against a vertical surface, such as, a wall, and rollable ladders, such as, those madeup of rope or aluminium that may be hung from the top. The vertical rods of a rigid ladder are called stringers or rails. Rigid ladders are usually portable, but some types are permanently fixed to a structure, building or equipment. They are commonly made of metal, wood or fiberglass, but they have also been known to be made of tough plastic.

Assignment

Identify and name the various tools and their parts

 *Fig. 3.32*	
 *Fig. 3.33*	
 *Fig. 3.34*	
 *Fig. 3.35*	
 *Fig. 3.36*	
 *Fig. 3.37*	

Assignment

List the names of general hand tools and write down the use of listed tools.

Clamp Meter

A clamp meter is a tool for measuring current in a wire. A typical clamp meter is shown in Fig. 3.38. When compared to multimeter, the clamp meter does not need to be connected to the circuit in order to read the current. Clamp meter does not require unnecessary procedure of breaking the circuit to measure the amount of current. The clamp on the device is simply placed around a live wire. This allows one to measure the current in a wire without interrupting the operation of the electrical appliance.

Fig. 3.38: Clamp meter

Practical Exercises

Activity 4

Measure the current using clamp meter.

Material required

Wire in which current flow is to be measured, clamp meter.

Procedure

Follow the steps for measuring AC or DC current by using a clamp meter's jaws:

Choose an electrical conductor to test

The clamp can easily measure the current on a load without the need to disconnect the electrical conductor from the circuit. To get reading, the electrical wire should be connected to an electrical appliance that is running or operating.

Choose the appropriate function and range

Set the rotary selector on the clamp meter to the correct function and range. Measuring current that is higher than that specified in the range can damage the device. If you are not sure about the range of current which is to be measured, choose a high range and decrease it as needed.

Clamp the conductor

Push the trigger on the device to open the jaw. Clamp the device around the conductor and close it. If the electrical conductor is not yet connected to a power source, connect it. Note the reading on the display of the clamp meter.

NOTES

Use an AC line separator

When measuring AC current, the device may give a false reading. Hot and neutral current cancel each other out, which causes the device to display nothing on the LCD screen. To correct the problem, connect the AC line separator between the electrical conductors, i.e., phase and neutral.

Measure Voltage

Set the clamp meter to the voltage symbol "V" to read the voltage on the conductor. Plug the probes to the meter as well. Connect the black probe to the Common (COM) jack and the red probe to the Voltage (V) Jack. Select the correct range and make sure not to measure voltages above the maximum range of the clamp meter. Touch the tips of the probes to the electric conductor to get a voltage reading. Read the voltage on the LCD screen.

A clamp meter will save you time during an electrical repair work, will help you get more efficient with your wiring projects, and will protect you from electrical-related accidents.

MEGGER

Insulation resistance (IR) quality of an electrical system degrades with time, environment condition, i.e., temperature, humidity, moisture and dust particles. It also gets impacted negatively due to the presence of electrical and mechanical stress, so has become necessary to check the IR (Insulation resistance) of equipment at a constant regular interval to avoid any fatal or electrical shock. Megger meter is used as a measuring instrument for insulation resistance tester.

Uses of Megger

The device enables us to measure electric current leakage in wire. The results are reliable as we pass electric current through the device while we are testing. The equipment is basically used for verifying the electric insulation level of any device such as motors, cables, generators, windings, etc. However, it may not necessarily show us the exact area of electrical puncture but shows the amount of leakage current and level of moisture within the electrical equipment and winding system.

Types of Megger

This can be separated into mainly two categories:

- Electronic megger (battery operated)
- Manual megger (hand operated)

There is also another type of megger which is motor operated type which does not use battery to produce voltage. It requires external source to rotate an electrical motor which in turn rotates the generator of the megger.

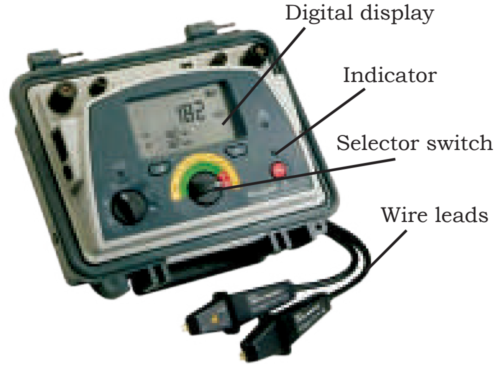


Fig. 3.39: Electronic megger

Electronic megger

Digital display: A digital display is to show IR value in digital form.

Wire leads: Two wire leads are used to connect megger with an electrical external system to be tested.

Selection switches: Switches used to select electrical parameters.

Indicators: To indicate various parameters status i.e. On-Off. For example power, hold, warning, etc.

Fig. 3.40: Analog megger

Manual megger

Analog display: Analog display provided on front face of tester for IR value recording.

Hand crank: Hand crank is used to rotate and helps to achieve the desired RPM (rotation per minute) required to generate voltage, which runs through electrical system.

Wire leads: Used in the same way as in electronic tester, i.e., for connecting tester with electrical system.

Soldering

Soldering is the process of melting a metal onto other metal components in order to bind them. Soldering differs from welding.

Fig. 3.41: Soldering Kit

Notes

In welding, the component pieces are melted together; in soldering, a softer metal with a lower melting point is used to connect them. Because soldering does not melt components, it is useful for more delicate applications, such as, electronic works, or plumbing. The purpose of soldering is to bind two components together. Solder can be thought of as a sort of metal glue. It can be used to fill in gaps or hold pieces in place, but does not serve any more complicated purpose. Since the solder is metallic, it conducts electricity, which is another reason it is popular for connecting electronic components.

Practical Exercises

Activity 5

Demonstrate the soldering and de-soldering techniques. To practise soldering and de-soldering for the given electronic circuit in a general purpose printed circuit board (PCB).

Material required

PCB board for a given circuit, soldering iron, solder, copper plate, flux, connecting wires, lead and nose plier.

Procedure

Follow the procedure given below to perform the soldering operation.

Soldering

1. Clean the given PCB board.
2. Clean the tip of the soldering iron before heating and also clean the components which are to be soldered.
3. Heat the soldering iron and apply solder to the tip as soon as it is hot to melt on it.
4. Considering the given circuit, the components are to be soldered in their respective places by applying hot tip to the joints.
5. Trim the excess component lead with a side cutter.

De-soldering

1. Hold the component to be unsoldered by a nose plier.
2. Place the tip of the soldering iron on the joint until the solder is melted.
3. When the solder is melted, remove the component with a tweezer and brush away the molten solder.
4. Clean the components so that they can be used to make other circuits.

Result: Thus the soldering and de-soldering practice is done for the given electronic circuit successfully.

Total Dissolved Solids (TDS) Meter

Total Dissolved Solid (TDS) meter specifies the purity of water. It defines the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water. It is expressed in units of mg per unit volume of water (mg/L), also referred to as parts per million (ppm). TDS is directly related to the purity of water and the quality of water purification systems.

Notes

Fig. 3.42: Total Dissolved Solids meter

Check Your Progress

A. Multiple Choice Questions

1. A screw is made up of __________ wrapped around a post or rod.
   (a) springs
   (b) threads
   (c) switches
   (d) knob
2. Which of the following tools is used for shaping the metal into a sheet?
   (a) Hammer
   (b) Screwdriver
   (c) Stripper
   (d) Wrench
3. Pipe wrenches are available in sizes of __________ inches up to ____________ inches.
   (a) 1, 50
   (b) 3, 48
   (c) 4, 58
   (d) 1, 45
4. Wire stripper is categorised as ________ and ________.
   (a) vertical and horizontal
   (b) straight and aligned
   (c) manual and automatic
   (d) fix and movable
5. Which of the following is used as a wire connector?
   (a) Lugs
   (b) Screwdriver
   (c) Stripper
   (d) Hammer
6. Which of the following meters is used for insulation resistance testing?
   (a) Ammeter
   (b) Voltmeter
   (c) Wattmeter
   (d) Megger meter

NOTES

7. Which of the following equipment is used to measure AC voltage?
   (a) Tachometer
   (b) Multimeter
   (c) Ammeter
   (d) Megger meter
8. Which of the following is used to measure insulation resistance?
   (a) Tachometer
   (b) Multimeter
   (c) Ammeter
   (d) Megger meter
9. Which of the following tools is used for turning soft iron pipes and fittings with a rounded surface?
   (a) Wrench
   (b) Plier
   (c) Wire stripper
   (d) Screwdriver
10. Which of the following tools is used for the removal of insulation of wire?
    (a) Plier
    (b) Wrench
    (c) Wire stripper
    (d) Hammer

B. Fill in the Blanks

1. Combination plier is used for ________ and ___________.
2. Pipe wrench is classified by the length of the handle; they are available in sizes from ___________ inches up to ___________ inches.
3. The process of melting a metal onto other metal components in order to bind them is called __________.
4. Tong meter is also known as ____________ meter.
5. Megger meter is classified as __________ and ___________.
6. Soldering is also known as ___________.
7. Ladder is classified as __________ and __________.
8. In line tester, __________ bulb is used for the indication of live wire.
9. In drilling practice, __________ is used for making a hole on the wall or wood.
10. Multimeter is used for the measurement of resistance, voltage and _____________.

C. State whether True or False

1. Soldering is known as glue.
2. Clampmeter is used to measure the current flowing inside the wire.

3. Multimeter is used for the testing of diode.
4. Combination plier is used for stripping of insulation in the wire.
5. Line tester is used for testing diode.
6. Multimeter can measure AC and DC voltage.
7. Lugs are used as a wire connector.

D. Match the Columns

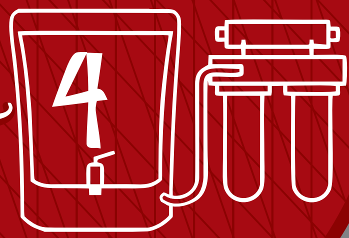
1. Hammer	(a) to check the line or live wire
2. Screwdriver	(b) grip and twist the pipe
3. Phase tester	(c) tighten the screw
4. Plier	(d) shaping of metal sheet
5. Wrench	(e) used for cutting, stripping of wires and holding wire

E. Short Answer Questions

1. List out the uses of a screwdriver.
2. Does a screwdriver have insulator and conductor? If yes, identify the parts which are insulator and conductor.
3. Write down the electrical quantities which can be measured using multimeter.
4. Write down the different parts of a combination plier. Mention its specific use.
5. What is the purpose of a line tester in electrical network?
6. What material is required to solder a wire?
7. What functionality can be performed using total dissolved solids meter?
8. What is the benefit of clampmeter over multimeter?
9. What steps are to be used to find the anode and cathode of the diode?
10. What precautions need to be taken during soldering?

NOTES

Chapter 4



Installation of RO Water Purifier

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We mostly associate diseases with a change in weather or consuming unhealthy food. However, we tend to overlook the fact that even water can cause these diseases. You might be unknowingly consuming substances like chlorine, bacteria, pesticides and much more through tap water. One simple step to avoid this problem is by installing a water purifier. Make sure to choose water purifiers with an extensive filtering process, so that drinking water can be consumed without any worry.

Reverse Osmosis (RO) water purifiers feature advanced purification process and even provide you with a digital advance alert system that reminds you before the germ kill kit expires. These purifiers use reverse osmosis and ultraviolet technology to make water drinkable for you. In this chapter, we will learn about the installation and parts of a water purifier.

Reverse Osmosis (RO)
It is a technique used to remove contaminants from water by pushing the water under pressure through a semi-permeable membrane.

Basics of Water-based Appliances

Water is essential to all known forms of life. Water is the most abundant compound found on Earth. It is the basic requirement of living beings for their survival. More than 70 per cent of Earth's surface is covered with water in the form of snow, glaciers, oceans, rivers and lakes. However, very little of this water is drinkable. This is because 97 per cent of the earth's water is salt water. Approximately, 98 per cent of the remaining fresh water is in the form of glaciers and polar ice caps. This leaves just about 1 per cent of the freshwater on the surface in the form of rivers and lakes. Not all of this fresh water is safe for human consumption as it is contaminated with a large number of harmful chemicals and bacteria. To make fresh water safe for drinking, it needs to be made free from impurities. So that its intake does not cause any harm. The various properties of water make it a necessity for supporting life.

Fig. 4.1: Distribution of water on Earth

Structure of Water

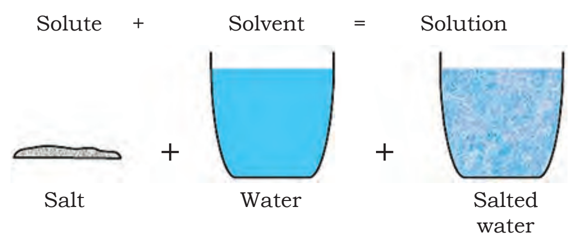
Water is a transparent, odourless, tasteless and colourless liquid as shown in Fig. 4.2. Its chemical formula is H_2O and it is made up of two hydrogen atoms and one oxygen atom joined together by covalent.

The various properties of water are listed below.

Fig.4.2: Characteristics of water

Universal solvent

A molecule of water forms intermolecular hydrogen bonds with other molecules of water and also with molecules of many other components. These bonds make it a powerful solvent. Water can dissolve different chemicals. Water contains various minerals, nutrients and chemicals. This property of water helps to support the life on Earth.



A solution is a homogeneous mixture. The most abundant part is called the solvent, and the less abundant part is called the solute.

Fig. 4.3: Water as a universal solvent

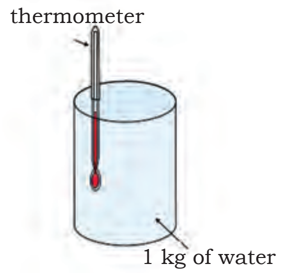


Fig. 4.4: Specific heat capacity of water

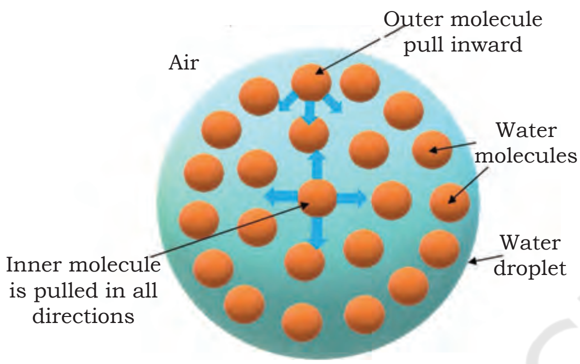


Fig. 4.5: Surface tension of water

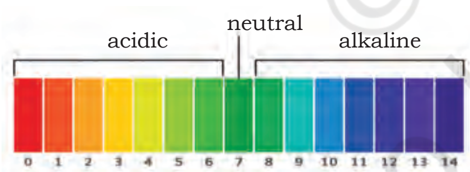


Fig. 4.6: pH of water

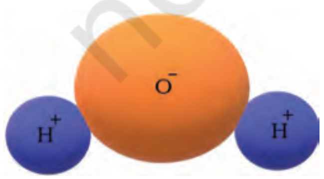


Fig. 4.7: Polar nature of water

High specific heat

Water is helpful in maintaining the moderate temperature of earth as it has the capacity to absorb the heat. Water has high specific heat. Specific heat is the amount of heat required by a substance to raise the temperature of one kilogram of water by one degree Celsius. Each molecule of water has specific heat which helps to maintain the temperature of earth.

Strong surface tension

Water has a high surface tension and the molecules of water have high adhesive property. High surface tension is responsible for the capillary action of water. This capillary action helps to move water through the plant roots and stems and even through blood vessels in animals.

Neutral pH

Water is neither acidic nor basic; it has a neutral pH value of 7.

High polarity

A water molecule consists of one oxygen atom and two hydrogen atoms. Oxygen has high electronegativity, means it has high affinity for electrons. The oxygen in water molecules pulls the electrons from the hydrogen atoms closer to it, creating two poles in the molecule, where the hydrogen end is partially positive and the oxygen end is partially negative. Water has high polarity. The difference in the electronegativity of oxygen and hydrogen atoms makes a strong polar compound.

Lower density of ice

The density of ice is lower than the density of water. Water expands when it freezes.

Its molecules form a crystalline structure. As density of ice is less than water, ice floats on the surface of water. It prevents water from freezing after a certain depth, thereby allowing life to exist in these water bodies.

> **Assignment**
>
> **Group discussion:** More than 70 per cent of Earth's surface is covered with water in the form of snow, glaciers, oceans, rivers and lakes. Still there is a lack of water. Discuss.

Water Treatment Methods

In everyday life, clean and safe water is essential. But, contaminants like germs, virus, bacteria, parasites and many harmful substances, etc., are present in water. Therefore, for making the water drinkable, treatment of water is necessary. Water treatment is the process of removing the microorganisms and harmful substances from water. Fig. 4.9 shows the method of water treatment.

Contaminants of Water

There are four common types of contaminants that are generally found in water. These are shown in Figs. 4.10(a) and 4.10(b).

Bacteria: These are a group of very small organisms. Some bacteria are harmless while some are harmful. Bacteria cause sickness and disease in humans. Diseases caused by bacteria are vomiting, diarrhea, intestinal infection, etc.

Minerals: These are substances that are formed naturally in the soil. Minerals are usually formed by geological processes. Minerals like calcium, potassium and magnesium are considered good for

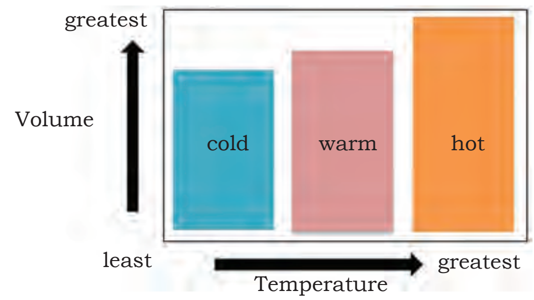


Fig. 4.8: Effect of temperature on water density

Fig. 4.9: Method of water treatment

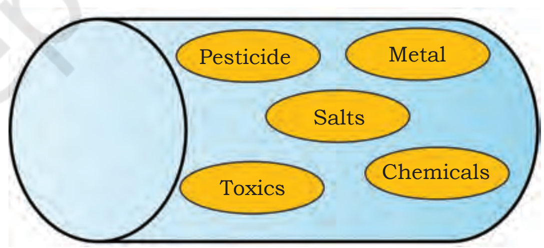


Fig. 4.10(a): Contaminants in water

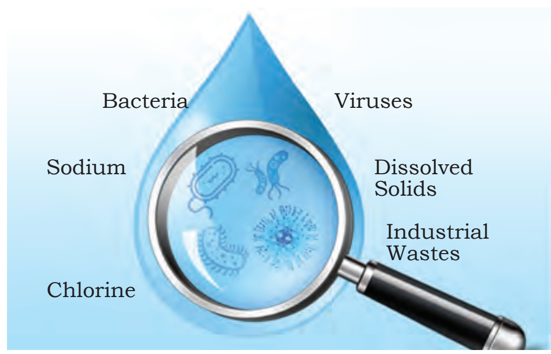


Fig. 4.10(b): Dissolved impurities in tap water

humans while some, such as, lead, arsenic and aluminium are considered harmful for them. Water has both types of minerals dissolved in it. The level of calcium and magnesium salts dissolved in water determines its hardness.

Particulates: These are small particles present in the environment due to air pollution. They are dust, sand, sediment, rust, etc., found in the water. Particulates carry harmful diseases with them. They are measured in microns where one micron is one millionth of a meter.

Chemicals: Chemical substances present in water can be natural or can be added as a result of human activities. Mainly chemicals are added into water through industrial discharge, urban activities, agriculture and disposal of waste. Water treatment methods remove these contaminants from the water to make it safe for human consumption. Water treatment is done at two levels.

Community water treatment	Surface water treatment plant is used for the removal of contaminants to make it fit for use by community.
Domestic water treatment	Individual water treatment at home is done to improve the quality of water and make it potable.

Water Treatment Agents

Different types of agents are used for treatment of water to make it safe for drinking. These water treatment agents are classified into three categories.

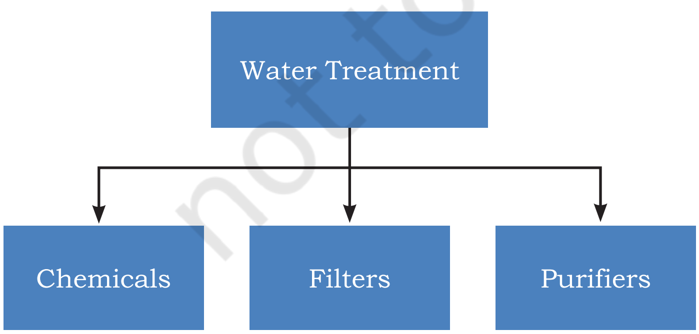


Fig. 4.11: Classification of water treating agent

Chemicals

Different chemicals are used for treatment of water. Commonly used chemicals for water treatment are chlorine, chlorine dioxide and ozone. These chemicals kill unwanted small organisms or microorganisms present in the water. This will improve the taste, odour and clarity of water. Excessive use of chemicals for the treatment of water is harmful to the human body.

Fig. 4.12: Sediment filter

Filters

Filters reduce contamination of water by removing the impurities. A filter removes certain forms of impurity from water. There are four main types of filters —

- Sediment filter
- Carbon block filter
- TFC/TFM Membrane filter
- Inline carbon filter

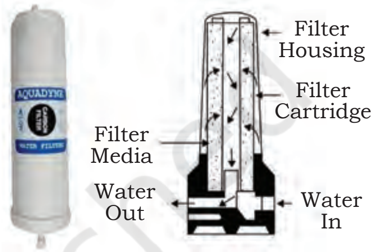


Fig.4.13: Carbon filter

Sediment filter

Sediment filters are used to reduce solid particulate. Sediment filters remove suspended matter, such as sand, silt, loose scale, clay or organic material from water. Untreated water passes through the sediment filter, which removes insoluble or suspended particles. In treatment of drinking water, sediment filtration can be an option for reducing water contamination. Sediment filters do not remove dissolved material and contaminants such as, chlorine, lead, mercury, etc.

Fig. 4.14(a): TFC/TFM membrane filter

Carbon filter

The use of carbon filter is based on the principle of chemical adsorption. Carbon is activated by adding positive charge which enhances the surface area as well as the ability of the filter. Carbon filter removes chlorine, arsenic, lead, asbestos, salts of metals, etc.

Thin-film Composite (TFC) Membrane filter

Thin-film composite is a semi-permeable membrane used in the Reverse Osmosis (RO) water purification system. Untreated water is forced through the membranes which act like a strainer and allows pure water to pass through leaving the dissolved contaminants behind.

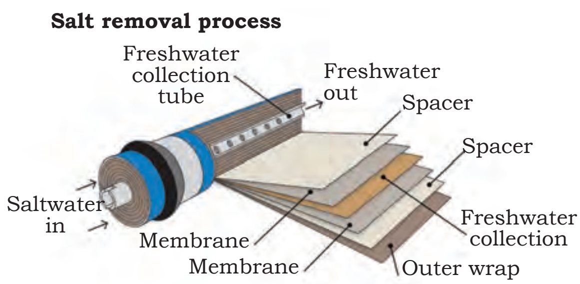


Fig. 4.14(b): Internal Features of TFC/TFM membrane filter

Fig.4.15: Inline carbon filter

Inline carbon filter

Carbon filters can also be installed inline as a part of the reserve osmosis water purification system. They are used as pre-treatment to safeguard other water treatment units such as, TFC/TFM membranes, from any damage due to organic pollutants or oxidation.

Purifiers

Water purifiers remove contaminants, such as, excess salts, suspended particles and microbes dissolved in water and preserve its necessary minerals. Purifiers deactivate deadly bacteria and viruses making the water safe for consumption. These unique water purifiers also come with a storage tank. They are ideal for purifying tap and municipal water. Water purifiers are based on patented Mineral RO technology. Purifiers use double purification to combine Reverse Osmosis (RO) and Ultraviolet (UV)/Ultra Filtration (UF) in a multistage filtration process. It removes even dissolved impurities and retains essential minerals giving pure and safe drinking water. The difference between water filters and purifiers is based on the type of impurities removed by each one of them.

Fig. 4.16 lists the main differences between the two.

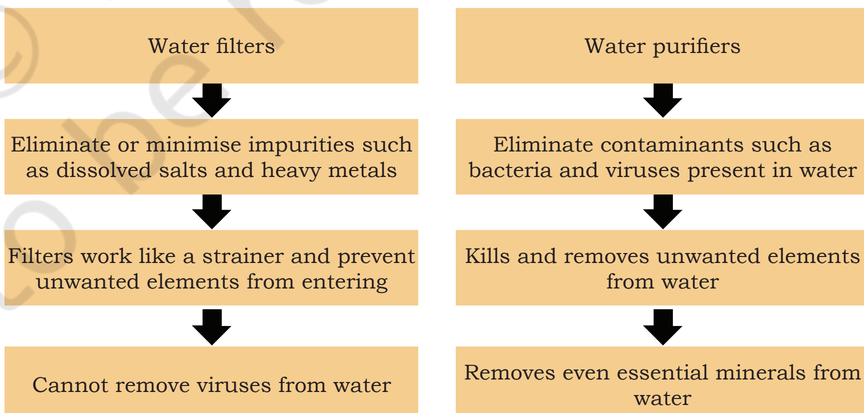


Fig. 4.16: Difference between Water Filters and Water Purifiers

Assignment

Identify the structural requirements of a water purifier.
Discuss the functions of its different structural parts.

Flow of Water and Electric Current in RO Water Purifier

Fig. 4.17 shows the flow of water in an RO purifier.

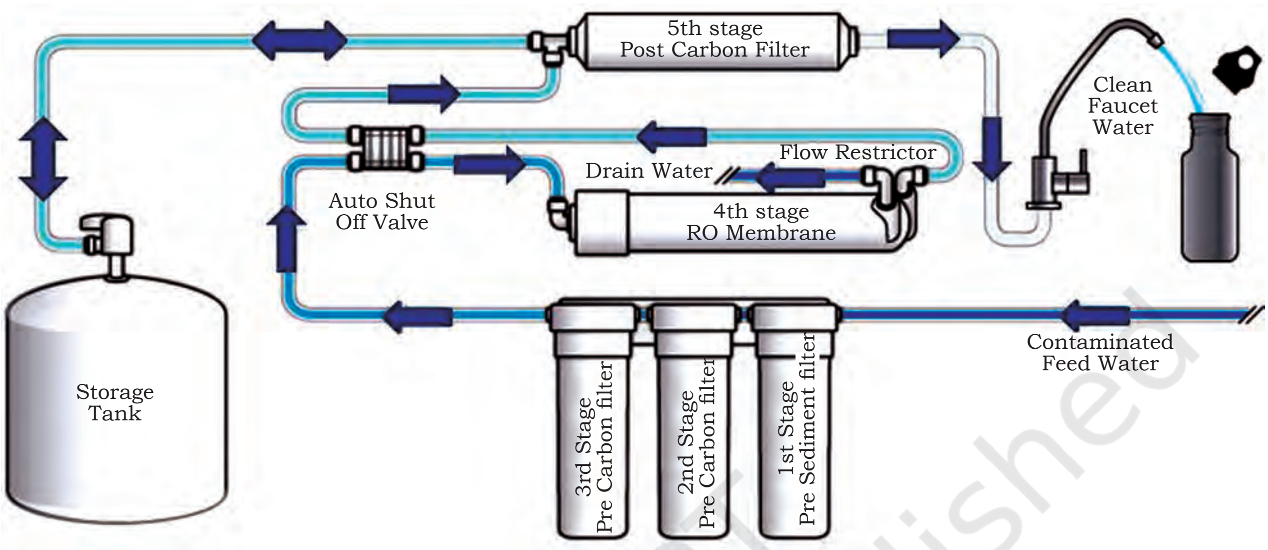


Fig. 4.17: Water flow in an RO water purifier

Fig. 4.18 shows the flow of electric current in on RO purifier.

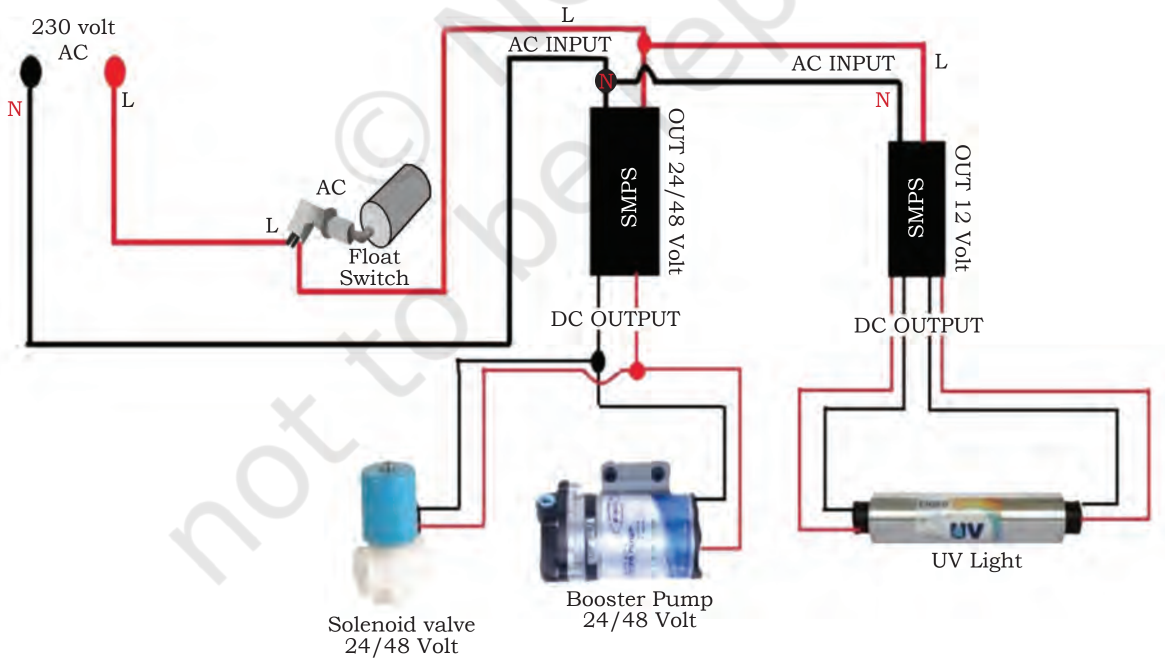


Fig. 4.18: Electrical circuit diagram of an RO Water Purifier

Water Purification and Different Layers of Filter

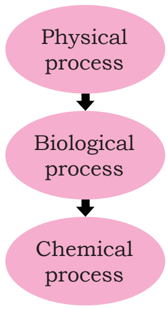


Fig. 4.19: Stages of water purification

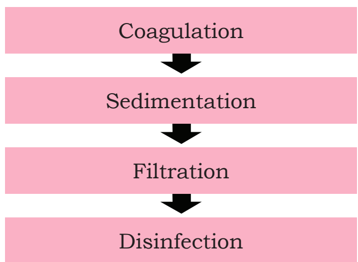


Fig. 4.20: Water purification processes

Water Purification

Water purification is the process of removing contaminants from untreated or raw water to get pure water that is safe for consumption. It consists of three different processes.

Physical process	Filtration, sedimentation and distillation
Biological process	Slow sand filters or biologically active carbon filters
Chemical process	Flocculation, chlorination and the use of ultraviolet light

Steps of the purification process

The water purification process consists of four major steps as shown in Fig. 4.20.

Coagulation

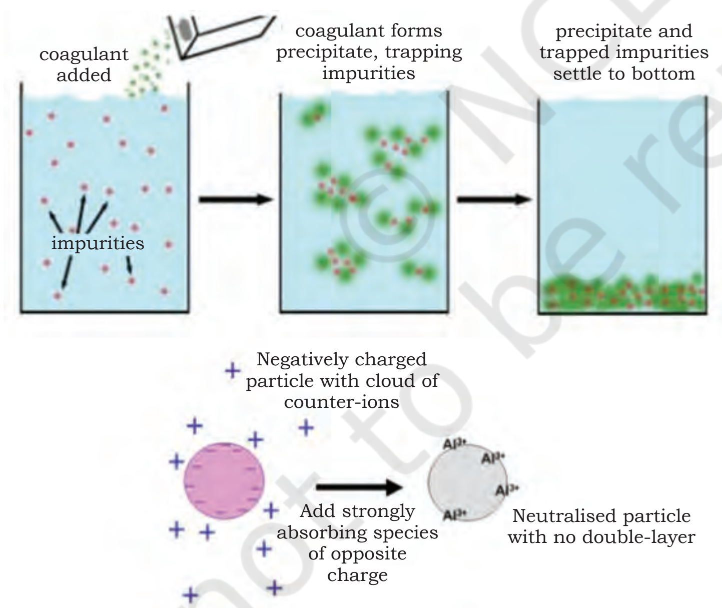


Fig. 4.21: Coagulation

Coagulation in water purification is a process of transforming small particles to bigger particles. In impure water, very small particles are present and hence these particles are not removed using a strainer. To filter out these small particles, chemicals are added. The most common form of chemical used is alum. Alum is positively charged. It neutralises the negative charge of small particles. Then the particles can stick together, forming larger particles which are more easily removed by filteration. When the water from the ground, lakes or river enters a water treatment plant, it is coagulated by the addition of alum and other chemicals. These heavy particles settle at the bottom.

Sedimentation

Sedimentation is a physical process of water treatment. It uses the gravitational force to settle the small particles. All the suspended particles settle down at the bottom by the effect of gravity.

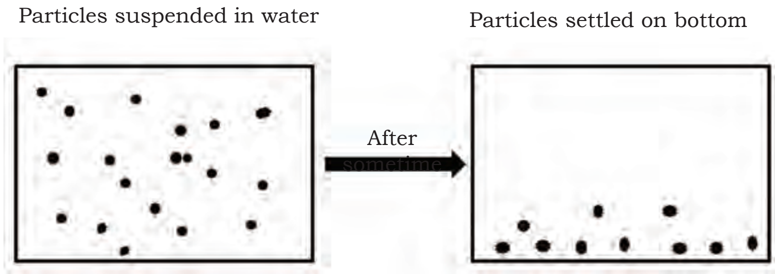


Fig. 4.22: Force of gravity used to settle the small particles

Filtration

Filtration is the process of separating suspended solid matter from a liquid. This is performed by passing the water through some material having pores, called filter. The filtration tanks consist of layers of gravel and sand which filter out the remaining contaminants.

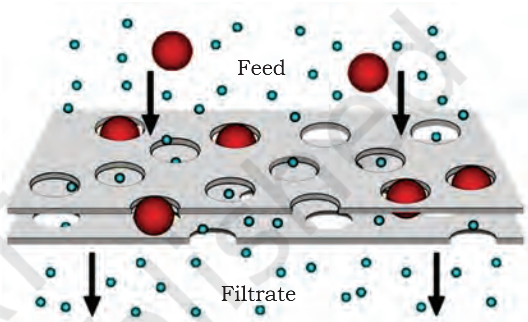


Fig. 4.23: Filtration

Disinfection

The water is passed into a closed reservoir containing disinfectants such as chlorine. These disinfectants kill the bacteria or microorganisms present in water. The purified water then flows through pipes to homes.

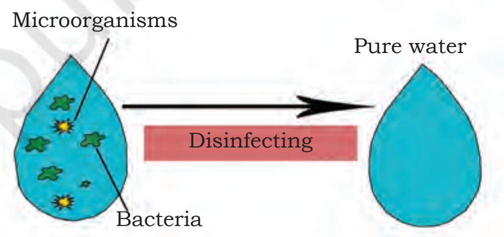


Fig.4.24: Disinfection

Assignment

Label all the parts of standard carbon black filter following image.

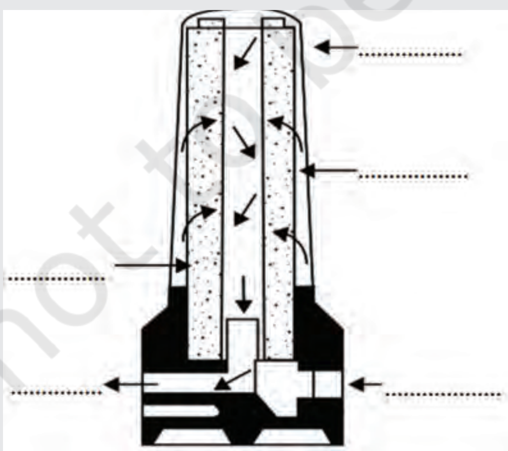


Fig. 4.25

Different Technologies in Water Purification

Water Purifiers

Fig. 4.26: Water purifier

Pure, clean and safe drinking water is a necessity for human life and health. Water that is supplied in homes is contaminated with organic and inorganic impurities. It becomes critical to purify the tap water to ensure that it is safe for consumption.

A water purifier removes contaminants, such as, excess salts, suspended particles and microbes dissolved in water. The process of purification preserves the necessary vitamins and minerals of water. Fig. 4.26 shows a common water purifier.

Types of water purifiers

There are five major categories of water purifiers, depending on the purification methods they use. Fig. 4.27 lists these categories.

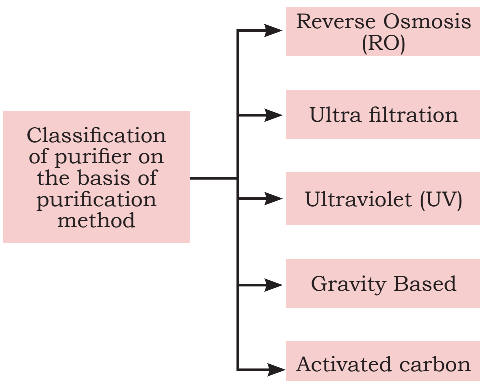


Fig. 4.27: Types of water purifiers

Reverse Osmosis (RO) water purifiers

RO water purifiers are the most commonly used purifiers and they are based on the principle of reverse osmosis. They make use of the membrane technology to eliminate contaminants such as, salts, heavy metals and germs dissolved in water. Fig. 4.28 shows an RO purifier membrane.

The main advantages of using an RO purifier are—

- Removes impurities such as lead, arsenic, mercury and germs from water
- Environment friendly
- Suitable for hard water
- Suitable for water with high total dissolved salts (TDS)
- Easy to install and maintain

Fig. 4.28: RO purifier membrane

There are certain disadvantages of an RO water purifier:

- Removes essential minerals along with dissolved impurities.
- Changes the taste of water.
- Wastes large quantity of water.

- Requires electricity to purify water.
- Requires special care and maintenance for its membrane.

Ultra Filter water purifiers

Ultra Filter (UF) water purifiers use membranes similar to an RO membrane but with larger pores. They remove all the germs and bacteria from water but do not remove dissolved salts or solids. They are suitable in homes where the water supplied is not very hard and has less dissolved salts. The process of purification in a UF purifier is shown in Fig. 4.29.

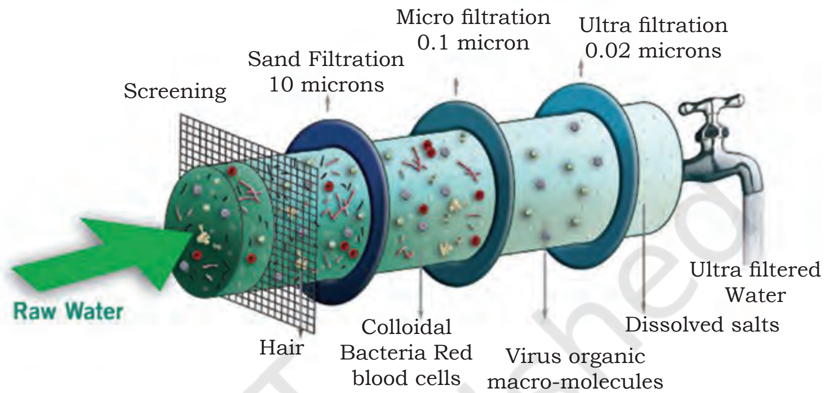


Fig. 4.29: Process of purification in a UF purifier

The main advantages of using a UF purifier are—

- Removes impurities and germs from muddy water
- Environment friendly
- Does not require electricity to purify water
- Retains the taste of water
- Easy to install and maintain

There are certain disadvantages of a UF purifier. They are—

- Unable to remove dissolved impurities, such as, arsenic, lead, nitrates and fluorides
- Ineffective as compared to an RO water purifier as it cannot block dissolved salts and solids
- Ideal only for water with low TDS

Ultraviolet (UV) Water Purifiers

Ultraviolet (UV) water purifiers use ultraviolet rays to kill all germs, bacteria and microbes dissolved in water.

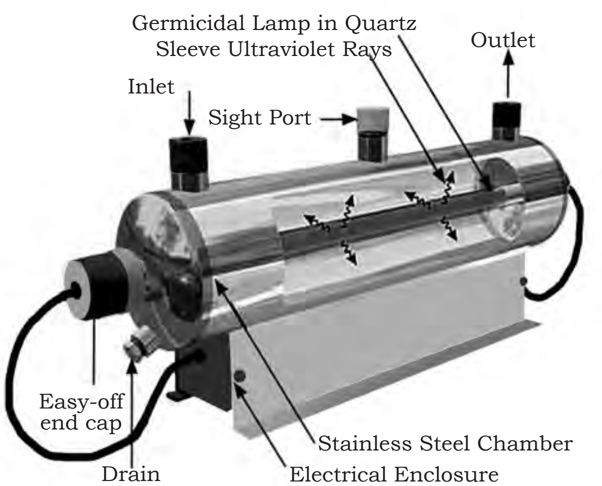


Fig. 4.30: UV water purifier

A small mercury lamp is placed inside the purifier, which produces high frequency short wavelength UV radiations. When water passes through this element, it is exposed to the Ultraviolet light which kills all the living organisms. Separate filters then remove these dead organisms. Ultraviolet purifiers are used in residences, water stores, restaurants and municipalities. Fig. 4.30 shows the working of UV water purifiers.

The main advantages of using a UV purifier are—

- It removes viruses, bacteria and germs from water.
- It is environment friendly.
- No chemicals are added to water.
- It retains the taste of water.
- It is easy to install and maintain.

There are certain disadvantages of a UV purifier:

- It is unable to remove dissolved impurities, such as, arsenic, lead, nitrates and fluorides.
- It requires electricity to purify water.

Gravity Based water purifiers

Gravity based water purifiers are based on the principle of gravity. The water flows from a higher compartment over the filters to a lower compartment. They do not require electricity and use either chemical based, UF based or ceramic cartridge based filters to purify water. Fig. 4.31 shows the parts of a gravity based purifier.

The main advantages of using a gravity based purifier are—

- Removes impurities and germs from muddy water
- Environment friendly
- Does not require electricity to purify water
- Suitable for soft water
- Portable and easy to install

There are certain disadvantages of a gravity based purifier:

- Unable to remove dissolved impurities, such as, arsenic, lead, nitrates and fluorides

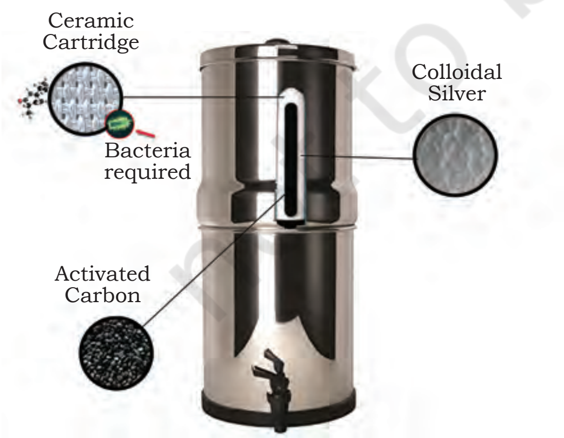


Fig. 4.31: Gravity based purifier

- Ineffective as compared to an RO water purifier as it cannot block dissolved salts and solids
- Good only for water with low TDS

Fig. 4.32(a): An activated carbon block filter

Fig. 4.32(b): Carbon block filter absorbed impurities

Activated Carbon water purifiers

Carbon with a positive charge added to it is called activated carbon. When water flows over it, the negative ions of contaminants get attracted to the surface of the activated carbon filter. Activated carbon water purifiers can remove volatile organic compounds, pesticides, herbicides, chlorine and other chemicals found in tap water. This makes the water safe to drink.

The process of purification uses activated carbon water purifier. Typical, carbon block filters are shown in Figs. 4.32(a) and 4.32(b).

Assignment

Match the following

1. Gravity Based water purifiers	(a) Removes impurities, such as, lead, arsenic, mercury and germs from water
2. UV water purifiers	(b) Removes volatile organic chemicals
3. RO water purifiers	(c) Removes viruses, bacteria and germs from water
4. Activated Carbon water purifiers	(d) Removes impurities and germs from muddy water

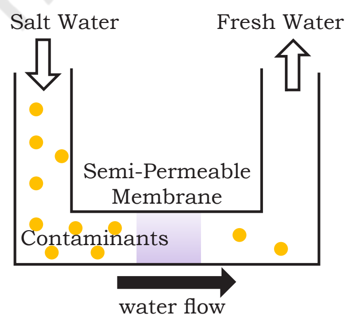


Fig. 4.33: Reverse osmosis process

Different features and function of purifier

RO water purifier

In this process, pressure is applied on contaminated water to force it through a semi-permeable membrane. Water passes through the membrane and impurities are left behind. The water is purified by filtering and flushing out the impurities as shown in Fig. 4.33.

Properties of RO water purifier

The properties of an RO water purifier are shown in Fig. 4.34.

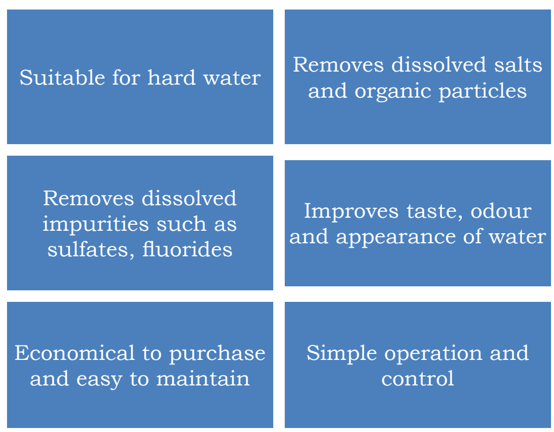


Fig. 4.34: Properties of RO water purifier

NOTES

Components and functions of RO water purifier

The following table lists the basic components of an RO system.

Supply line valve  *Fig. 4.35(a)*	Attaches the inlet of the RO pre-filter to the water source through a tube
Pre-filter sediment  *Fig. 4.35(b)*	Removes sand, dirt and other sediments
Carbon filter  *Fig. 4.35(c)*	Adsorbs chemical impurities such as, chlorine pesticides and improves odour and taste of water
RO membrane  *Fig. 4.35(d)*	Removes almost all dissolved salts, impurities and bacteria
Water tank  *Fig. 4.35(e)*	Stores water for post-filtration
Post filter  *Fig. 4.35(f)*	Also known as polishing filter as it removes the remaining taste and odour from the treated water

Shut-off valve  *Fig. 4.35(g)*	Automatically shuts-off water supply to the membrane when the storage tank gets full
Check valve  *Fig. 4.35(h)*	Prevents backward flow of water from the tank to the membrane
Flow restrictor  *Fig. 4.35(i)*	Maintains pressure on the inlet of the membrane to ensure the highest quality of water
Drain line  *Fig. 4.35(j)*	Connects one outlet of the membrane to the drain to dispose off waste (contaminated) water

Functioning of RO water purifier

Following steps explain the functioning of an RO water purifier.

Step 1: Water enters from the supply line.

Step 2: Water enters the sediment filter, which strains out sand, dirt and sediments.

Step 3: Water enters the carbon filter, which removes chlorine and other contaminants.

Step 4: Water enters the RO membrane, which filters out all the additional contaminants.

Step 5: Water enters the storage tank. Waste water containing impurities is drained out.

Step 6: Water enters post filter to remove any remaining odour and taste in water.

Step 7: Water leaves the filter and goes to faucet.

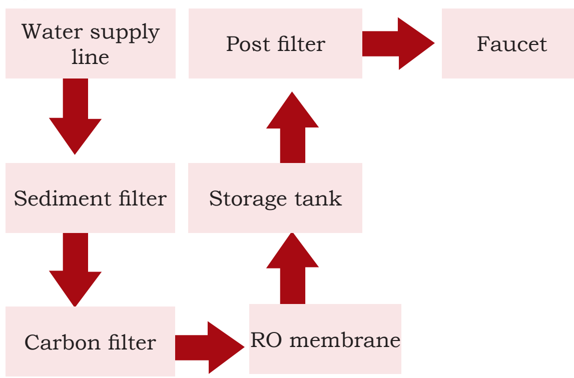


Fig. 4.36: Functioning of an RO water purifier

Notes

Practical Exercises

Activity 1

Maintaining adequate water pressure at the inlet source.
For maintaining suitable pressure in the inlet of purifier, the following steps have to be considered.

Material required

Pressure gauge, pipe, pressure regulator

Procedure

1. To measure the pressure of water flowing in the pipe of water purifier, first turn off the water supply.
2. Locate the main water supply, there is a threaded spigot as shown in Fig. 4.37.

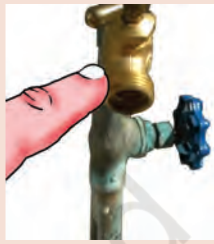


Fig. 4.37

3. This spigot has a valve or a lever next to it as shown in Fig. 4.38.

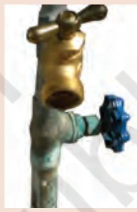


Fig. 4.38

4. Screw the end of the pressure gauge in the threaded spigot as shown in Fig. 4.39.

Fig. 4.39

5. Twist the valve to turn ON the water supply in the pipe as shown in Fig. 4.40.

Fig. 4.40

6. This will allow the water to flow through the spigot and will give you a reading on your pressure gauge.
7. The needle on the gauge should move to a number that represents the water pressure in pounds per square inch or PSI.
8. Note down the reading on the pressure gauge.
9. The average pressure for the purifier is 50–70 PSI.
10. If the reading is greater than this average value, release the pressure using the pressure regulator till it reaches the appropriate value.

Fig. 4.41: Pressure release valve

Notes

Installation

Specifications for installation of water purifier

System location

The RO system should be located on a level surface. The area where water purifier is going to be installed must be sheltered from Sun, wind and rain. The temperature in this area should be maintained, and should not fall below 35°F, or greater than 95°F. If these limits are exceeded, the components may be damaged and the warranty may be considered void. It is important to allow sufficient space around the unit for easy maintenance.

Plumbing

The membranes and high pressure pumps require a continuous and stable flow of water to the system. Please refer to the manual for minimum flow rate and minimum feed pressure.

NOTES

Feed water

Piping used for feeding water to the RO system should be either copper or plastic. Iron and carbon steel pipe will increase the iron content of the water. This will adversely affect the RO system's performance. Temperature of the feed water must not exceed 95^{o}F.

Important: It is recommended to install a pressure gauge on the feed water line. This will help to maintain the pressure of the feed water.

Concentrate (waste) line connection

Connect the waste line to the backside of the system. The tubing or piping used for discharge of the concentrate should be run to an open drain in a free manner. Any blockage in the drain can increase pressure in the back, which will increase the system operating pressure. This may result in damage to the system components.

Electrical supply

A properly sized electrical service must be provided by the customer. Motors and electrical requirements must be according to the supply voltage. Electrical supply to the system must be compatible with the requirements for each model. Install the system in accordance to local and national electrical codes.

Pre-filtration

Most RO systems come with particulate pre-filters to remove suspended particles down to five (5) micron in size. Change pre-filter cartridges at least once every month. Additional pre-treatment may be required, depending on the feed water parameters.

Caution: If the pre-filters become blocked and the water flow to the pump is reduced or interrupted, it will result in the formation of an empty space with in the pipe. This may damage the pump.

Inspections

Prior to start-up, carefully inspect the system. Check plumbing, electrical connections and make sure no connections have become loose during shipment.

Guidelines for Installation of Water Purifier

Fig. 4.42 lists the guidelines that should be followed before installing an RO water purifier.

The installation process begins with site preparation. The recommended site preparation steps are —

- Ensure that single-phase power socket connection is within 3 m of the point of installation.
- Ensure that raw water supply is within 3 m from the point of installation.
- Ensure that raw water supply tank is at least 10 feet above the purifier.
- Ensure that there is a sink near the purifier.
- Ensure that waste water drain is within 3 m from the point of installation.
- Ensure that enough space is there as per the dimensions of the purifier.

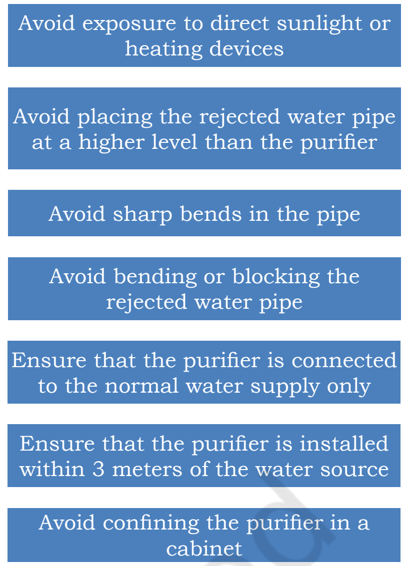


Fig. 4.42: Pre-installation guidelines

Steps to be performed while installing RO water purifier—

Step 1: Unpacking the purifier

1. Carefully place the water purifier packing box on a plane surface as shown in Fig. 4.43.
2. Cut the packing strips on the packing box with the help of a knife as shown in Fig. 4.44.
3. Open the water purifier packing box as shown in Fig. 4.45.

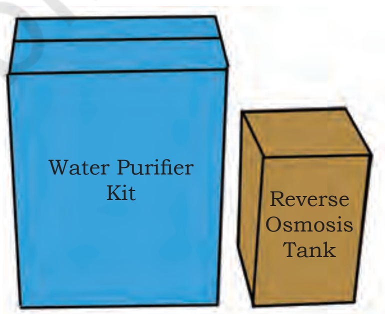


Fig. 4.43: Water purifier kit

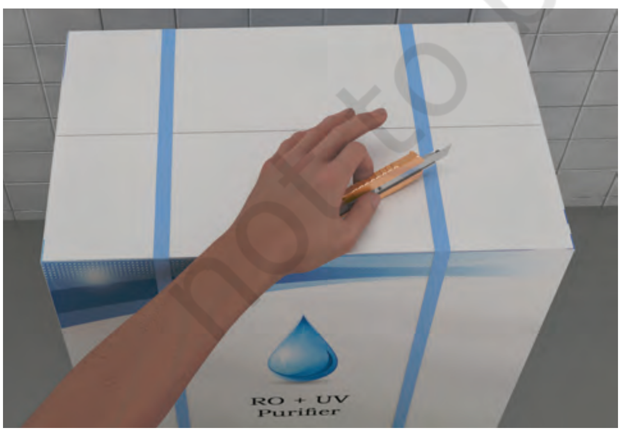


Fig. 4.44: Unpacking the box

Fig. 4.45

4. Take out all the accessories from the packing box as shown in Fig. 4.46.
5. Take out RO water purifier from the packing box carefully as shown in Fig. 4.47.

Fig. 4.46

Fig. 4.47

6. Place the water purifier on the plane surface as shown in Fig. 4.48.
7. Remove the thermocol packing and remove the polythene cover from the water purifier as shown in Fig. 4.49.

Fig. 4.48

Fig. 4.49

Practical Exercises

Notes

Activity 2

Demonstrate the points that have to be considered for site inspection and preparation.

Material required

Water purifier to be installed

Procedure

The following points have to be kept in mind while selecting the site for the installation of water purifier:

1. Placing the water purifier near a source of water
2. Placing the water purifier near an electrical point.
3. Make sure that the socket through which the purifier is to be powered should have proper earthing.
4. Distance between the purifier and the water source should be within 3 m.
5. Distance between the purifier and the electrical supply should be within 3 m.
6. Distance between the purifier and the drainage system should be within 3 m.
7. Place the purifier away from direct heat or sunlight.
8. Remember that the membrane needs to be changed periodically. Keeping in mind this step; select a location where the membrane can be easily replaced.
9. If there is an issue of space, purifier can be mounted on the wall.

Assignments

1. A customer has asked you the names of all the components of RO water purifier. List all the components that you will tell them.
2. Visit the site and identify the place for installation. Suppose, you got a call regarding the installation of a purifier. List the factors which have to be considered for selecting the site for installation.
3. Remove the packaging of water purifier and dispose the packaging material waste as per norms. Write the steps to unpack the water purifier and discuss the precautions to be taken while unpacking the water purifier.

Fig. 4.50 (a): Water purifier

NOTES

Items in the box

(a) Water purifier as shown in Fig. 4.50(a)

(b) Three-way connector

Fig. 4.50 (b): Three-way connector

(c) SS ball valve

Fig. 4.50 (c): SS ball valve

(d) Grade pipe

Fig. 4.50 (d): Grade pipe

(e) Screw and plastic inserts

Fig. 4.50 (e): Plastic insert

(f) Drilling sticker

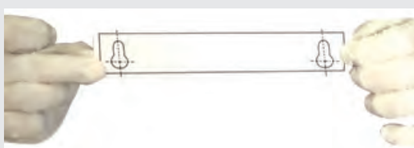


Fig.4.50 (f): Drilling sticker

Assignment

Check the product specifications and other supporting accessories. List the items that are present in the box and note down their specifications.

Items in the box	Name
 *Fig. 4.51*	
 *Fig. 4.52*	
 *Fig. 4.53*	
 *Fig. 4.54*	
 *Fig. 4.55*	
 *Fig. 4.56*	

NOTES

Notes

Assignment

Arrange tools and fittings required for the installation. List the tools required for the installation and maintenance of the water purifier.

Tools and equipment	Name
 *Fig. 4.57*	
 *Fig. 4.58*	
 *Fig. 4.59*	
 *Fig. 4.60*	
 *Fig. 4.61*	

Step 2: Setting up the water connection

1. Keep all the plumbing accessories and tools ready before turning off the main water supply line, so that it is interrupted for minimum possible time.
2. Turn off the main supply line.
3. Always install purifier on the normal water supply and not on the hot water supply as shown in Fig. 4.64.
4. Take out the tap from the water supply line carefully, using pipe wrench as shown in Fig. 4.65.
5. Fix the three-way connector with an external thread as shown in Fig. 4.66.
6. Use teflon tape to create a leak-free joint as shown in Fig. 4.67.
7. It should be wrapped tightly on a three-way connector in a clockwise direction, otherwise it may loosen while tightening on the water supply line as shown in Fig. 4.68.
8. Insert the end of the external thread of the three-way connector into the water supply line as shown in Fig. 4.69.
9. Use teflon tape on the tap to create a leak free joint as shown in Fig. 4.70.
10. Now, insert the tap into the hex end of the three-way connector and tighten it using pipe wrench as shown in Fig. 4.71.


Fig. 4.62: Plumbing accessories


Fig. 4.63: Main supply valve

Fig. 4.64


Fig.4.65


Fig. 4.66


Fig. 4.67


Fig. 4.68

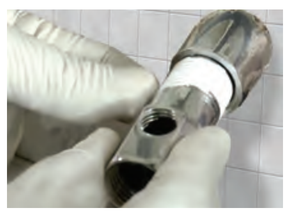


Fig. 4.69

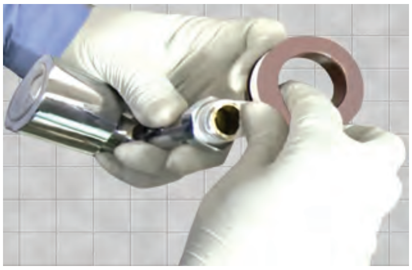


Fig. 4.70

Fig. 4.71

Fig. 4.72(a)

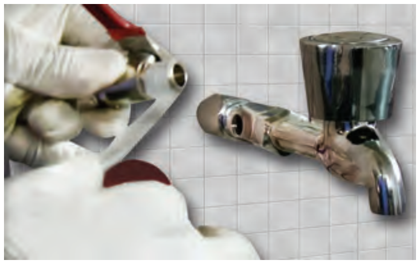


Fig. 4.72(b)

Fig. 4.73

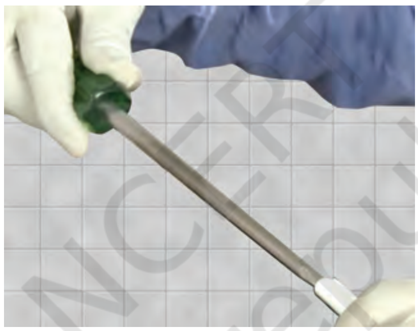


Fig. 4.74

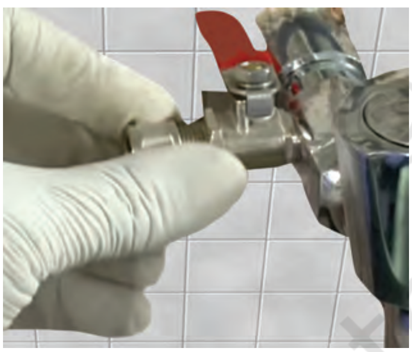


Fig. 4.75(a)

Fig. 4.75(b)

11. Use SS ball valve; use Teflon tape again on the SS ball valve thread to create a leak free joint as shown in Fig. 4.72 (a) and 4.72 (b).
12. Insert the SS ball valve into the ¼ inch port of the three-way connector as shown in Fig. 4.73.
13. Take a white pipe. Broaden up its mouth from one end by inserting a screwdriver into it as shown in Fig. 4.74.
14. Move a hex nut present on the SS ball. Insert this hex nut into the white pipe from the non-broadened end as shown in Fig. 4.75 (a) and 4.75 (b).
15. Push the broad end of the white pipe onto the SS ball valve. Make sure that pipe completely slips over the nipple of SS ball valve as shown in Fig. 4.76.
16. Tighten the hex nut securely on the SS ball valve to lock the pipe in its place as shown in Fig. 4.77.

17. The water supply remains OFF when the lever is perpendicular to the SS ball valve.
18. The water supply remains ON when the lever is parallel to SS ball valve.

Step 3: Preparing to mount the purifier

1. Every purifier has a drilling sticker with measured marking as shown in Fig. 4.78.
2. Check for the proper horizontal level that should be plane and even surface as shown in Fig. 4.79.
3. The drilling sticker should not be pasted in an inclined angle as water may overflow as shown in Fig. 4.80.
4. Stick the drilling sticker in a proper horizontal straight line as shown in Fig. 4.81.

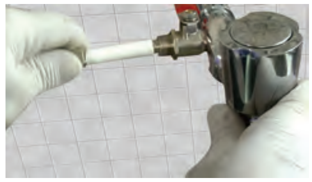


Fig. 4.76

Fig. 4.77

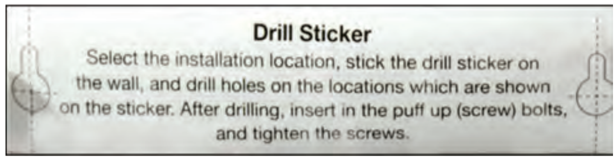


Fig. 4.78

Fig. 4.79

Fig. 4.80

Fig. 4.81

5. Drill two holes carefully into the sticker using the 8 mm drill bit as shown in Fig. 4.82.
6. Drill to such a depth that the plastic inserts could go completely inside the hole as shown in Fig. 4.83.

Fig. 4.82

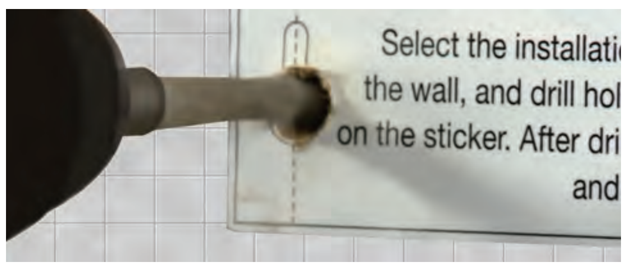


Fig. 4.83

7. Push plastic inserts into the hole using a hammer as shown in Fig. 4.84.
8. Insert two self-taping screws in both the holes using screwdriver as shown in Fig. 4.85. Do not use hammer.

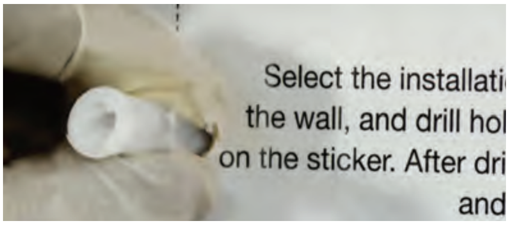


Fig. 4.84

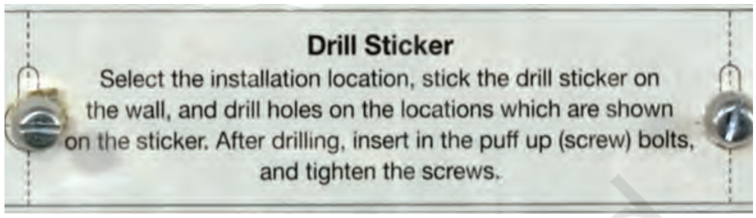


Fig. 4.85

Practical Exercises

Activity 3

Demonstrate the steps for the installation of filter according to the installation guide.

Material required

Hacksaw, bucket, filter, pencil, pipe wrench.

Procedure

1. Turn off the water supply.
2. Next, open a tap to release any remaining water in the pipe and release the pressure in the pipes.
3. Select a location to set up the filter.
4. Mark the spot where you are going to install the filter.
5. Selected location should be visible and accessible.
6. Make two cuts and remove a part of the pipe.
7. But, before removing the cut piece of the pipe, make sure that a bucket is kept nearby for any water that may not have been drained.
8. Now, tighten the fittings but do not tighten too much.
9. The next step is to install the filter. When you place it on the pipe, you have to ensure that it is positioned on the right side.
10. If the filter is working properly, leave the pipe running for several minutes.
11. Sometimes, there may be dirt and sediments in the pipe that need to come out.
12. Once these are expelled and water appears clear, then it is safe for drinking and consumption.

Activity 4

Write down the steps for installing the inlet water supply line before connecting it to the water purifier.

Material required

Bucket, adjustable wrench, pipe cutter.

Procedure

1. Drain the system by turning off the water supply.
2. Now, release the pressure from the lowest point of the water supply system.
3. Drain the remaining water from the lowest point of the water supply system.
4. Locate the place for the purifier, once it is finalised, cut the pipe as per the measurement.
5. Use the template provided with the kit to mark the pipe for exact placement.
6. Attach the fittings.
7. Check the water pressure, using a pressure gauge.

Assignment

Discuss the power requirement of the water purifier.
Hint: Points to be discussed are —

Input voltage: ______________________________

Output voltage: ______________________________

Current capacity: ___________________________

Operating frequency: _________________________

Overload protection: _________________________

Over temperature protection: ________________

Step 4: Installing the purifier

1. Place the purifier on a flat surface and remove the transparent tank tray of the purifier as shown in Fig. 4.86.

Fig. 4.86

Notes

Fig. 4.87

Fig.4.88

2. Remove the mounting plate cover by opening the side screws as shown in Fig. 4.87.
3. Cut the tied wires holding the sediment filter, activated carbon block, RO membrane housing and UV chamber in place as shown in Fig. 4.88.
4. These components are tied so as to save them getting damaged or dislocated from their position during transportation.

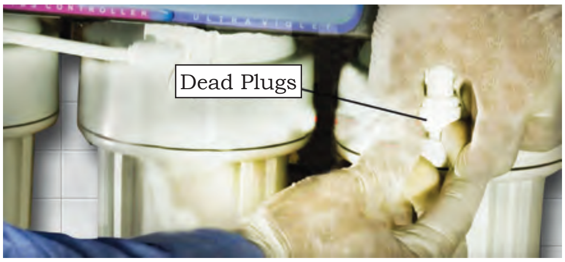


Fig.4.89

Fig. 4.90

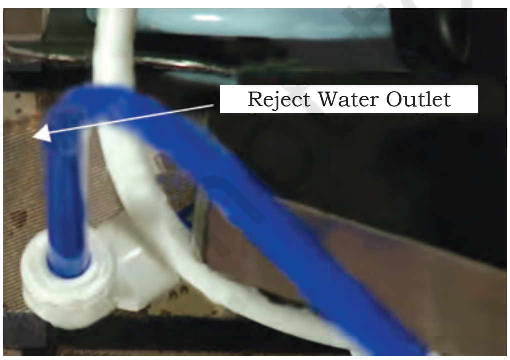


Fig. 4.91

5. Fix the mounting plate cover back.
6. Remove the dead plug from rejected water outlet by pressing the elbow collet with one hand and pulling the dead plug with the other as shown in Fig. 4.89.
7. Remove the dead plug from the raw water inlet by pressing elbow collet with one hand and pulling the dead plug with the other as shown in Fig. 4.90.
8. Fix one end of the blue pipe into the rejected water outlet of water purifier. Push the pipe into the elbow to avoid any leakage as shown in Fig. 4.91.
9. Lead the other end of the blue pipe into the drain as shown in Fig. 4.92.

Fig. 4.92

10. Fix the end not fixed to SS ball valve of the white pipe into the water inlet of the water purifier as shown in Fig. 4.93.

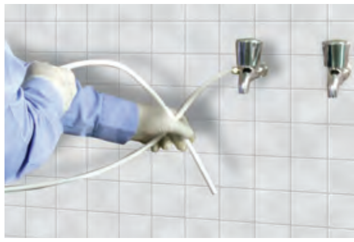


Fig. 4.93

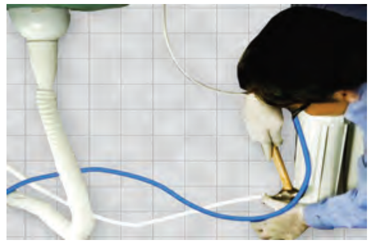


Fig. 4.94

11. Clamp both white and blue pipes on the flat surface as shown in Fig. 4.94.
12. Make sure that the rejected water pipe is not placed at a level higher than the purifier, otherwise the rejected water may flow backward into the purifier as shown in Fig. 4.95.

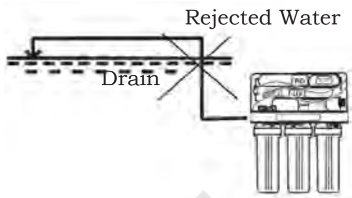


Fig. 4.95

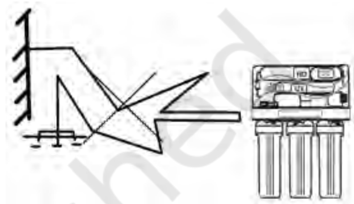


Fig. 4.96

13. Avoid sharp turns in the pipe fitting. Do not bend or block the rejected water pipe as shown in Fig. 4.96.
14. Put the transparent tank as well as tank tray on the mounting plate cover.
15. Insert the power plug into the three-pin socket. Clamp the electric cable on the wall.
16. Turn ON the water supply with the help of SS ball valve lever as shown in Fig. 4.97.

Fig. 4.97

17. Wait for 2–3 minutes after turning on the water supply to pre-soak the filters as shown in Fig. 4.98 and 4.99.

Fig. 4.98

Fig. 4.99

18. Switch on the electric supply.
19. The UV lamp will take approximately three seconds to glow to ensure that it is pre-heated and it is working at its optimum level before it starts disinfecting water as shown in Fig. 4.100.

Fig. 4.100

20. UV and pump will start operating five seconds after being turned on to ensure that the idle water lying in the internal pipes and in the UV chamber

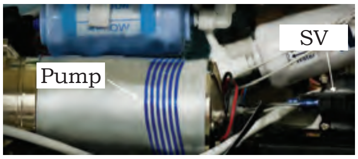


Fig. 4.101

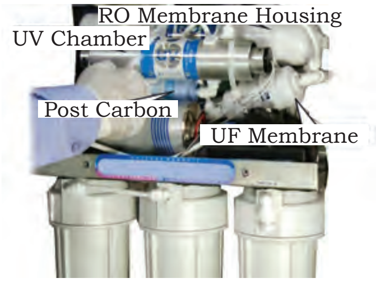


Fig. 4.102

is disinfected before being passed in the storage tank as shown in Fig. 4.101.

21. To check for leakage, shift the mounting plate cover as explained earlier.
22. Take out the post carbon outlet pipe (Fig. 102), check and fix the leakage, and place the mounting plate cover on its previous position.
23. Let the purifier operate until the storage tank is filled.
24. The purifier will shut off automatically. This shows whether the float sensor is working properly or not as shown in Fig. 4.103.

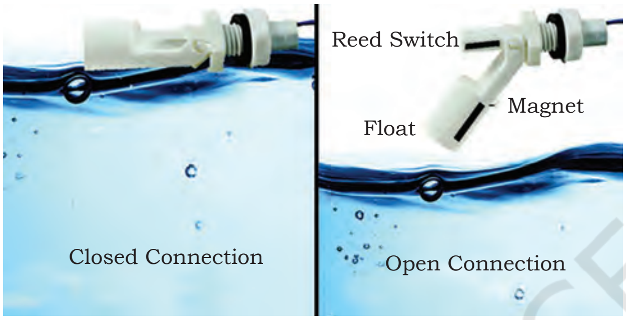


Fig. 4.103

Fig. 4.104

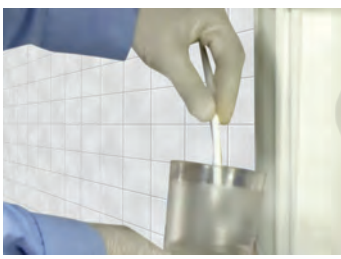


Fig. 4.105

Fig. 4.106

25. Switch off the purifier. Completely drain the storage tank into a container because the first few litres of water purified by the RO membrane are not fit for drinking.
26. Recheck the TDS (Total dissolved solid) level of raw water supply as shown in Fig. 4.104.
27. Check the TDS level of the water coming out from the outlet of the post carbon filter and not the tap water as shown in Fig. 4.105.
28. The purified water level should reduce by approximately 90 per cent of raw water TDS and should not be less than 50 PPM.
29. The recommended TDS level is 50–75 PPM. However, it could be adjusted to the customer's choice of raw water TDS as shown in Fig. 4.106.

Step 5: Adjusting TDS level

1. Firstly, remove transparent tank as well as mounting plate cover.
2. To adjust the TDS levels, unscrew the locking nut first as shown in Fig. 4.107.
3. To increase the TDS level of the purified water, slightly turn the adjustment knob in anti-clockwise direction and to decrease the TDS level of the purified water, slightly turn the adjustment knob in clockwise direction (Fig. 4.108).
4. After adjustment, screw the locking nut as shown in Fig. 4.109.
5. The adjustment roughly takes 3–4 minutes to reflect in the purified water, so wait before checking the TDS level of the purified water as shown in Fig. 4.110.
6. Recheck overall functioning of the purifier and also any leakage, sound, etc., as shown in Fig. 4.111.
7. Now fix the mounting plate by screwing all the screws taken out earlier as shown in Fig. 4.112.
8. Before leaving, clean the stains on the purifier with a moist cloth and mild soap or detergent.
9. Now, the installation is complete (Fig 4.113).

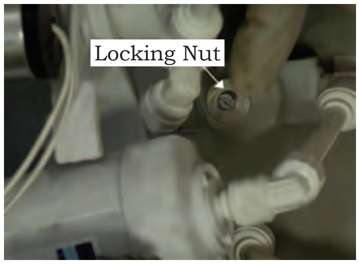


Fig. 4.107

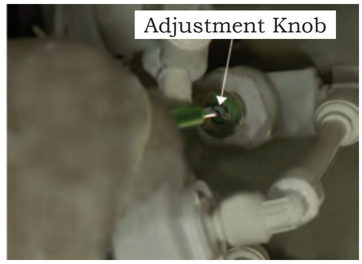


Fig.4.108


Fig. 4.109

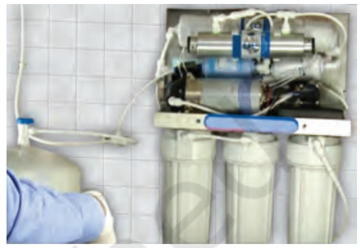


Fig.4.110


Fig. 4.111


Fig. 4.112


Fig. 4.113

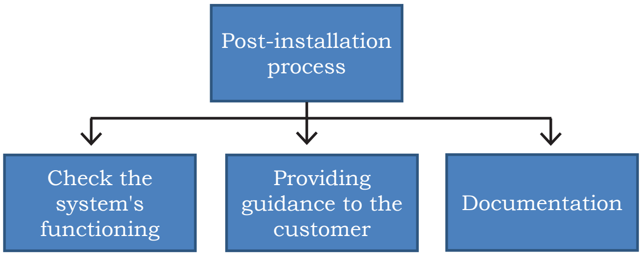


Fig. 4.114

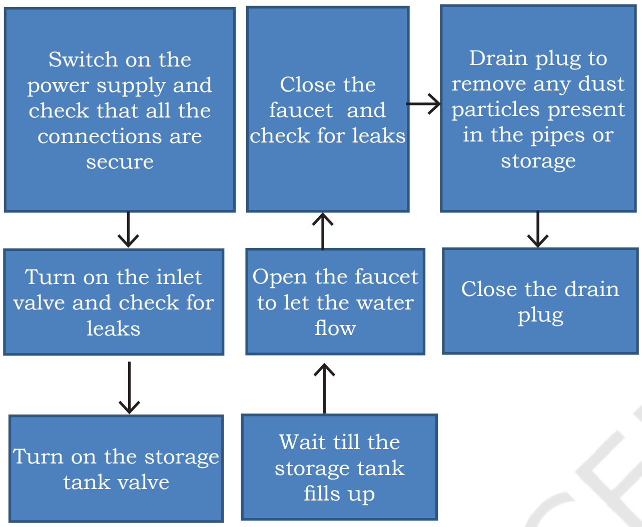


Fig. 4.115: Checks to ensure proper working of an RO purifier

Post-installation Process

Once the purifier has been successfully installed, it is time to follow the post-installation process. This process consists of tasks as shown in Fig. 4.114.

Checking the function of the system

Perform the checks as shown in Fig. 4.115 to ensure that the purifier is working properly.

Guiding the customer

After installing the purifier, the field technician should give a demonstration of how the purifier works and explain the complete operation. The goal of demonstrating is to show the customer how to operate and use the purifier. There are a few rules to be considered while preparing for the demo.

- Customise your demo
- Rehearse before presenting
- Test everything beforehand
- Take customer feedback

Inform the customer about the dos and don'ts of maintenance

Inform the customers that an RO water purifier lasts for many years if it is maintained properly. The dos and don'ts that should be followed are:

- Do not place heavy or sharp objects on the purifier.
- Drain the water from the tank if it has not been used for over two days.
- Do not apply force on the water-dispensing lever.
- Use only genuine spare parts.
- Change the filters and membrane regularly.

Assignments

1. Demonstrate the steps for checking the filter installation alignment according to the instructions given in the installation manual.
2. List the points where leakage can occur in the purifier. Also, discuss the steps to identify the leakage in the purifier.

Hint: Points where probability of leakage is high are at the—

- inlets of water supply
- joint of pressure gauge and main water supply pipe
- joint of carbon filter, sediment filter and membrane filter
- joint of drainage pipe
- faucet
- joint of water tank

Practical Exercises

Activity 5

Demonstrate the steps which a technician must explain to the customer after the completion of installation.

Material required

Pamphlet containing instructions for maintenance

Procedure

1. Do not place any heavy or sharp object on the purifier.
2. Replace the water of the purifier after a day.
3. Purifier should be dusted at regular intervals.
4. Monitor the pressure gauge periodically.
5. Use genuine spare parts in case of replacement.
6. Change the membrane and filter regularly.
7. Check the specification of power supply.
8. Periodically check the total dissolved solids (TDS) of water.

Assignments

1. Suppose you are a water purifier technician. Which point must you communicate to the customer for maintaining the water purifier after completion of installation?
2. Visit a nearby installed purifier assembly. Note down the desired standard parameters, such as, the water pressure and power supply connection according to the water flow diagram.

Notes

NOTES

Documentation Required in the Installation of Water Purifier

The last task of post-installation process is to fill in all the details in the installation report clearly and get feedback from the customer.

Customer acknowledgment form

Customer acknowledgement form is the form in which feedback of the customer is taken. This form acts as a documental proof of being served by the water purifier executive at the customer premises. This shows the satisfactory service of the executive to the customer. Every company has its own format of acknowledgement forms.

Call centre number

Customer care is the monitoring and complaint registering authority of the company. Customers can directly contact the company to file their complaints and give feedback. Customer care is like a bridge between the customer and the company.

Assignments

1. Understand and discuss the parameters mentioned on the customer acknowledgment form. Also, discuss the need of customer acknowledgement form.
2. Suppose, you are a water purifier installation technician. After installation, list out the other documents to be collected for installation of water purifier.
3. Suppose you are a water purifier installation technician. You have installed the water purifier. Discuss the points that have to be informed to the customer care regarding the completion of job.
4. List the important numbers in the table below.

RO Customer Service	Contact number
Service number	
Complaint number	
Toll free number	
RO call centre number	
RO help line number	
RO customer service number	

Check Your Progress

A. Multiple Choice Questions

1. Which of the following is not a type of water purifier?
   (a) RO
   (b) UF
   (c) UV
   (d) UAV
2. Which of the following is not a purification process of water purifier?
   (a) Coagulation
   (b) Sedimentation
   (c) Filtration
   (d) Carbonisation
3. Water treatment agents are classified as ___________ .
   (a) chemical, filters and purifiers
   (b) chemical, membrane and purifiers
   (c) carbon, membrane and purifiers
   (d) sedimentation, filters and chemical
4. Which of the following are not the types of common contaminants that are found in water?
   (a) Bacteria
   (b) Minerals
   (c) Particulates
   (d) Protozoa
5. Which of the following is not a type of water purifier filter?
   (a) RO
   (b) UV
   (c) Gravity based
   (d) Carbon stone
6. Which of the following is the correct distance for waste water drainage from the water purifier?
   (a) 3m
   (b) 4m
   (c) 5m
   (d) 6m
7. Which of the following can be the ideal height to place the raw water supply tank above the purifier?
   (a) 10 feet
   (b) 15 feet
   (c) 20 feet
   (d) 25 feet
8. What is the raw water TDS value?
   (a) 50 PPM
   (b) 100 PPM
   (c) 110 PPM
   (d) 120 PPM

Notes

NOTES

9. Full form of TDS is _____________ .
   (a) total dissipated substance
   (b) total dissolved solid
   (c) total dissolved substance
   (d) total dissipated solid
10. Which of the following can be the average pressure value for the purifier?
   (a) 70–80 PSI
   (b) 60–50 PSI
   (c) 50–70 PSI
   (d) 40–50 PSI
11. The water supply remains _______________ when the lever is parallel to SS ball valve body.
   (a) ON
   (b) OFF
   (c) first ON and then OFF
   (d) water supply does not depend upon the SS ball valve
12. The water supply remains ______________ when the lever is perpendicular to the SS ball valve body.
   (a) ON
   (b) OFF
   (c) first ON and then OFF
   (d) water supply does not depend upon the SS ball valve

B. Fill in the Blanks

1. The process in which small particles are transformed to bigger particles is known as _____________.
2. In ____________ process of water treatment, all the suspended particles settle down at the bottom under the effect of gravity.
3. A purifier based on the principle of reverse osmosis is __________________ .
4. UV water purifiers use _____________ to kill all germs, bacteria and microbes present in water.
5. In UV water purifier, a small mercury lamp is placed inside the purifier, which produces _____________ short wave UV radiations.
6. In water purifier installation, raw water supply is within _____________ from the water purifier.
7. To create a leakage free joint, _____________ is used on the tap and pipe.
8. A purifier based on the principle of gravitational force of earth is known as ____________ .
9. Disinfectants kill the ___________ present in the water.
10. TFC/TFM is a semi-permeable membrane used in the _____________ water purification system.

C. State whether True or False

1. At the time of installation of water purifier, sharp turns in the pipe fittings are avoided.
2. Drill two holes carefully into the sticker using the 8 mm drill bit.
3. Stick the drilling sticker in a proper horizontal straight line.
4. Temperature of the feed water must not exceed 100°F.
5. Most RO systems come with particulate pre-filters to remove suspended particles down to five (5) micron in size.
6. The temperature in the area around the purifier should be maintained, and should not fall below 20 °F.
7. Water treatment methods remove contaminants from water to make it safe for human consumption.
8. In purification process, necessary vitamins and minerals of water are preserved.
9. Gravity based water purifier works on the principle of reverse osmosis.
10. Total dissolved solid level of raw water supply is approximately 974 PPM.

D. Answer in Brief

1. Write down the steps to replace the membrane.
2. List the different types of water purifier.
3. Discuss the water purification process.
4. Write down the specification for power supply in the water purifier.
5. List the items present in the packing box of the water purifier.

NOTES

Chapter 5

Repair and Maintenance of Water Purifier

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Introduction

When we buy a new appliance, after a period of time, it requires repair and maintenance. This routine maintenance of a machine uplifts its efficiency and working life. Likewise, a water purifier is also a machine, which we use in our daily lives. Among all the appliances, which are there at home, water purifier is an appliance, which works continuously. Therefore, to maintain its performance and efficiency one needs to have the knowledge of repairing its non-working parts. In this unit, students will learn the repair and maintenance of water purifier.

Identify the Concerns of the Customers

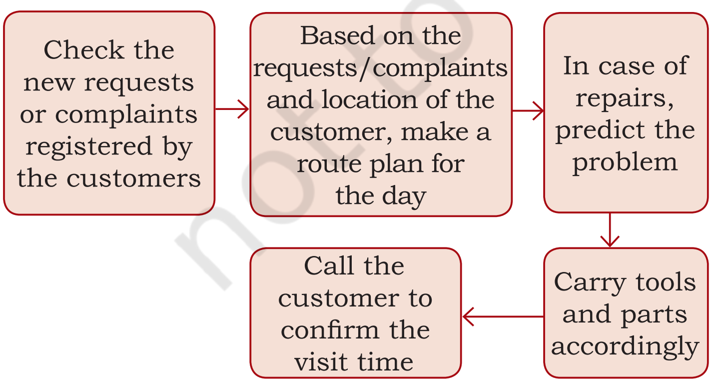

Fig. 5.1: To-do list for a technician

A field technician is responsible for the maintenance and repair of RO systems installed at customer's premises. It is very important to clearly understand the concerns of the customer. Fig. 5.1 represents the various activities which should be done before scheduling a visit to the customer.

Interact with the Customers on Phone

Prior to visiting a customer's premises for repairing and servicing, it is important to call the customer first and ask about the problem in detail as shown in Fig. 5.2.

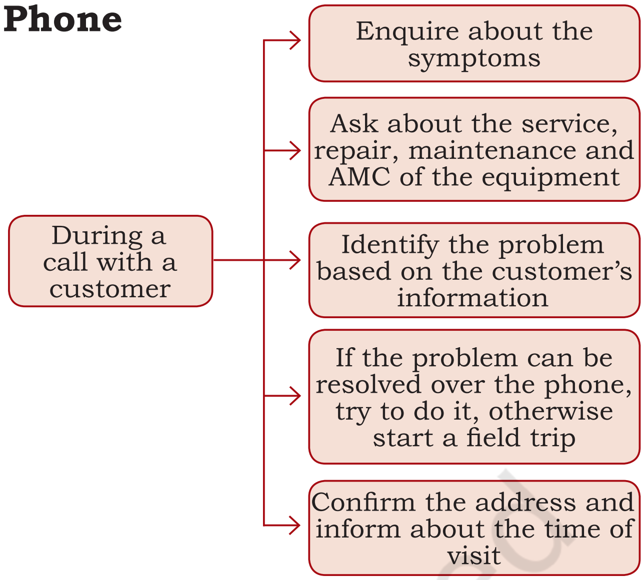

Fig. 5.2: Interacting with customer on phone

Interact with the Customer at their Premises

It is a good practice to be humble and respectful towards the customer. Fig. 5.3 represents how to interact with a customer when visiting the premises for service or repair.

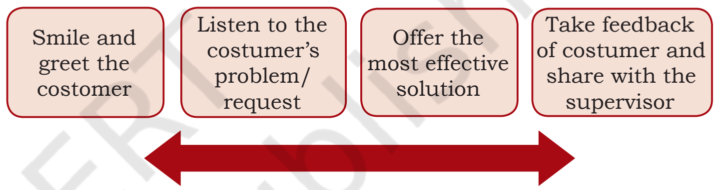

Fig. 5.3: Good practices while interacting with the customer

Identify the Fault

It is very important for a technician to identify the fault correctly. Wrong identification of the fault will lead to wrong solution, which will be a waste of time and money and can cause damage to the appliance. Steps to be followed in case of fault are shown in Fig. 5.4.

When visiting a customer for a repair or servicing request, it is important to know the details of

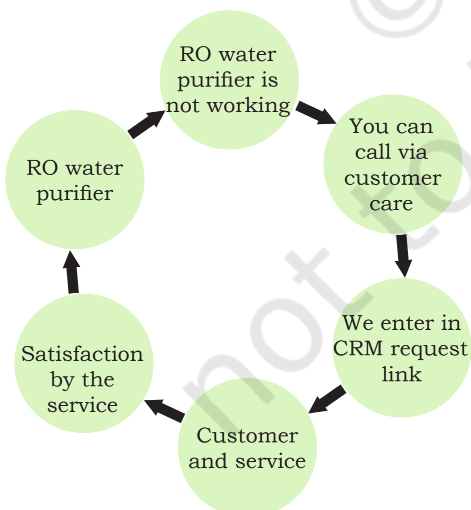

Fig. 5.4: Steps to be taken by the customer and company in case of fault

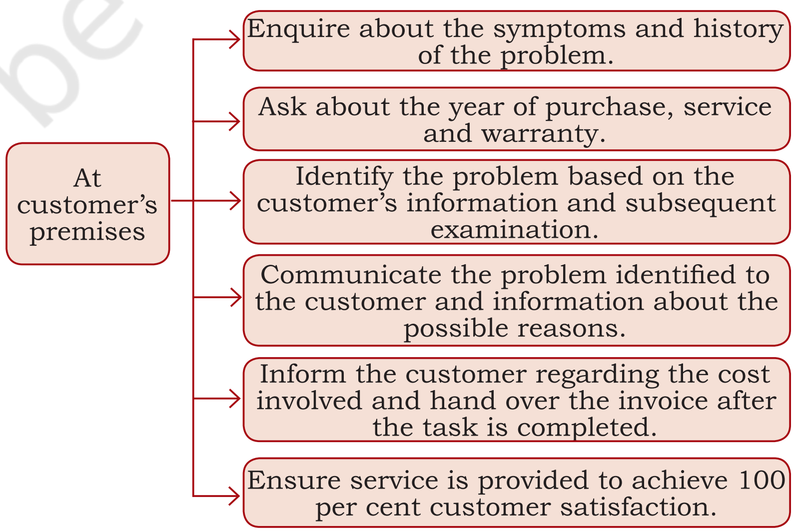

Fig. 5.5: To-do list to be followed at a customer's premises

the problem and accordingly suggest a corrective measure. The customer should be satisfied with the suggested solution.

Fig. 5.5 highlights the to-do list to be followed at a customer's premises.

Suggest a Solution to the Customer

After identifying the issue, the field technician needs to offer solutions. They should explain all the possible solutions along with the cost associated. They should then propose the best solution and let the customer decide whether to go ahead with the given solution or not. Fig. 5.6 shows the steps involved in offering solutions to a customer.

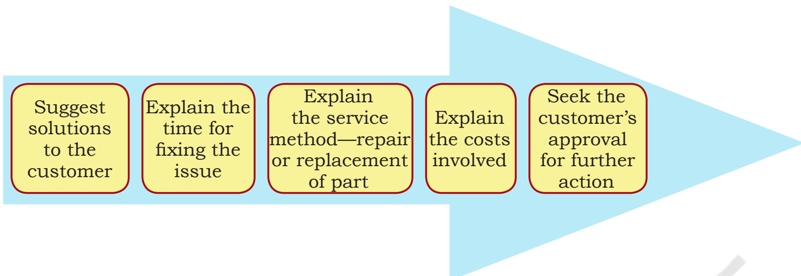

Fig. 5.6: Suggesting a solution to the customer for an issue

Assignment

1. You are a home appliance repair technician. You just received a phone call from a customer who is very angry for a poor service done by one of your colleagues. The person is threatening to charge you for the bad service. How should this situation be handled?
2. Diagnose and list the possible faults based on customer interaction and initial inspection. The following table defines some of the common faults and diagnosis of water purifier based on initial inspection and customer interaction.

Common fault	Diagnosis
Problem of leakage	Check and tighten the joints of water purifier
Increase in TDS level	TDS level can be decreased by replacing the membrane or by changing the filters
Rise in water pressure	This can be diagnosed by releasing the extra pressure using pressure regulator
Interrupted power supply	Proper earthing is required for uninterrupted power supply
Improper flow of water, slowdown of water supply	This can be diagnosed by replacing the filter or membrane, and by maintaining the proper inlet flow of water in the water purifier.

Practical Exercises

Activity 1

Demonstrate the steps for maintaining the water pressure as per company standards.

Material required

Pressure gauge, spanner

Procedure

Step 1: Check the pressure of the inlet water supply using pressure gauge as shown in Fig. 5.7.

Fig. 5.7

Step 2: Check if reading in the pressure gauge exceeds the average value of water flow pressure as shown in Fig. 5.8.

Fig. 5.8

Step 3: Use the spanner to release the pressure of the water flow by unscrewing the nut as shown in Fig. 5.9.

Fig. 5.9

Step 4: Again, check the pressure gauge and note down the reading. Make sure that it has reached the specified average value of the water flow pressure as shown in Fig. 5.10.

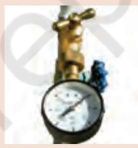

Fig. 5.10

Activity 2

Demonstrate the steps for shutting off the system by turning OFF water supply and unplugging the unit.

Material required

SS ball, spanner, wrench

Procedure

Step 1: SS ball valve is used to control the flow of water in the water purifier.

Step 2: The water supply remains OFF when the lever is perpendicular to the SS ball valve body.

Step 3: The water supply remains ON when the lever is parallel to the SS ball valve body.

Step 4: To unplug the unit, remove the plug from the socket.

Assignments

3. Discuss the points which should be followed in order to avoid spilling on the floor.
4. List the point which is to be considered while inspecting the feed water valve and tank valve.

Replace the Dysfunctional Part in the Water Purifier Unit

Troubleshooting

Troubleshooting refers to identifying and repairing the faulty products or processes. It begins with searching for the source of the problem and ends with finding the solution for that to ensure that the product or process functions properly. Good troubleshooting consists of the following four steps.

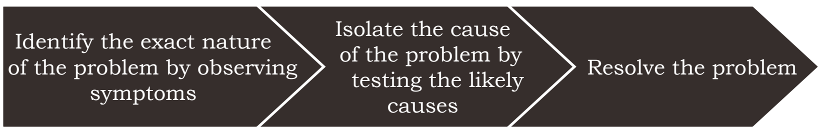

Fig. 5.11: Steps for troubleshooting

- Identification of the symptoms
- Elimination of the causes of a problem
- Verification of the solution
- Restoration of the product or process

The field technician should follow some simple steps for troubleshooting as shown in Fig. 5.11.

Troubleshooting chart

The following table lists some common problems and their solutions.

Issue	Reason for fault	Solution
Not enough or no water from the tap	Blocked or closed feed water input	Open or unblock valve
	Blocked sediment or carbon filter	Replace the filters
	Closed tank valve	Open valve
	Blocked drain flow restrictor	Replace drain flow restrictor
	Membrane housing valve stuck	Replace or check the valve
	Malfunctioning automatic shut-off valve	Replace automatic shut-off valve
	Polluted membrane	Replace the membrane

Low pressure from water outlet tap or faucet	Incorrect air pressure in storage tank	• Empty the storage tank • Pressurise the tank to 8 PSI • Re-install the tank • Turn on the feed supply
	Blocked post carbon filter	Replace the post carbon filter
	Partially closed tank valve	Open the tank valve
	Faulty faucet	Replace the faucet
High TDS in output water	Blocked pre-filter	Replace the pre-filter
	Incorrectly sealed membrane	Install the membrane correctly
	Exhausted membrane	Replace the membrane
	Output and drain water lines reversed	Swap the connections
	Malfunctioning automatic shut-off valve	Replace the automatic shut-off valve
	Dirty post-carbon filter	Clean or replace the post-carbon filter
Bad taste or odour	Blocked post carbon filter	Replace the post carbon filter
	Exhausted membrane	Replace the membrane
	Dirty storage tank	Clean the storage tank
	Water in storage tank left for a long time	Drain and clean the storage tank
Leaking membrane housing	Leak in the threaded end cap	• Lubricate O-ring and tighten the cap • Replace O-ring if the leak continues
	Leak in cap or body of housing	• Check the housing or cap for cracks • Replace if cracked or damaged

Leaking filter housing	Improper O-ring seating	• Seat O-ring in the groove • If dirty, clean and lubricate the O-ring • Replace if cracked or damaged
	Loose housing cap	Properly tighten the cap by hand
	Damaged housing	Replace if cracked or damaged
Leaking fitting	Damaged or cracked fitting	Replace the fitting
	Improper tubing or thread installation	Check and correct the tubing and thread installation
System continuously running	Automatic shut-off valve not working	Replace the automatic shut-off valve
	Low incoming water pressure	Increase the water pressure to 40 psi
	Low air pressure in storage tank	Increase air pressure to 5 – 7 psi
	Worn out flow restrictor	Replace the flow restrictor
	Incorrectly installed membrane	Check membrane installation
Noisy drain or faucet	Air gap in faucet	Check for air gap and whether the faucet is properly installed
	Drain tube	Check drain line for loops, bends, dips or kinks

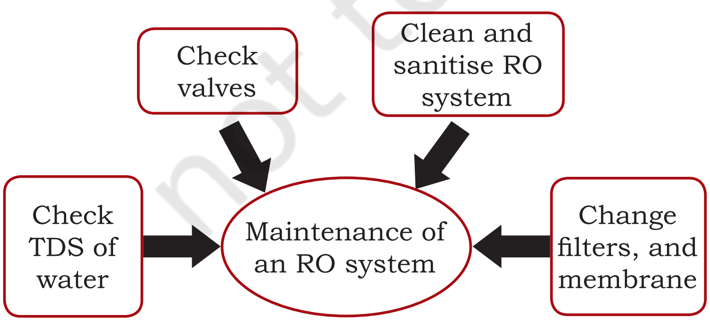

Fig. 5.12: Maintenance of an RO system

Maintenance of RO Water Purifiers

To ensure that the water purifier provides the same quality water, it is essential to perform periodic maintenance of the system. Fig. 5.12 lists the components of the maintenance of an RO system.

Check TDS of Water

Water is often called the universal solvent because it picks up impurities easily. The impurities can be minerals, salts, metals or ions and are also known as 'dissolved solids'. These dissolved solids increase the electrical conductivity of water. TDS is used as a measure to determine the purity of water and the quality of water purification systems.

Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) are the total amount of solids dissolved in water. It is the sum of positively charged ions (cations) and negatively charged ions (anions) in the water. It is measured in units of mg per unit volume of water (mg/L) and is also referred to as parts per million (ppm).

The maximum contamination level advised for TDS is 500 mg/L and a high level of TDS indicates the possibility of toxic ions such as lead, arsenic, cadmium and other substances dissolved in water. Fig. 5.13 shows the various levels of TDS in water.

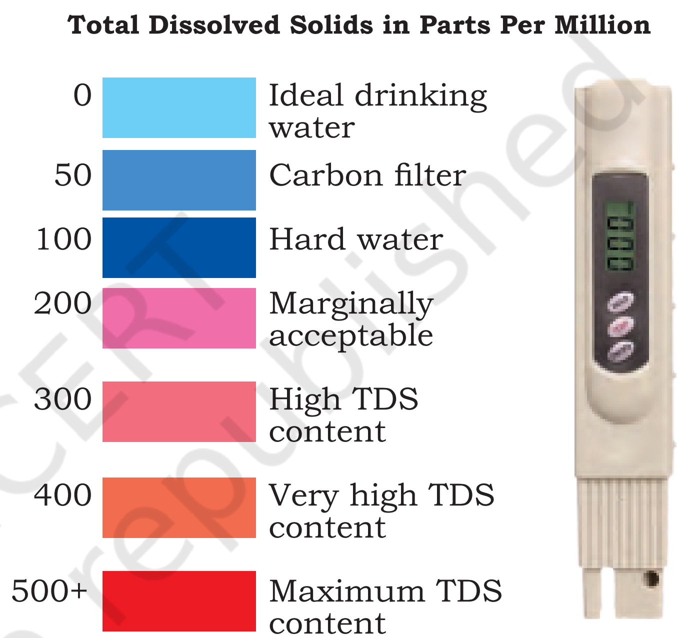

Fig. 5.13: Levels of TDS in water

It is important to monitor the TDS regularly to ensure that the water purification system is effective in removing unwanted particles from water. Fig. 5.14 lists the reasons for testing water for high TDS.

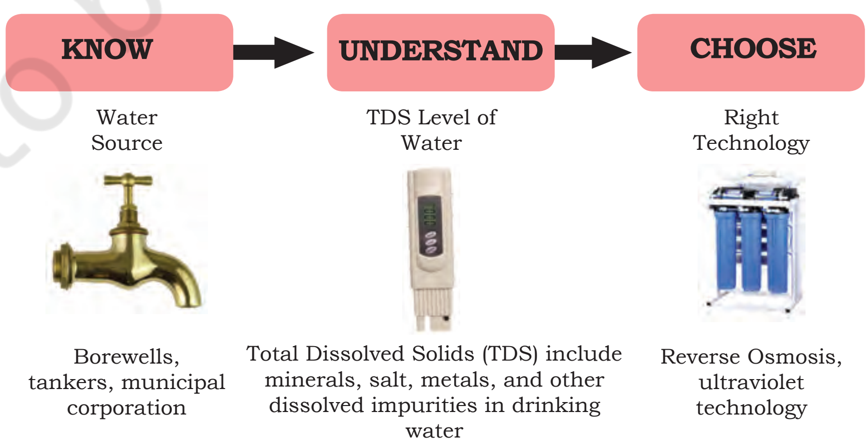

Fig. 5.14: Reasons for testing water for high TDS

Fig. 5.15: TDS meter

Ensure that the tank is not empty
↓
Remove the drain line from the drain saddle
↓
Turn off the water supply
↓
Turn on the tank valve
↓
Check if drain water is running
↓
If water is running, then ASV or CV is defective
↓
Replace the CV and check water drainage
↓
If water stops, stop testing
↓
If water continues to drain, replace ASV

Fig. 5.16: Steps to check valves of an RO system

TDS meter

TDS of water or any solution is measured with the help of TDS meter. A small hand held device measures the electrical conductivity of water and estimates the TDS from that reading.

Taking TDS measurements

A TDS meter is easy to use. The steps of taking TDS measurements using a TDS meter are as follows.

Step 1: Collect water in a clean glass.
Step 2: Remove the cap and turn the TDS meter ON.
Step 3: Insert the meter into the water.
Step 4: Lightly stir the water to displace any air bubbles.
Step 5: Wait for the display to stabilise.
Step 6: Press the HOLD button to view the reading.
Step 7: Remove the meter and shake off excess water.
Step 8: Replace the cap.

Valves

An RO system has two types of valves—Auto shut-off valve (ASV) and check valve (CV). If either of the two is defective then the RO system will not shut-off and the water will flow constantly.

Fig. 5.16 lists the steps involved in checking auto-shut-off valve and check valve.

Assignments

1. A technician needs to take TDS measurement of a water sample. Fill in the blank steps to complete the procedure.

   Step 1: Collect water in a ____________.

   Step 2: ____________ the water.

   Step 3: Lightly ____________ the water to __________ any _________.

   Step 4: Wait for the display to ___________.

   Step 5: Press the __________ to view the reading.

   Step 6: Remove the meter and shake off excess water __________ the cap.

2. The water purifier is giving low water pressure from dispensing faucet. How would you fix this?

Clean and Sanitise RO System

An RO system should be cleaned and sanitised at least once every year. The steps to sanitise an RO system are listed in Fig. 5.17.

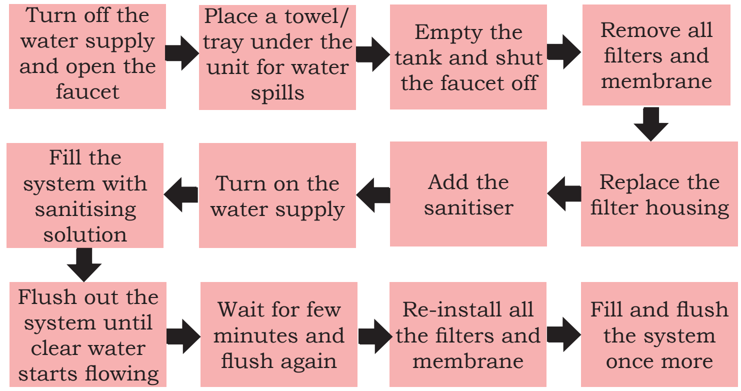

Fig. 5.17: Steps to sanitise an RO system

Changing Filters and Membrane

It is recommended to change the filters and membrane of an RO system as per the following schedule.

Filter	Duration
Sediment filter	Change after 6–12 months
Carbon filter	Change after 6–12 months
Post carbon filter	Change after 12 months
Reverse osmosis filter	Change after 24 months

Changing filter

Fig. 5.18 lists the steps involved in changing the filter.

Changing membrane

Membrane is one of the filtering components of purification. All membranes are shipped loose. They should be installed prior to start-up. They are also shipped dry to better handle extreme temperatures during shipment and storage.

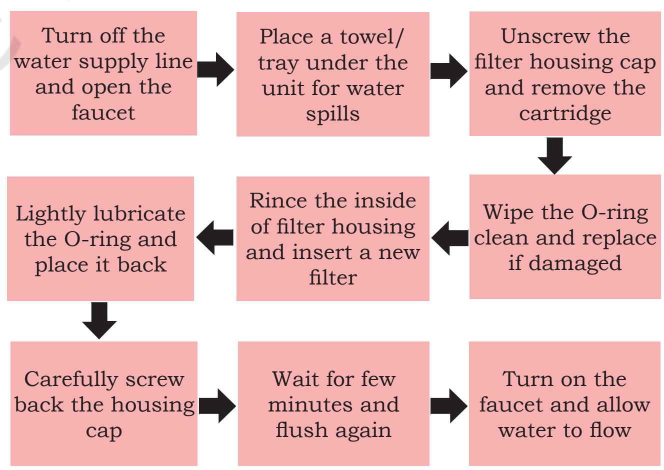

Fig. 5.18: Steps of changing the filter

Monitoring of membrane

Membrane can be monitored by checking the TDS (Total dissolved solids) level of purified water. The given TDS level chart represents the quality of water.

TDS level	Water Hardness
0–80 ppm	Very soft (Ideal for drinking)
80–150 ppm	Soft (might be used for drinking)
150–400 ppm	Hard (use RO purifier)
Above 400 ppm	Very hard (use RO + UV purifier)

Constant TDS level of water in the range 0–150 ppm is a good indication that RO water purifier is working properly. It is highly recommended to replace the membrane when the TDS level increases above 150 ppm. For this reason, it is essential to monitor the TDS level of the purified water. The timing of membrane replacement depends on feed water quality and a number of other factors.

Practical Exercises

Activity 3

Demonstrate how to replace the damaged components—membrane, filter, valve and water tank.

Material required

Screwdriver, plier

Procedure

A. To replace the membrane

1. Unscrew the membrane housing by removing the blue clip as shown in Fig. 5.19.
2. Once the membrane housing is unscrewed, remove the old membrane by pulling it upward using pliers, if necessary, as shown in Fig. 5.20.

Fig. 5.19

Fig. 5.20

3. Install the new membrane by inserting it downward into the housings, with the seal at the top end of the membrane. Be sure to push each membrane as far down into the housing as possible.

Fig. 5.21

4. Make sure the black ring on the membrane must be at the top end of the membrane housing as shown in Fig. 5.22.

Fig. 5.22

5. When installing membranes, orientation of the black ring must be properly done. The black ring must not fold over when inserting it into the membrane housings as shown in Fig. 5.23.

Fig. 5.23

6. Now, again tighten the cap of the membrane housing using membrane wrench as shown in Fig. 5.24.

Fig. 5.24

7. Fig. 5.25 explains the steps involved in changing the membrane.

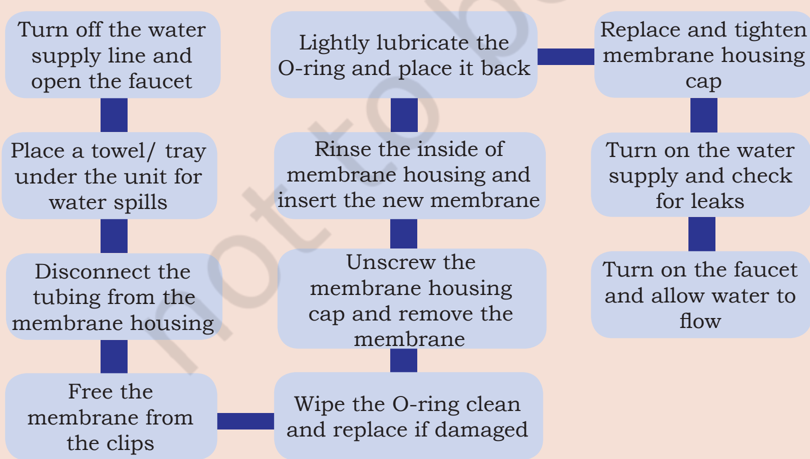

Fig. 5.25: Steps of cleaning the membrane

B. Replacement of filter

1. Turn off the feed water line using the SS ball valve.

Fig. 5.26

2. Turn OFF the SS ball valve by turning the lever in perpendicular direction to the SS ball valve body.

Fig. 5.27

3. Release the excessive pressure using the pressure release valve.

Fig. 5.28

4. Put the wrench to first filter housing, open the housing by rotating the wrench in clockwise direction as shown in Fig. 5.26.

5. Remove the filter from the housing and discard the filter if necessary (Fig. 5.27).

Fig. 5.29

6. Put the new filter into the housing as shown in Fig. 5.28.

7. Ceramic filter is used in stage one and carbon black filter in stages two and three.

Fig. 5.30

8. Before closing the housing, make sure that every housing has a black O-ring as shown in Fig. 5.30.

9. Tighten the housing by turning it in anti-clockwise direction as shown in Fig. 5.31.

Fig. 5.31

C. Replacement of valve

1. Turn off the main water supply.

2. Release the excessive pressure using the pressure release valve.

Fig. 5.32

3. Cut the water supply pipe using pipe cutter over which the SS ball valve has to be placed as shown in Fig. 5.32.

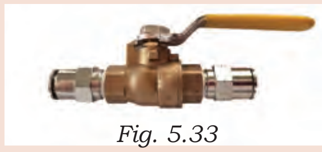

Fig. 5.33

4. SS ball valve has two ends having threads, one lever at the top to turn the supply OFF or ON as shown in Fig. 5.33.

Fig. 5.34

5. Fit the SS ball valve at the appropriate place on the main water supply pipe as shown in Fig. 5.34.

6. Use thread tape for tightening the SS ball pipe as shown in Fig. 5.35.

Fig. 5.35

7. After properly tightening the SS ball valve, turn the SS ball valve ON by turning the lever parallel to the SS ball valve body as shown in Fig. 5.36.

Fig. 5.36

8. Check for any leakage at the joint.

D. Replacement of water tank

Water tank must be replaced when there is not enough air pressure in the water tank.

1. Turn off the SS ball valve by turning the lever in the perpendicular position w.r.t. to the SS ball valve body.
2. Release the excessive pressure using the pressure release valve.

Fig. 5.37

3. Disconnect the storage tank pipe using pipe wrench which is connected to the filter unit as shown in Fig. 5.37.
4. Wait for the water to flow out through the pipe of water tank.
5. Replace the water tank, connect the new tank to the filter unit using pipe wrench as shown in Fig. 5.38.

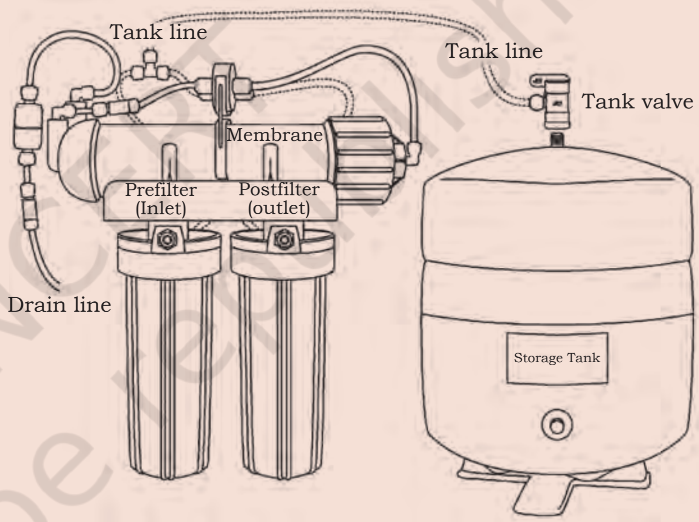

Fig. 5.38

Assignments

1. Discuss the steps for the maintenance of RO water purifier.
2. Match the RO system with the recommended duration for changing them.

1. Post carbon filter	(a) Changes every 6–12 months
2. Reverse Osmosis membrane	(b) Changes every 6–12 months
3. Carbon filter	(c) Changes every 12 months
4. Sediment filter	(d) Changes every 24 months

Confirm Functionality of the Repaired Unit

Reassembling Components of the Water Purifier

After detecting the faulty components or modules, these are replaced by new ones. Reassembling is the relocation of components or module at their respective place. Reassembling is a very critical task and is done after replacement of the component or module. All the components must be located at their respective places. The steps of reassembling are discussed in Practical Activity 4.

Check that all connections are secure

Check for leaks

Check the flow of water

Check the TDS of water

Fig. 5.39: Checks performed after repair

Confirmation of Functionality of the Repaired Module

Once the purifier has been repaired, ensure that the unit is functioning properly with the repaired or replaced parts. Fig. 5.39 lists the checks that should be performed after repairs are done.

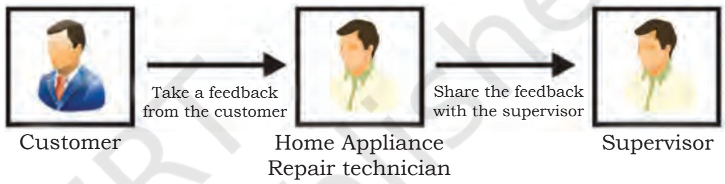

Fig. 5.40: Procedure for taking customer feedback

Take Feedback from the Customer

The last step of understanding the customer's concerns is to take feedback from the customer, as this is the most important thing for an organisation. The procedure to collect customer feedback is given in Fig. 5.41.

The time taken to resolve an issue and the difficulties that a customer encountered while communicating the problem should be understood. The misunderstandings observed during the interaction should be clearly documented. The methods of interaction and

Customer Feedback Form

Please fill the form. We value your feedback.

date: ________________ Location ____________________

Service: Complaint ☐ New Connection ☐

1. How would you rate our service?
   ☐ Very Good
   ☐ Good
   ☐ Poor
2. Did the technician come with all the necessary tools and equipment to do the job?
   ☐ Yes ☐ No
3. Did the technician behave politely with you?
   ☐ Yes ☐ No
4. Did the wireman have knowledge of the work to be done?
   ☐ Yes ☐ No
5. Any suggestion which you would like to share.

Fig. 5.41: Sample customer feedback form

behavioural aspects also need to be considered in drawing conclusions after each task or problem handling routine. Getting honest feedback from the clients helps to improve the organisational functioning. The field technician can get a feedback form filled by the customer at the premises. Fig. 5.41 shows a typical template for a customer feedback form.

Practical Exercises

Activity 4

Demonstrate the steps for reassembling the unit and start the water supply and confirm the functioning.

Material required

Water purifier unit, screwdriver, pipe wrench, pipe cutter, hacksaw, RO+UV water purifier, Sediment filter, Pre-carbon filter, post-carbon filter, Membrane housing, UV filter, Pump, Adapter, Water tank, Connecting pipe, Pipe Cutter.

Procedure

1. Connect the output wire of the adapter to provide the supply to the pump.
2. Connect the sediment filter to the inlet of the water supply as shown in Fig. 5.42.

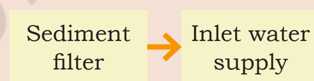

Fig. 5.42

3. Next, connect the inlet of pre-carbon filter to the outlet of sediment filter as shown in Fig. 5.43.

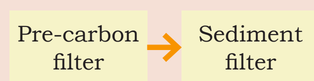

Fig. 5.43

4. Outlet of the pre-carbon is connected to the inlet of pump as shown in Fig. 5.44.

Fig. 5.44

5. Now, outlet of pump is connected to the inlet of the membrane housing as shown in Fig. 5.45.

Fig. 5.45

6. As membrane housing has two outlets, one is connected to the reject pipe through which waste water gets drained out. The other outlet of membrane housing through which mineral water passes to next stage, is the post carbon filter as shown in Fig. 5.46.

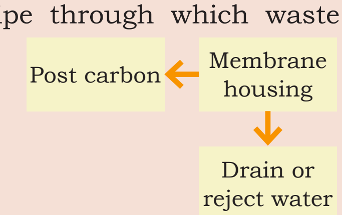

Fig. 5.46

7. Outlet of post-carbon is connected to the UV filter as shown in Fig. 5.47.
8. UV filter is the last stage of the filtration process.

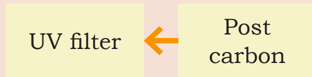

Fig. 5.47

9. Outlet of the UV filter is connected to the inlet of water storage tank as shown in Fig. 5.48.

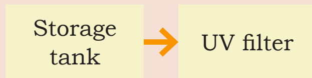

Fig. 5.48

10. Connect the UV lamp power supply with the terminals of UV filter.
11. Now, start the water supply by turning the SS ball valve.
12. After turning 'ON' the water supply, feed water enters into the sediment filter and from there, water passes through the different stages of filtration as explained above.
13. Check for the proper functioning of different filtering stages, power supply, pump, UV lamp, SS ball valve, etc.

Activity 5

Demonstrate and confirm functionality of the water purifier.

Material required

Functional water purifier

Procedure

1. Check for any leakage in the water purifier unit.
2. Read and note down the reading in pressure gauge.
3. If the reading of pressure gauge is found greater than the average value of predefined pressure of feed water, then regulate the pressure of water flow by using pressure regulator.
4. Check the TDS level of the purified water using the TDS meter.
5. If the TDS level is higher than the recommended value, adjust the TDS level of the purifier.
6. Check for the power supply and pump.
7. Check for proper working of the sediment filter, pre-carbon post, carbon filter, membrane housing, UV filter, etc.

Activity 6

Demonstrate the cleaning procedures.

Material required

Cleaning kit, water purifier unit.

Procedure

Follow the given steps for cleaning water purifier:

1. Clean the purifier after reassembling the purifier unit.
2. Clean the different filters of the purifier.
3. Check for proper functioning of the drainage system.
4. Clean the floor where water purifier is installed.
5. Regularly check the filter and membrane.

Check Your Progress

A. Multiple Choice Questions

1. Which of the following is not a step of maintenance of RO Water Purifier?
   (a) Check TDS of Water
   (b) Check valves
   (c) Clean and Sanitise RO System
   (d) Draining of waste water
2. Which of the following meter is used to measure the TDS level of water?
   (a) Multimeter
   (b) Clampmeter
   (c) TDS meter
   (d) Purifier meter
3. Where is the compressed air present in the water tank?
   (a) Between rubber bladder and steel housing
   (b) Between plastic housing and steel housing
   (c) Between rubber bladder and plastic housing
   (d) Between plastic bladder and plastic housing
4. Which form is filled by the customer at the premises?
   (a) Customer complaint form
   (b) Customer suggestion form
   (c) Customer acknowledgement form
   (d) Customer service form
5. Which of the following is a type of impurity?
   (a) Minerals
   (b) Salts
   (c) Metals or ions
   (d) All of the above
6. TDS greater than 500 ppm indicates the possibility of which of the following toxic ions?
   (a) Lead
   (b) Arsenic
   (c) Cadmium
   (d) All of the above

7. PPM stands for __________________.
    (a) parts per meter
    (b) particle per million
    (c) particle per million
    (d) parts per million

B. Fill in the Blanks

1. An RO system has two types of valves. They are ______________ and ________________.
2. An RO system should be cleaned and sanitised at least once _____________.
3. The maximum contamination level advised for TDS is _____________ mg/L.
4. The dissolved solids increase the _____________ conductivity of water.
5. Rise in water pressure can be diagnosed by releasing the extra pressure using _____________.

C. State whether True or False

1. Improper O-ring seating causes inadequate flow of water from the tap.
2. Blocked post carbon filter causes bad taste or odour.
3. Incorrect air pressure in the storage tank causes low pressure from water outlet tap.
4. Incorrectly sealed membrane causes high TDS in output water.
5. Leakage in threaded end cap causes leaking membrane housing.
6. Dirty storage tank causes leaking filter housing.
7. Damaged or cracked fitting causes leakage.
8. PPM stands for parts per million.
9. Water will be soft if the PPM level is 80–150 PPM.
10. Water will be very hard if the PPM level is above 400 PPM.

D. Match the columns

PPM	Level of Hardness
1. 0–80 ppm	(a) Hard (use RO purifier)
2. 80–150 ppm	(b) Very hard (use RO + UV purifier)
3. 150–400 ppm	(c) Very soft (ideal for drinking)
4. Above 400 ppm	(d) Soft (might be used for drinking)

E. Short Answer Questions

1. Write down the steps for maintaining the water pressure as per company standards.
2. Write down the steps for the replacement of valve.
3. Write down the steps for the replacement of filter.
4. What are the steps for checking the TDS level of water?
5. Discuss the steps for reassembling a water purifier unit.

Chapter 6

Health and Safety

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Workplace hazardous systems should be designed to protect the health and safety of workers. Information must be provided about the safe handling, use, storage, and disposal of hazardous equipment. Workplace hazard is something that can have potential to harm the technician. There are material hazards in every type of job and workplace. Everyone at the workplace should share the responsibility to identify and control hazards. Technicians must first recognise their workplace hazards.

While installing or assembling the components, a technician has to face hazards related to the workplace. These hazards are associated with the installation and assembly process of water purifier. The technician should be aware of the hazards associated with installation of water purifier. Many of the hazards can be avoided by being aware and taking appropriate precautions.

Hazards Related to Water Purifier Installation

The following points show the hazards associated with the water purifier installation.

- Accident hazards
- Physical hazards

NOTES

- Psychological, psychosocial and organisational factors
- Chemical hazards

Accident Hazards	Falls, slips and trips on wet and slippery floors during the handling of water.
	Falls from ladder while mounting the water purifier at a height.
	Electric shock caused by contact with 'live' wires or defective electrical installations (the danger is especially high because the work is done in a wet and humid environment).
	Exposure to hazardous substances due to the sudden release of toxic materials as a result of an accident or human error.
	Fire hazard due to contact of a very strong oxidiser (disinfectant) with a flammable substance, as a result of improper storage of chemicals or human error.
	When drilling from a ladder, do not try to overreach as this can cause the ladder to slide or tip. Never stand on the top step of a stepladder. Stand at least two steps down from the top.
Physical Hazards	Exposure to high noise levels, from electro-mechanical equipment and a noisy environment.
	Exposure to adverse weather conditions, risk of catching cold as a result of working in windy weather, at low temperatures and while raining; or as a result of over-sweating in the summer; and suffering from heat and cold strokes.
	Exposure to UV radiation during water disinfection may damage eyes and skin.
Psychological, psychosocial and organisational factors	Musculoskeletal injuries caused by awkward working postures during the cleaning/inspection of the pipe system and/or of the installation.

	Over exertion while moving or handling heavy and bulky equipment or big packages of chemicals may affect various systems of the body.
	Psychological stress and pressure due to environmental factors—annoying noise, water splashing, odours, high humidity, etc.
	Psychosocial problems due to increased workload, requirements of improving work output, constant need of high skill levels, etc.
Chemical Hazards	If chemicals are incorrectly stored causing a chemical leak.
	Absence of any safety measures by the technician.
	Mishandling of chemicals due to inadequate training or negligence.
	Diseases and environmental illnesses that can be caused by exposure to toxic substances in the workplace.
	After a person has been exposed to chemical hazards in the workplace, some of the symptoms of exposure to toxins can include— • chemical burns • itchy burning eyes • nausea, vomiting and diarrhoea • headaches • fever or chills • rapid heart rate

Possible Errors during Cleaning the Filters

1. Cap of the filter housing is not properly tightened.
2. O-ring is not present in the filter housing and results in leakage.
3. While replacing the membrane, it should be correctly inserted in the filter housing.
4. While reassembling the filter unit, filter sequence is not followed properly i.e., sediment filter, pre-carbon filter, post-carbon filter, membrane are not connected incorrect sequence.

NOTES

Notes

Electrical Hazard

An electrical hazard defines a condition related to energised equipment or a conductor at the workplace. If a technician comes in contact with these energised equipment, these may injure the technician. There is a possibility of getting the shock or receiving an arc flash burn, thermal burn, or blast injury. When assembling the components in a unit, many of the hazards can be avoided by being aware and taking appropriate precautions. This will ensure safety at workplace. Faults which may result in electrical hazards are—

- Exposure to high electromagnetic fields.
- Electrical fires due to incorrect and outdated wiring and faulty outlets.
- Electric shock due to incorrect grounding or earthing of electrical equipment.
- Defective or inadequate insulation on electrical cables.

To avoid electrical hazards, necessary precautions to be taken are—

- Ensure the power tools used in the assembly process include extension cord of proper rating.
- Do not use damaged electrical tools.
- Inspect and test the installed electrical equipment and system at regular intervals.
- Check the rating and physical condition of the components and cables.
- Use standard techniques for assembling the components.
- Use protective equipment for safety purpose.

Electrical Rescue Techniques

Approaching the accident place

- Never rush into an accident situation.
- Call 108 as soon as possible.

- Get the aid of trained field technician if possible.
- Cautiously approach the accidental place.

Examining the accident place

- Visually examine victims to determine if they are in contact with energised conductors.
- Metal surfaces, objects near the victim or the earth itself may be energised.
- Do not touch the victim or conductive surfaces while they are energised as shown in Fig. 6.1. Else, you may become a victim if you touch an energised victim or conductive surface.
- De-energise electric circuits if at all possible as shown in Fig. 6.2.

Methods to de-energise

- An extension or power cord probably powers portable electrical equipment. Unplug portable electrical equipment to remove power as shown in Fig. 6.3.
- De-energise fixed electrical equipment by using circuit breaker or by disconnecting the device as shown in Fig. 6.4.

Hazards and solutions

The following are some common causes of hazards.

- Be alert for hazards, such as, stored energy, heated surfaces and fire.
- Technicians or other persons must be cautious if the power source cannot be de-energised.
- Ensure that hands and feet are dry.
- Wear protective equipment, such as, protective gloves, rubber shoes, etc.
- Stand on a clean dry surface.

Fig. 6.1: Do not touch the victim

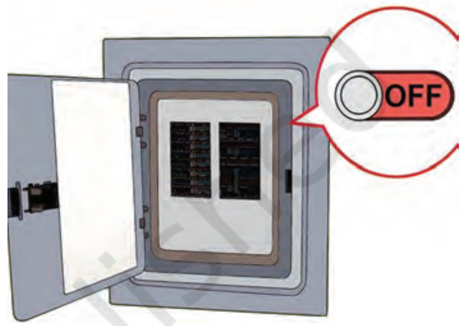

Fig. 6.2: De-energise electrical circuits

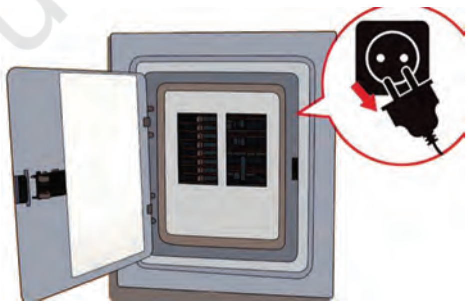

Fig. 6.3: Unplug electrical equipment

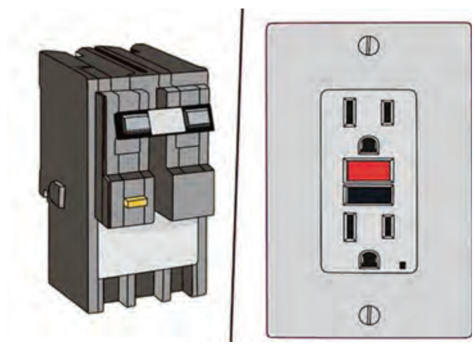

Fig. 6.4: Disconnect using circuits

Fig. 6.5: Person should not be on wet surface while doing electrical work

Fig. 6.6: Insulating material must be used while rescuing the victim

Fig. 6.7: Training of rescue operation

Fig. 6.8: Rubber gloves

Fig. 6.9: Rubber shoes

Fig. 6.10: Insulated tool kit

- Use insulating material to remove a victim from the conductor as shown in Fig. 6.6.

High voltage rescue

- Working with high voltage requires special training for rescue as shown in Fig. 6.7.
- Protective equipment, such as, high voltage gloves and overshoes must be used as shown in Figs. 6.8 and 6.9.
- Highly insulated tools should be used as shown in Fig. 6.10.

Insulated tools

- Insulated tools are lifesavers.
- These tools must have high voltage rating.
- Use wooden sticks to remove a victim from energised conductors.
- In some cases, non-conductive rope or cord may be used to remove a victim from a conductor.

Rescuing the victim

- Stand on a dry rubber mat or other insulating material if possible.
- Do not touch the victim or conductive material near the victim until the power is off.
- Once the power is off, examine the victim to determine if they should be moved. Give first-aid.

First-aid

- A victim may require Cardio-Pulmonary Resuscitation (CPR) or artificial respiration.

- If the victim is breathing and has a heartbeat, give first-aid for injuries and treat for shock.
- Ensure that the victim gets medical care as soon as possible.
- Provide medical personnel with information on voltage level, shock duration, entry and exit points. The attending physician must have detailed specific information to properly diagnose and care for the victim.

Hazard due to Tools

A list of some tools is given here. When introducing any tool, the technician should follow the steps for using tools and equipment safely.

Fig. 6.11: Drill machine

Hand drill

A hand drill is a small hand-operated drill. It is used to bore holes in materials. Handle operates through a gear mechanism that turns the drill bit. Hand drills are safe enough for technicians to use if they follow safety procedures.

Hazard	Precaution
Hair and clothing can be caught in the drill	Do not wear loose dress and cover hair while drilling.
Dust and particles can enter eyes while drilling	If there is a risk of dust or particles entering into eyes, technician should wear safety glasses or goggles.
Can cause injury to hands if it is caught in the drill and spin	Always secure the material to be drilled to the workbench using clamps or a vice. Place scrap wood underneath the material so that the drill can pass through without damaging the work surface.
The drill bit can snap due to excessive force	Warn students not to force the drill bit. They should drill at a speed suited to the material and the size of the drill. Smaller drills can be rotated at a faster speed. The drill bit should be sharp.

Fig. 6.12: Tap and dies

The drill bit and material being drilled will become hot.	Allow time for the drill bit to cool between usage.

Tap and dies

Taps and dies are used to create a thread in metals.

Hazard	Precaution
Punching out a broken tap can cause fragments to be propelled into eyes.	Students must wear safety goggles or a face shield when punching out a broken tap.
Sharp threads and metal fragments can cut hands.	Students should avoid handling fragments and cut the thread slowly.

Pliers

Pliers come in a variety of shapes and sizes, each with a different function. Their main purpose is to bend, hold or curve metal. They are also used to hold material or components while soldering or hammering and as a heat sink in electronics. Combination pliers have jaws for gripping and cutting a section. They are suitable for primary students to use.

Hazard	Precaution
The main hazard is pieces of wire shooting off when cut.	Students should wear safety glasses, or small pieces can be propelled into eyes.

Screwdrivers

A screwdriver is used to tighten and loosen screws. There are two types of screwdrivers—slotted head and phillips head. Slotted head screwdrivers have a flat-edge blade that fits into the slot on a screw. Phillips head screwdrivers fit into the cross-shaped screw heads. The choice of screwdriver depends on the screw.

Hazard	Precaution
Screwdrivers can be hazardous, if used for the wrong purpose.	Do not use a screwdriver as a cold chisel, punch or to open joints.

The point of a screwdriver can cause an injury if carried incorrectly.	Students should carry screwdrivers with the point facing down.
Screwdrivers can break suddenly if used with force.	Do not use excessive force to turn a screw.
Screwdrivers can slip if used incorrectly.	When choosing a screwdriver, ensure the tip edges fit neatly in the screw slot. Soap can be used to help the screw enter materials more easily. Students should keep their free hand away from the blade.
The metal of the screwdriver can conduct electricity, causing an electric shock if it contacts a live surface.	Insulated screwdrivers should be used in electronic activities.

Spanners and wrenches

Spanners and wrenches are designed to turn different types of nuts and bolts. Spanner generally refers to a tool that turns nuts and bolts, while wrench refers to a tool that grips cylindrical work. Ensure that students know how to choose a suitable spanner for their task.

Fig. 6.13: Spanner

Hazard	Precaution
The spanner slipping can injure the student, or damage the nut or the spanner.	The spanner should fit the nut or bolt firmly.
Spanners can break suddenly and break if used with excessive force.	Do not allow students to strike a spanner with a hammer. Apply pressure by hand only.

Hammers

A variety of hammers are used. Some are used with metal (ball peen), others with wood (claw). Hammers pose a number of hazards. Ensure that technician use hammers suitable for their job.

Hazard	Precaution
Loose heads can fly off while in use.	Warn students never to use a hammer with a loose head and not to hit hammer faces together. They should check hammers before using them.

The item being hammered can chip and pieces may fly off. Nails can fly out of materials when using a claw hammer to remove them.	Students should wear safety glasses when using hammers.
Hammers can fall if not used or carried properly.	Hold the hammer tightly by its handle.
Hands can be injured if near the point of impact of the hammer.	Technician should properly hold materials to avoid injury. Secure work with a clamp or vice. Hold the object with pliers.
Hammers pose a noise hazard when striking tools or materials.	Use ear protection wear to protect the ears.

Soldering irons

A soldering iron has a pointed copper head attached to a steel rod with a wooden handle. It is used for soft soldering, a technique where soft solder is heated and used to join metals.

Note: Lead-free solder can be used with electric soldering irons.

Hazard	Precaution
Heated soldering iron can cause burns or damage work surfaces.	Technician should position hot soldering irons on a heatproof surface.
Fluxes and solders can be hazardous. Solder and flux fumes may contain lead or other substances, which may be harmful, if inhaled.	Soldering irons must be used in a well-ventilated area. Technician should avoid skin contact with solders and fluxes and wash hands after use. Cotton gloves can be used.
Solder fumes can affect eyes.	Students should wear safety glasses when using soldering irons.

Assignments

1. List the general safety precautions to be observed while installing, repair and maintenance.
2. List the general safety rules, policies and procedures.

Practical Exercises

Activity

Demonstrate the disposal of packaging and installing waste.

Material required

Dustbin, safety wears.

Procedure

Follow the given points for handling the packaging waste and its disposal.

1. During unpacking of water purifier and filters, the boxes must be disposed in the dustbin as shown in Fig. 6.14.

Fig. 6.14

2. While installing the filter, small particles come out from filter. These may get scattered on the floor. They must be properly cleaned otherwise they may cause damage to the customer and technician.
3. Water which has been drained out of the purifier can be utilised for gardening, floor cleaning, washing clothes, etc.

Assignment

List the general hazards during repairs.

Check Your Progress

A. Multiple Choice Questions

1. Which of the following should give to the victim at the time of first aid?
   (a) Artificial respiration (CPR)
   (b) Drinking water
   (c) Open space for air
   (d) Antiseptic

Notes

2. Which thing can be used to move away a victim from energised conductor?
   (a) Iron rod
   (b) Aluminium rod
   (c) Wooden stick
   (d) Copper tube
3. Person should carry the screwdriver with pointed head facing ________________.
   (a) Right
   (b) Down
   (c) Left
   (d) Up
4. Person should wear ____ while using hammer.
   (a) Safety glasses
   (b) Loose clothes
   (c) Safety belt
   (d) Safety boots
5. In case of accidental emergency person should call ____.
   (a) 102
   (b) 101
   (c) 106
   (d) 108
6. Technician must avoid __________ contact with solder and flux.
   (a) Soldering wire
   (b) Skin
   (c) Soldering stand
   (d) Soldering paste
7. Disposal of packing and waste of the repairing parts is keep ________________.
   (a) Road
   (b) Open area
   (c) Workplace
   (d) Dustbin
8. Handle of tools should have ________________.
   (a) Design
   (b) Insulation
   (c) Metal
   (d) Rough surface
9. Which of the following is the common cause of hazard?
   (a) Working with wet hands
   (b) Wearing insulated tools
   (c) Wear rubber shoes and gloves
   (d) Correct storage of tools
10. Which of the following is necessary to place in order to avoid the water leakage in filter?
   (a) P ring
   (b) C ring
   (c) F ring
   (d) O ring

B. Fill in the blanks

1. CPR stand for _______________.
2. Electric shock caused by contact with __________ wires or defective electrical installations.
3. Incorrect chemicals storage leads to a____________.
4. _______ solder can be used with electric soldering irons.
5. Defective or inadequate insulation may result in ____________.

C. State whether True or False

1. Circuit breaker is used to protect the circuit from faulty and large current flowing through an appliance.
2. Artificial respiration is cardiopulmonary resuscitation.
3. Common injuries that can be caused due to lifting heavy loads include back ache, neck strain, wrist sprain, back sprain, shoulder pain.
4. The aim of first-aid treatment is to cool down the affected area rapidly to minimise damage and loss of body fluids, and therefore reduce the risk of developing shock.
5. Rubber is a good conductor of electricity.
6. Fire extinguisher is used in case of an earthquake.
7. Copper is a good conductor of electricity.
8. Earthing is necessary in an electrical equipment.

D. Short Answer Questions

1. What are the factors that result in hazard?
2. List out the various remedies to be taken in workplace.
3. What are the precautions to be taken for preventing electric shock on the job?
4. How will you perform artificial respiration?
5. How will you reduce the risk associated with handling of heavy and hazardous loads?

Notes

Answer Key

Unit 1: Fundamentals of Electricals and Electronics

A. Multiple Choice Questions

1. (b)	2. (d)	3. (c)	4. (d)	5. (a)
6. (a)	7. (c)	8. (b)	9. (c)	10. (a)
11. (b)	12. (b)	13. (a)	14. (c)	15. (a)
16. (b)	17. (c)	18. (a)	19. (c)	20. (b)
21. (d)	22. (a)	23. (a)	24. (b)	25. (b)
26. (a)	27. (b)	28. (c)	29. (c)	30. (b)

B. Fill in the Blanks

1. Series
2. Parallel
3. Work
4. Switch
5. Positive
6. Power
7. Ohm's law
8. 1000, 3600
9. Opening and Closing
10. Positive
11. Voltage and resistance
12. Voltage and current.

C. State whether True or False

1. F	2. F	3. T	4. F	5. T
6. F	7. F	8. T	9. T	10. T

Unit 2: Electrical and Electronic Components

A. Multiple Choice Quesions

1. (d)	2. (c)	3. (a)	4. (a)	5. (c)
6. (a)	7. (b)	8. (c)	9. (b)	10. (c)
11. (a)	12. (b)	13. (b)	14. (a)	15. (a)
16. (b)	17. (d)	18. (b)	19. (a)	20. (a)
21. (b)	22. (d)	23. (b),	24. (d)	25. (c)
26. (c)	27. (b)	28. (b)	29. (a)	30. (a)
31. (b)				

B. Fill in the Blanks

1. AC
2. Impure
3. Pure
4. Electric
5. Magnetic
6. Two
7. Semiconductor
8. Three
9. ON
10. Transistor
11. 53×10^3 +/-20%
12. 71×10^3 +/-10%
13. 22×10^3 +/-5%
14. 43×10^4 +/-5%
15. 20×10^4 5%

C. State whether True or False

1. F	2. T	3. T	4. T	5. F
6. F	7. T	8. T	9. T	10.F
11. T	12. T	13. T	14. F	15. F
16. T	17. T	18. T	19. T	20. F

F. Match the columns

1. (d) 2. (c) 3. (e) 4. (b) 5. (f)
6. (a)

Notes

Unit 3: Tools and Equipment

A. Multiple Choice Quesions

1. (c) 2. (a) 3. (b) 4. (c) 5. (a)
6. (d) 7. (b) 8. (d) 9. (a) 10. (c)

B. Fill in the Blanks

1. cutting and gripping 2. 3, 48
3. soldering 4. Clampmeter
5. electronic and manual 6. metal glue
7. rollable and rigid 8. neon
9. drill bits 10. current

C. State whether True or False

1. F 2. T 3. T 4. F 5. F
6. T 7. T

Unit 4: Installation of RO Water Purifier

A. Multiple Choice Quesions

1. (d) 2. (d) 3. (a) 4. (d) 5. (b)
6. (a) 7. (a) 8. (d) 9. (a) 10. (a)
11. (d) 12. (b) 13. (c) 14. (a) 15. (b)

B. Fill in the Blanks

1. Coagulation 2. Sedimentation
3. RO water purifier 4. Ultravoilet ray
5. High frequency 6. 3 meters
7. Teflon tape 8. Gravity based water purifier
9. Microorganism and bacteria 10. Reverse Osmosis

C. State whether True or False

1. T 2. T 3. T 4. F 5. T
6. F 7. T 8. T 9. F 10. F

Unit 5: Repair and Maintenance of Water Purifier

A. Multiple Choice Quesions

1. (d) 2. (c) 3. (a) 4. (c) 5. (d)
6. (d) 7. (d)

B. Fill in the Blanks

1. Auto-shut-off valve (ASV) and check valve (CV)
2. Every year
3. 500
4. Electrical conductivity
5. Pressure release valve

NOTES

C. State whether the statement given below are True or False

1. T	2. T	3. T	4. T	5. T
6. F	7. T	8. T	9. F	10. T

D. Match the Columns

1. (c) 2. (d) 3. (a) 4. (b)

Unit 6: Health and Safety

A. Multiple Choice Quesions

1. (a)	2. (c)	3. (b)	4. (a)	5. (d)
6. (b)	7. (d)	8. (b)	9. (a)	10. (d)

B. Fill in the Blanks

1. Cardio-Pulmonary Resuscitation (CPR)
2. Live
3. Chemical leak
4. Lead-free
5. Electric shock

C. State whether True or False

1. T	2. F	3. T	4. T	5. T
6. T	7. F	8. F	9. T	10. T

Glossary

Adapter: *A device for connecting pieces of equipment that cannot be connected directly.*

Alternating Current (AC): *It refers to an electric current that reverses direction at regular intervals. The abbreviation AC is commonly used.*

Ammeter: *It is meter, whichis used to measure the amount of electric current flowing in an electric circuit.*

Amperage: *It refers to the strength of an electrical current. It is measured in amperes.*

Amplitude: *It is the maximum absolute value reached by a voltage or current waveform.*

Armature: *It is a rotating part of motor which is used to generate the magnetic field in the motor.*

Automation: *It is the creation and application of technologies to produce and deliver goods and services with minimal human intervention.*

Bearing Ball: *It is rolling element, which is used to reduce the friction in a rotating part of a machine.*

Bias: *In electronics, it refers to a fixed DC voltage or current applied to a terminal of an electronic component such as a diode, transistor and many more.*

Capacitor: *It is a device used in electrical circuits. A capacitor stores an electrical charge for a short duration, and then, returns it to the circuit. Common types of capacitor includes tantalum, electrolytic, ceramic and film capacitors.*

Capacitance: *It is the property of a capacitor to hold charge. It is measured in Farad.*

Cathode: *A cathode is a type of electrode through which electrons move.*

Cartridge: *A closed container that holds something that is used in a machine, for example ink for printing, etc. Cartridges can be removed and replaced when they are finished or empty. In a same way, we use cartridge in the water purifier.*

Charging: *It is a time required to charge the capacitor.*

Clampmeter: *It is an electrical test tool that combines a basic digital multimeter with a current sensor. It is also called as tong tester.*

Coil: *It refers to a series of circles formed by the winding of an insulated wire, which creates a magnetic field when electric current passes through the circles.*

Conductor: *It is a substance that allows electricity or heat to pass through it.*

Direct current (DC): *It refers to electric current flowing in one direction only (i.e., current produced using a battery). The abbreviated form DC is commonly used.*

NOTES

Dissipation: *In electricity, dissipation represents the term loss of energy. Energy can be electrical energy, chemical energy, solar energy and many more.*

Data sheet: *A document that summarizes the performance and other characteristics of a product, machine, components.*

Dielectric: *Dielectric, insulating material or a very poor conductor of electric current.When dielectrics are placed in an electric field, practically no current flows in them. They are used in the capacitor.*

Density: *It is defined as mass per unit volume of a material substance. The formula for density is d = M/V, where d is density, M is mass, and V is volume.*

Discharging: *It is a time required for the discharging of capacitor.*

Drill Machine: *It is a hand handle tool primarily used for making round holes.*

Electro Motive Force (EMF): *It is the measurement of energy that causes current to flow through a circuit. It can also be defined as the potential difference in charge between two points in a circuit.*

Earthing: *It is the connection between electrical installation systems via a conductor to the buried plate in the ground.*

Electricity: *It is a form of energy produced from charged elementary particles, usually, supplied as electric current through cables, wires, etc., for lighting, heating, driving machines, etc.*

Electromagnet: *It is a coil of wire, usually wound on an iron core, which produces a strong magnetic field when current is passed through the coil.*

Electromagnetic induction: *The phenomenon in which electric current is generated by varying the magnetic field.*

Emission: *In electronics, emission refers to release of electron from the surface of a semiconductor.*

Electric potential: *It is the amount of work needed to move a unit charge from a reference point to a specific point against an electric field.*

Elbow collet: *It is an 'L' shape pipe connector used to connect the pipe of the water purifier.*

Fault Current: *The fault current is the electrical current, which flows through a circuit during an electrical fault condition.*

Filter: *In a water purifier, filters are used to purify drinking water. They remove the contaminants from the water.*

Flocculation: *It is a two-step particle aggregation process in which a number of small particles form large aggregates which are easier to separate.*

Frequency: *It is the rate at which a sound or electromagnetic wave vibrates per unit of time. It is expressed in Hertz (Hz).*

Ground Fault: *It refers to inadvertent contact between an energised conductor and ground or equipment frame.*

High frequency transformer: *These are also called audio transformers as they are used in the audio frequency range of 20 Hz to 20 kHz. They are mostly used in the electronic circuit due to their high working frequency and compact structure.*

Hazard: *It is a source or a situation with the potential for harm in terms of human injury or ill-health, damage to property, damage to the environment.*

Indicator: *They are used to indicate the state or level of something.*

Insulator: *It is a material or a device used to prevent heat, electricity or sound from escaping something. In other words, it is a material whose internal electric charges do not flow freely. Little electric current will flow through it under the influence of an electric field. This is opposite to other material, semiconductors and conductors, which conduct electric current easily.*

LED: *It stands for Light Emitting Diode. Semiconductor material is used in their manufacturing.*

Leakage Current: *This current in equipment flows when an unintentional electrical connection occurs between the ground and an energized part or conductor.*

Load: *Any device or equipment, which consumes electric power, is defined as load.*

Magnetic field: *The portion of space near a magnetic body or a current-carrying body in which the magnetic forces due to the body or current can be detected.*

Membrane: *They are the gatekeepers or a wall which protect the substance from the outer surrounding.*

Microcontroller: *It is a compact integrated circuit designed to execute a specific operation in a system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip.*

Electric Motor: *It is an electrical machine which converts electrical energy into mechanical energy.*

Multimeter: *It is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter can measure voltage, current and resistance.*

Mutual Induction: *It is a phenomenon in which an EMFis induced across a coil, due to rate of change current in adjacent coil.*

Osmosis: *The gradual passing of a liquid through a thin layer of material a membrane.*

Power Supply: *It is an electrical device that supplies electric power to an electrical and electronic loads.*

Push Button: *It is a simple button which is used to control the switch mechanism in a machine or a process*

Probes: *They are the cords which are used in the measuring equipment to measure the various parameters.*

Notes

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Pressure Gauge: *It is measuring instrument, which is used to measure the pressure of the fluid.*

Rectifier: *It is circuit that converts AC power supply to DC power supply.*

Relay: *It refers to an electrically controlled device that opens and closes electrical contacts to affect the operation of other devices in same or another electrical circuit.*

Semiconductor: *It is a solid material, whose electrical conductivity at room temperature is between that of a conductor and insulator. The most common semiconductor material is silicon.*

Sensor: *A device detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure and many more.*

Silicon: *It is a chemical element with the symbol 'Si' and atomic number 14. It is a hard, brittle crystalline solid with a blue-grey metallic lustre. It is a tetravalent metalloid and semiconductor.*

Single-phase: *In electrical engineering, single-phase electric power is the distribution of alternating current electric power.It is a two wire system. It has one phase and one neutral.*

Specific Heat: *It is amount of heat required to raise the temperature of one gram of a substance by one-degree Celsius.*

Spigot: *A small peg or plug, especially for insertion into the vent of a cask.*

Surface tension: *It is the energy, or work, required to increase the surface area of a liquid due to intermolecular forces.*

Stator: *It is a stationary part of a rotary system found in electric generators and motors.*

Surge: *It is the sudden rise in the flow of charge due to thundering and lightning effect.*

Semiconductor: *It is a solid material, whose electrical conductivity at room temperature is between that of a conductor and insulator. The most common semiconductor material is silicon.*

Switch: *It is device which can complete or incomplete the electric circuit.*

Teflon: *It is a brand name for a synthetic chemical called polytetrafluoroethylene (PTFE). Teflon is used to coat a variety of products because it is waterproof, creates a non-stick surface.*

Test Lamp: *It is a portable lamp with free leads to connect to various points of a faulty circuit to locate a defect.*

Tolerance: *It is a range, in which a resistance can work in a safe manner.*

Torque: *It is the measure of the force that can cause an object to rotate about an axis.*

Transistor: *It is a small electronic device, containing a semiconductor and at least three electrical contacts used in a circuit as an amplifier, detector or switch.*

Transmission Tower: *They are large structures that support the high-voltage transmission lines. Transmission lines carry electricity over long distances.*

Trip: *It refers to automatic opening (turning off) of a circuit by a circuit breaker*

UV rays: *These are the ultraviolent rays, used in water purifiers to inactivate airborne pathogens and microorganisms like mold, bacteria and viruses.*

Volt: *It is the unit of electric potential and its symbol is 'V'.*

Voltmeter: *It is meter used to measure the supply voltage.*

Valves: *A device in a pipe or tube, which controls the flow of air, liquid or gas, letting it move in one direction only.*

NOTES

List of Credits

Figures taken from Internet with source mentioned

Fig.3.24 Insert the chunk to loosen the bit,
Courtesy: https://www.wikihow.com/Change-a-Drill-Bit
Fig.3.25 Counter clockwise rotate the chunk to loosen the bit,
Courtesy: https://www.wikihow.com/Change-a-Drill-Bit
Fig.3.26 Pull out the bit,
Courtesy: https://www.wikihow.com/Change-a-Drill-Bit
Fig.3.27 (a) Replace the bit,
Courtesy: https://www.wikihow.com/Change-a-Drill-Bit
Fig.3.27 (b) Again tighten the bit using chunk,
Courtesy: https://www.wikihow.com/Change-a-Drill-Bit
Fig.4.15 Inline carbon filter,
Courtesy: http://hydro4u.com.au/wp-ontent/uploads/2017/05/22973154-origpic-7ff308.jpg
Fig.4.17 Water flow in an RO water purifier,
Courtesy: http://hydro4u.com.au/wp-ontent/uploads/2017/05/22973154-origpic-7ff308.jpg

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