

## Electricity in Our Homes

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Today, electricity has become so essential part of our life that we can not think of life without it. Our households are full of electrical appliances such as electric bulb, electric bell, electric fan, electric iron, electric heater, refrigerator, washing machine, dish washer, radio, television, air conditioner and so on. In a way, we can say that man has gained a partial control over forces of nature with the help of electrical energy. Electricity runs our industries and pumps out water for irrigation of our fields. Use of electricity in the transport system is also increasing.

In the previous lesson you studied about the story of the wonderful genie of electrical energy. In this lesson also, we will continue with the same story and highlight its uses in our daily life. We will try to understand how electrical energy is generated, distributed and used. The principle, construction and working of electric motor, generator and some of the domestic electric gadgets will be explained. The important features of distribution systems and domestic wiring systems will also be highlighted in this lesson.

### OBJECTIVES

After completing this lesson, you will be able to:

- explain the principle and working of an electric motor;
- demonstrate the flow of electric current in a closed loop of conducting wire when magnetic field associated with it is changed;
- explain the principle and working of an a.c. generator;
- draw circuit diagram to indicate how wiring is done to supply electric power to various devices in our houses or in industry;
- state the hazards involved in using electric energy and describe safety measures to minimize them;
- highlight the importance of fuse and earthing in electrical circuits; and
- identify different household electrical appliances and explain their construction and working.

### 13.1 ELECTROMAGNETISM

In the previous lesson we have seen that a magnetic field is developed around a current carrying conductor due to which a magnetic needle placed alongside shows deflection from its N-S orientation. Fig. 13.1 shows magnetic field due to a circular loop of wire carrying current. It is evident here that the magnetic field due to the loop at its centre is

quite strong, because, every part of the current loop is providing field in the same sense. The current-carrying loop, in fact, behaves as a magnet, one face of it being North Pole and the other South Pole.

If we make a *cylindrical coil of insulated wire having many turns (called solenoid)* and pass current through it, the coil will behave as a temporary magnet – one end serving as a north pole and the other as a south pole. Hold your right hand above the coil with the curling fingers pointing in the direction of the current, then the stretched thumb indicates that end of the coil, which functions as the north pole. The stretched thumb also indicates the direction of the magnetic field inside the coil. This rule is called the **right hand thumb rule**. If you wind the coil on a cylindrical tube of cardboard and study the magnetic field by placing a magnetic needle inside it we can see that the magnetic field inside the coil increases when,

- the current flowing through the coil is increased,
- number of turns in the coil is increased,
- length of the coil is decreased, and
- a soft iron bar is introduced in the card board tube.

### 13.1.1 Electromagnets

A current-carrying solenoid with soft iron core is called an electromagnet (Fig. 13.2).

A comparison of an electromagnet and a permanent magnet is given in the table below.

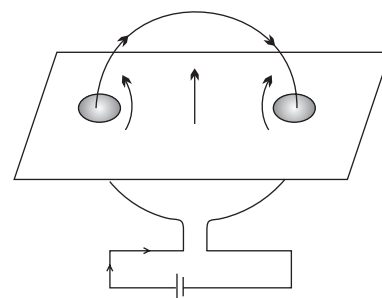


Fig. 13.1 Magnetic field due to a current-carrying loop

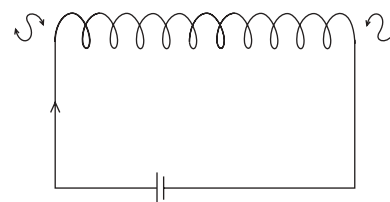


Fig. 13.2 A solenoid carrying current behaves like a magnet

**Table 13.1 : Distinction between a bar magnet and an electromagnet**

Bar magnet	Electromagnet
Bar magnet is a permanent magnet.	An electromagnet is a temporary magnet. It remains magnet only for the duration the current flows through it.
The strength of a bar magnet cannot be changed.	The strength of an electromagnet can be changed by changing the amount of current flowing through it.
Bar magnet is a weak magnet.	Electromagnet produces comparatively stronger field.
The poles of a permanent magnet cannot be easily reversed.	Just by reversing the direction of current flow, we can reverse the polarity of electromagnet.

### 13.1.2 Force on a current carrying conductor placed in a magnetic field

Oersted's experiment showed that a current carrying conductor deflects a magnetic needle. Newton's third law of motion suggests that a current-carrying conductor placed in a magnetic field should experience a force.

#### ACTIVITY 13.1

**Aim :** To study the force experienced by a current carrying conductor in a magnetic field.

#### What do you need ?

A U-shaped magnet, two batteries, two rheostats, one tapping key, one plug key, two ammeters, mercury in a shallow dish, a flexible joint J and connecting wires.

#### What to do ?

- (i) Place the dish containing mercury between the pole pieces of the electromagnet.
- (ii) From a rigid support T, suspend flexible joint J. Let the thick copper wire AB hang on J so that its lower end B just touches mercury.
- (iii) Connect the positive terminal of the battery with J and the negative terminal to a rheostat which is connected to an ammeter and a tapping key. Wire from the other end of the tapping key is dipped in mercury.
- (iv) Connect a battery, a rheostat, an ammeter and a plug key across the electromagnet as shown in figure 13.3.
- (v) Insert plug in key  $K_2$  and press  $K_1$ .
- (vi) Repeat the experiment by increasing current in the electromagnet and the wire AB, one by one.

#### What do you observe ?

You will observe that (i) on pressing key, the wire AB swings out of the pole pieces of the electromagnet, (ii) the amplitude of swing increases when the strength of the electromagnet is increased by increasing the current in it or when the current in the wire is increased.

#### What do you infer ?

- (i) A current carrying conductor placed in a magnetic field experiences a force due to which the conductor moves out of the mercury cup, as a result of which the circuit breaks and wire falls back and swings in and out of the mercury cup.
- (ii) The force increases with an increase in the current flowing through the conductor.
- (iii) The magnitude of the force also increases with the increase in the strength of the magnetic field.

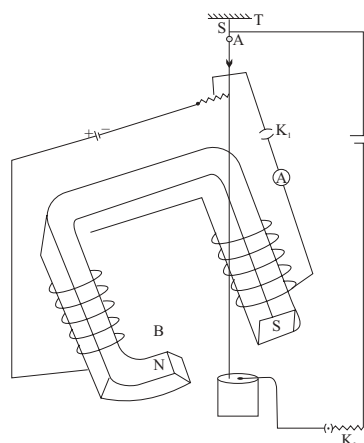


Fig. 13.3 Experimental set-up to demonstrate force on a current carrying conductor

The direction of the force experienced by a conductor placed in a magnetic field is perpendicular to the direction of current as well as magnetic field and is given by **Fleming's Left Hand Rule**. According to this rule, if you hold the forefinger, the central finger and the thumb of your left hand at right angles to each other in such a way that the forefinger points in the direction of magnetic field and the central finger is in the direction of current, then, the thumb will indicate the direction of the force experienced by the conductor (Fig. 13.4).

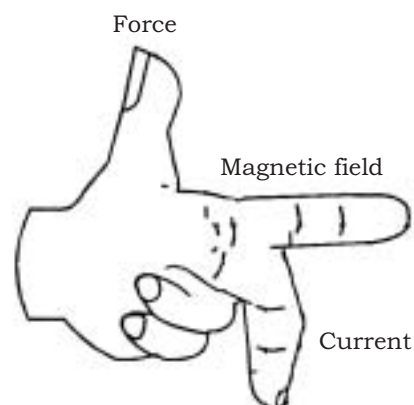


Fig. 13.4 Diagram to illustrate Fleming's Left Hand Rule

For example, if we consider a horizontal magnetic field running west to east in which a conductor hangs vertically and the current in it flows in a vertically downward direction, then the wire will experience a force in southward direction as shown in Fig. 13.5.

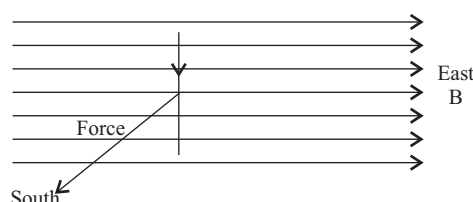


Fig. 13.5 Diagram showing application of Fleming's Left Hand Rule

### 13.1.3 Electric motor

Faraday's discovery of force experienced by a current carrying conductor placed in a magnetic field was a great discovery, because it helped in the development of electric motor. An electric motor is a device that can convert electrical energy into mechanical energy. Electric motor, as you already know, is the main component of electric fans, mixer-juicer-grinders, electric churners, centrifuges, etc.

#### a) Construction of electric motor

An electric motor (Fig. 13.6) consists of the following parts:

- i) **Field magnet (N-S)**, which is a U-shaped permanent magnet with cylindrically curved pole pieces.
- ii) **Rectangular coil (ABCD)** with large number of turns of insulated copper wire mounted on a rotor shaft R and having a soft iron core (core not shown in figure).
- iii) **Split ring commutator (XY)**, which is a copper ring split in two part X and Y and mounted on the rotor shaft. One free end of the coil is welded with X and the other with Y.
- iv) **Contact brushes (PQ)** kept in contact with the half-rings of the commutator to provide for the convenience of supplying current to the coil through them.

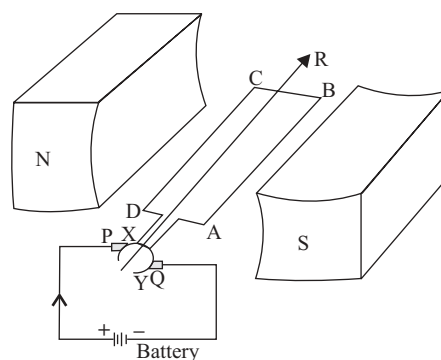


Fig. 13.6 Construction of an electric motor

### b) Principle and working of electric motor

When the contact brushes P and Q are connected to a battery, as shown, current flows through the coil. It can be seen by applying Fleming's Left Hand Rule that on the strand DC the force due to magnetic field acts in vertically downward direction where as on BA it acts in vertically upward direction. These two, unlike equal parallel forces acting on the coil, tend to rotate it. The coil makes a half rotation. Then the strands AB and CD interchange their positions and so do half-rings Q and P. Now the current in AB and CD again provides for a pair of equal, unlike parallel forces giving rotation to the coil in the same sense (anti-clockwise). Thus the coil and the shaft attached with it rotate continuously till the current is passed.

### CHECK YOUR PROGRESS 13.1

1. State Fleming's Left Hand Rule. What is the rule used for?
2. Name the rule you will use to find the direction of magnetic field due to a current loop. State the rule.
3. Give two points of difference between an electromagnet and a permanent magnet.
4. Give two factors on which the strength of an electromagnet depends.
5. State the principle of working of an electric motor.

### 13.2 ELECTROMAGNETIC INDUCTION

It again occurred to Faraday that if electric current can give rise to magnetic field, a changing magnetic field should also give rise to electric current. This phenomenon of producing electric current in a coil, by changing magnetic field associated with it, is called **electromagnetic induction**. One of the experiments that Faraday performed to demonstrate the phenomenon of electromagnetic induction you can also try in the form of the following activity.

#### ACTIVITY 13.2

**Aim :** To induce current in a coil by changing the magnetic field associated with it

#### What do you need?

A strong magnet, a tightly wound cylindrical coil of insulated copper wire mounted on an insulating pipe, a galvanometer

#### What to do?

Hold the coil horizontally. Connect free ends to a galvanometer. Hold the magnet at a distance from the coil. Move the magnet towards the coil. Move it away from the coil. Move the magnet towards and away from the coil at a faster rate.

#### What do you observe?

- i) The galvanometer shows a deflection whenever the magnet is moved relative to the coil.
- ii) The galvanometer pointer swings in one direction when the magnet moves towards the coil and in the opposite direction when the magnet moves away from the coil.

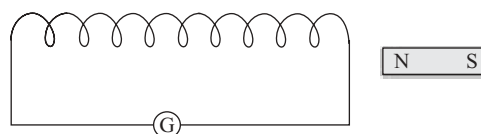


Fig. 13.7 Electric current induced in a coil due to a moving magnet

- iii) The galvanometer shows deflection only when the magnet is moving, the pointer of the galvanometer returns to zero position when the magnet is stopped at any position.
- iv) The deflection in the galvanometer is more when the magnet moves faster.

**What do you infer?**

An electric current is induced in a coil whenever the magnetic field associated with the coil is changed. When magnetic field threading the coil increases, the current flows in one direction but when the field associated with the coil decreases, it flows in opposite direction. More rapidly the field is changed greater is the magnitude of the induced current. This phenomenon of a changing magnetism into electricity is called electromagnetic induction and is the principle behind an electric generator.

### 13.2.1 Electric generator

Electric generator is a device that converts mechanical energy into electrical energy.

#### a) Principle of an electric generator

If we rotate a rectangular coil of wire in a uniform magnetic field about an axis perpendicular to the field lines, the magnetic field associated with the coil will change continuously. This will induce a continuously changing current in the coil.

Depending on the way the energy is tapped out and the type of current we get in the output, generators are of two types:

- **Direct current (d.c.) generators:** These provide steady and unidirectional current output.
- **Alternating current (a.c.) generators:** These provide an output current, which varies continuously in magnitude and periodically in direction.

Most of the generators in use these days are a.c. generators. Let us study the construction and working of this generator.

#### b) Construction of an alternating current generator

The construction and working of an a.c. generator is shown in Fig. 13.8.

An a.c. generator consists of the following parts:

- i) **Rectangular coil ABCD** made of very large number of turns of insulated copper wire, wound over an insulated frame and mounted on a rotor shaft.
- ii) **Rotor shaft R** attached to a **rotating system** (viz. a turbine, not shown in the figure) with the help of which it can be rotated rapidly between the pole pieces of the field magnet.

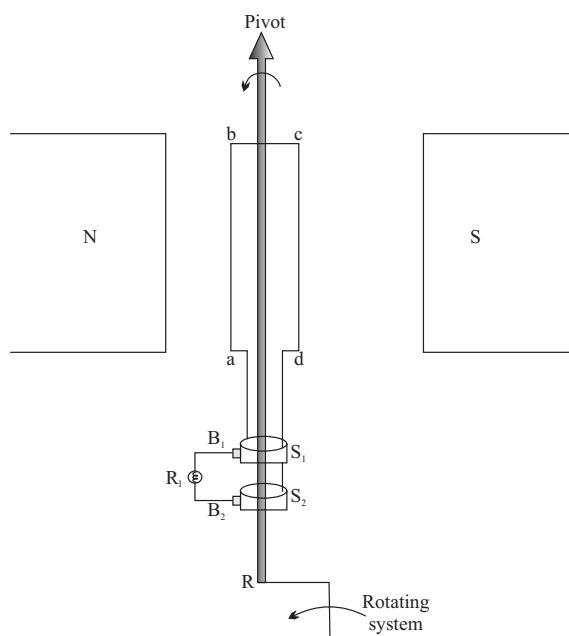


Fig. 13.8 An alternating current (a.c.) generator

- iii) **Field magnet N-S** is a strong horse shoe type permanent magnet.
- iv) **A pair of slip rings  $S_1$  and  $S_2$** , which are metallic rings, mounted on the rotor shaft insulated from each other and insulated from the shaft. One free end of the coil wire (say, a) is connected to  $S_1$  and the other (say, d) is connected to  $S_2$ .
- v) **Contact brushes  $B_1$  and  $B_2$**  are metallic (or carbon) brushes, kept in contact with  $S_1$  and  $S_2$ , through which current is taken out and passed in external circuits or appliances connected across them. The appliance connected across the generator is shown by  $R_L$  in Fig. 13.8 and is called load.

### c) Working of an alternating current generator

To understand the working of an a.c. generator let us consider that the coil, to begin with, is parallel to the magnetic field lines and starts rotating in anti-clockwise direction. The magnetic field entering into the face ABCD of the coil increases from zero to some finite value and continues to increase till the coil becomes normal to the field. The rate, at which the magnetic field linked with the coil changes, is the maximum in the beginning and then it decreases continuously. Thus the induced current in the coil is maximum at time,  $t = 0$ , and decreases with passing time. When the coil becomes normal to the field the rate at which flux changes becomes zero and hence current in the coil is zero.

When the coil further rotates the face of the coil through which magnetic field enters starts changing and hence the direction of field-change and hence direction of current is reversed. The field entering into the face DCBA now continues increasing till the coil again becomes parallel to the field at which position we find that the field linked with the coil is zero but change in magnetic flux is maximum resulting in maximum current.

As the coil rotates further the flux linked with DCBA increases with a lesser rate of change in field. Thus the current in the coil decreases and attains a zero value when the coil is normal to the field. Then again the face of the coil turning towards the north pole is reversed. The current starts flowing in the initial direction and attains a maximum value when the coil comes in the position we started with.

Fig. 13.9 shows the positions of the coil at crucial stages of rotation and the current in the coil at these instants.

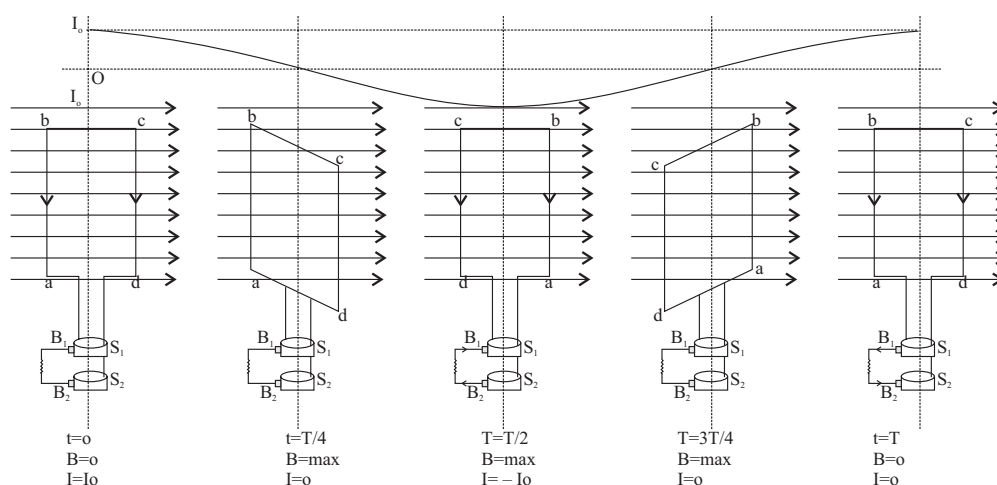


Fig. 13.9 Current in the coil of generator as it rotates



Thus, a continuously varying current which changes its directions after every  $T/2$  seconds is obtained. Such a current is called alternating current.

#### d) Direction of induced current: Fleming's Right Hand Rule

The direction of induced current that is indicated in Fig. 13.9 is the actual direction we obtain for the given situation. The direction of current induced in a conductor moving in a magnetic field is given by **Fleming's Right Hand Rule**. *According to the rule, stretch the thumb, the forefinger and the central finger of your right hand at right angles to each other and hold them in such a way that the forefinger points in the direction of magnetic field and thumb in the direction to motion of the conductor then the central finger will point in the direction of the induced current* (Fig. 13.10).

Using this law now you can easily check that the direction of induced current in Fig. 13.10 is towards north as shown.

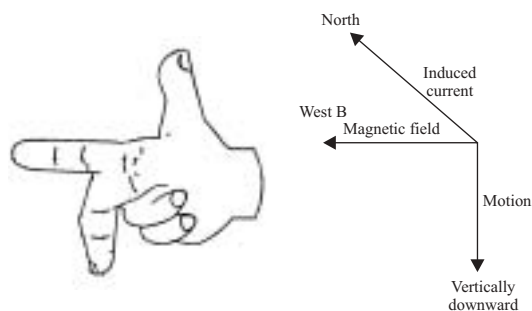


Fig. 13.10 Diagram to illustrate Fleming's Right Hand Rule

### CHECK YOUR PROGRESS 13.2

1. What is meant by electromagnetic induction?
2. State the principle of working of an electric generator.
3. State Fleming's Right Hand Rule and its use.
4. An LED is connected across a long solenoid (see the adjoining figure). When a strong permanent magnet is moved towards the solenoid, the bulb glows. Explain.
5. Who discovered the phenomenon of electromagnetic induction?

### 13.3 DISTRIBUTION OF ELECTRIC POWER

Generators are to be constructed near the source of energy. You cannot construct a dam for every house or a thermal power plant for every industry. Power is generated on large scale at one place and then it is distributed to consumers situated at far off places from the generating stations. How is it done?

The conductor system through which electric power is conveyed from a generating station to consumer's premises may be divided in two parts:

- Transmission System
- Distribution System

#### 13.3.1 Transmission system

Long distance transmission of DC power is technically impractical and financially non-viable. Because, we have to transmit power at the same voltage at which it is generated. But we have developed devices, which can increase or decrease the magnitude of alternating voltage. These devices are called **transformers**.

A transformer, which increases the level of voltage, is called **step-up transformer** and the one, which decreases the level of voltage, is called **step-down transformer**.

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In a transformer, if voltage is increased current decreases in the same proportion, and vice-versa. Thus, using a step-up transformer we can transmit power at high voltage and low current. Due to low current, the power losses and voltage drops on lead wires reduce to very low values. Also the cost of the distribution system decreases substantially. A typical transmission system is shown in Fig. 13.11.

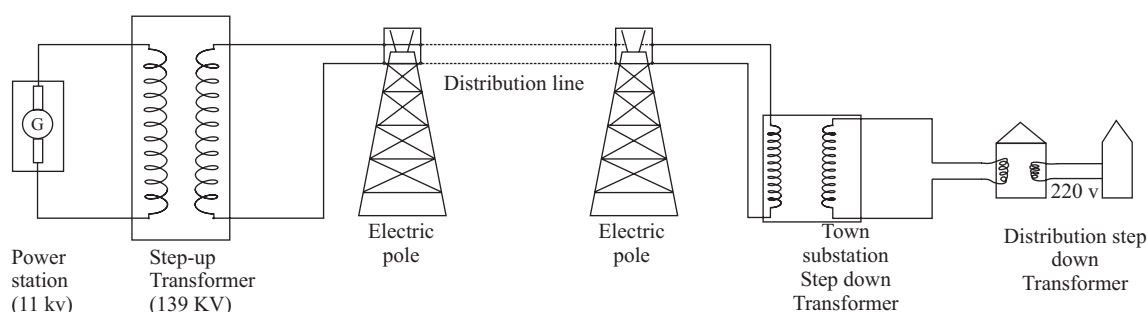


Fig. 13.11 A typical transmission system

In India, at the generating station the power is normally generated at 11000V, 50Hz. Using a step-up transformer this voltage is stepped up to 13.2 kV. Transmission is done at this high voltage. At the town substation, this voltage is first reduced to 33 kV with the help of a step-down transformer and then 33 kV is stepped down to user level 220V, 50 Hz using a step-down distribution transformer.

### 13.3.2 Distribution system

The distribution system is the arrangement, which provides power from town substation to the consumer. It involves feeders, distributors, sub-distributors and service mains. Normally there are two types of distribution systems:

- Tree system
- Ring system

These days, mostly, it is the ring system that we use. The arrangement of various components of ring mode distribution is shown in Fig. 13.12.

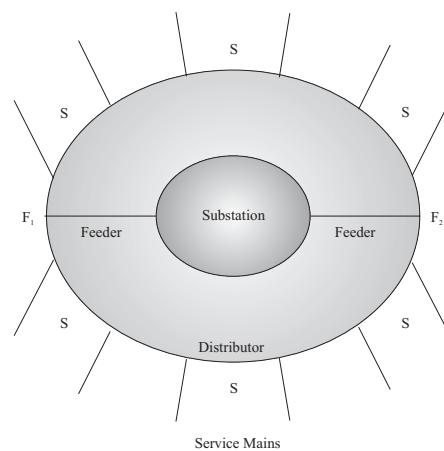
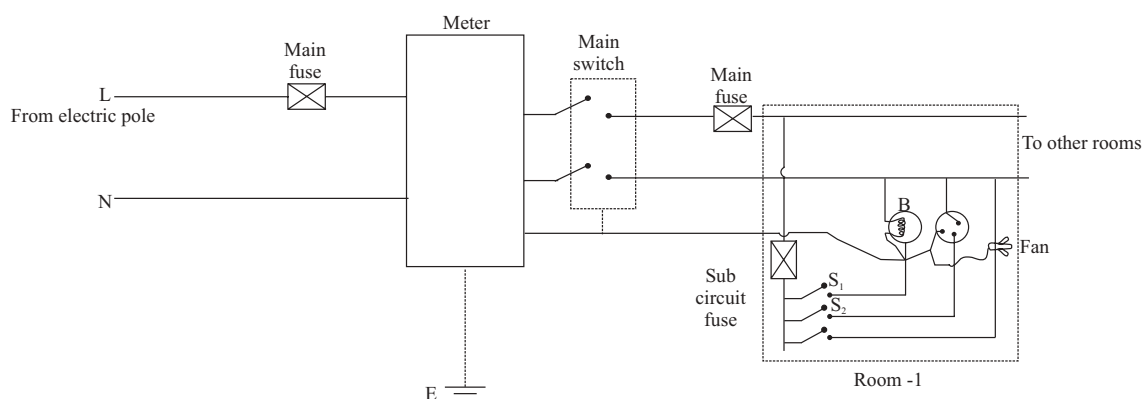


Fig. 13.12 A ring mode distribution system

### 13.3.3 Domestic wiring circuit

Through the distribution system the electricity reaches to an electric pole in our street from the pole two insulated copper wires come to our house. One of these wires is at a high potential of 220V. It is called **live wire** and is denoted by L. Normally, we use for live wire, a wire having red-coloured insulation. The other wire is ground potential of zero volt. It is called **neutral wire** and is denoted by N. For neutral wire we can use any colour except red or green. All the appliances in our house are connected in parallel to these two wires. A typical household circuit is shown in Fig. 13.13.



*Fig. 13.13 A typical domestic electric wiring circuit from electric pole to a room consisting of bulb, a fan and a plug prompt.*

Three specific features of the circuit are to be specially noted. These are as follows:

- (i) All the appliances are connected in parallel.
- (ii) All fuses and switches are to be placed on live wire.
- (iii) A third wire of green colour called earth wire also runs along with live and neutral wires. Bodies of all electrical appliances are earthed through this wire.

### CHECK YOUR PROGRESS 13.3

1. In domestic electrical wiring, on which wire do we normally place switch to operate light?
2. Which effect of electric current is used in the working of an electric fuse?
3. Why are domestic appliances connected in parallel? Give one reason.
4. Name the electrical device used to increase or decrease the magnitude of voltage. Can it be used with direct current?
5. What are the advantages in transmission of electric power at high voltage?
6. Switching off a bulb in one room has no effect on other lamps in the same building. Why?

### 13.4 HAZARDS IN USING ELECTRICAL ENERGY

When used with care, electricity is the most convenient form of energy. But carelessness in the use of electrical energy may prove to be fatal for the operator as well as for the installation. For example,

- If a person touches a live wire he or she may get a severe shock which may lead even to death.
- Short-circuiting due to damaged wiring or overloading of the circuit can cause electrical fire, which may damage the building.

Defects in household wiring like loose connections, defective switches, sockets, plugs, etc. may also cause sparking which may lead to an electrical fire. Some precautions and safety measures are, therefore, suggested in the next subsection below.

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### **13.4.1 Precautions in the use of electrical energy**

- a) For household wiring always use good quality wires having proper thickness and insulation. Plugs, sockets, switches and electrical appliances used should be ISI marked. All the wire connections should be tight and all the wire joints should be covered with an insulating tape. Defective switches, sockets, plugs, etc. should be immediately replaced.
- b) All the switches in your household electrical wiring circuit should be placed on the live wire of the circuit so that when the switch is off, the appliance is disconnected from the live wire and on touching the device you do not get shock.
- c) Switch off the mains before you start working on a repair job on the electrical circuit. In case it is necessary to work on live circuit put on rubber gloves, rubber shoes and use tools with insulated handles.
- d) In case of an electrical accident switch off the main switch of electrical supply. Try to insulate the person who has received a shock. In any case do not touch him directly. Never use water to extinguish fire arisen due to electrical sparking.
- e) Ensure that the safety measures of earthing and fuse are properly done in your household electrical circuit. Ensure that the fuses are placed on live wires and are of proper current rating.

### **13.4.2 Causes of electrical hazards**

There are basically three causes behind most electrical hazards:

- Current leakage
- Short-circuiting
- Overloading

#### **a) Current leakage**

Some times, due to wear and tear or due to excessive heating, the insulation covering of connecting wires is removed and the wire becomes naked. This naked live wire may touch the metal case of an electrical appliance raising its voltage to the level of the main voltage. The metal body of the appliance if connected to ground, current will flow through it to the ground resulting in current leakage. Body of a person also acts like a conductor and a person who touches the metal case of a current leaking appliance may get a shock.

#### **b) Short circuiting and over loading**

These are two faults in electrical circuits due to which heavy current may flow through the circuit resulting in the overheating of conducting live wires and consequent fire in the installation.

- Short-circuiting takes place when a naked live wire touches a naked neutral wire. Normally sub-standard wires wear out soon and may cause short-circuiting.
  - Overloading of electrical circuit results, when the number of appliances operated on the circuit at the same time exceeds the limits the circuit wiring can withstand. We know that in household circuits all the appliances are connected in parallel. In parallel circuits as we add more and more resistors (appliances) in parallel more current is drawn from the supply.
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A slight omission causing short circuiting or overloading may, therefore, cause fire and damage the whole installation. A safety device against this is a fuse.

### **13.4.3 Safety devices used in electrical circuits**

#### **a) Electric fuse**

Electric fuse is a weak link in the electrical circuit. It is a short piece of a thin wire made of a lead-tin alloy. The material that a fuse wire is made of has a low melting point and high resistance as compared to the material of live wire. Consequently, when current in the circuit starts increasing the specified limit the fuse wire gets heated up and blows off. The fuse wire thus saves the installation from getting damaged.

An electric fuse wire is always placed in series with the main supply on the live wire. Depending on the circuit specification we use fuse wires of different current rating normally 5A for domestic lights and 15A for domestic power. 15A fuse wire is thicker than a 5A fuse wire.

#### **b) Earthing the electrical appliance**

To avoid shock due to current leakage in electrical appliances the metal body of the appliance is earthed, i.e. connected to earth. For this purpose a separate wire, called earth wire, runs all through the circuits along with live and neutral wires. Metal bodies of all the appliances are kept connected with the earth wire. The free end of the earth wire is attached to a copper plate buried deep in the ground. This leaves the body of electrical appliances at the same potential (zero) as the earth and hence when we touch the metal body we do not get shock. Earthing is thus a safety device incorporated in an electric circuit to protect the operator.

The above discussion shows how important the provisions of earthing and fuse are in our electrical circuits.

### **CHECK YOUR PROGRESS 13.4**

1. Why do electricians wear, rubber shoes or rubber hand gloves while working on electric circuits?
2. State two hazards associated with the use of electricity.
3. Why is a fuse wire made of a tin-lead alloy?
4. What is the usual rating of an electric fuse used in the following:
  - (i) lighting circuits
  - (ii) power circuits
5. What will you do if you see a person in contact with a live wire?
6. Along with live wire and neutral wire, a third wire is also used in domestic electrical wiring. What is the name of this third wire? What is the purpose of this wire?

### **13.5 HOUSEHOLD ELECTRICAL APPLIANCES**

There is a long list of electrical appliances that we use in our houses for convenience in our work and comfort. Some of these appliances are based on thermal effect an electric current and the other are based on magnetic effect. We have already studied these effects in the previous lesson. In this section we will study the construction and working of some of the important electrical appliances we use in our houses.

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### 13.5.1 Electrical appliances based on thermal effect of electric current

When potential difference is applied across a conductor, the free electrons in it move up the potential to minimize their potential energy. In doing so they collide with other particles of the material of the conductor on their way. As a result the conductor gets heated up. The heat so produced can be utilized in a number of electrical appliances, such as electric bulb, electric iron, electric oven, electric water heater, electric room heater, soldering iron, electric kettle, etc. A brief description of some of these devices is given below.

#### a) Electric lamps

Generally two types of electric lamps are used in our houses for producing light

- incandescent lamps
- fluorescent lamps.

i) **Incandescent lamp:** An incandescent lamp, which is also called an **electric bulb**, is based upon the principle that when a conductor having a high melting point is heated electrically to a high temperature it becomes incandescent and starts emitting light.

If we closely examine an electric bulb we find that a small coil of tungsten wire (melting point 3300 K) called filament is mounted on insulating supports inside the bulb. The two ends of the filament are taken to the base of the bulb by two thick metal leads. This entire assembly is enclosed in a sealed glass bulb filled with noble gases at low pressure (Fig. 13.14).

When the bulb is put in its holder and switched on, current flows through the filament heating it to incandescence. The inert gas in the glass bulb prevents the filament from getting oxidised at that high temperature.

ii) **Fluorescent lamp:** A fluorescent lamp has a filament sealed in one end of a glass tube and another electrode at the other end. The tube contains little amount of mercury that vaporizes when the filament gets hot. An electric current is then set up through the mercury vapours from one end of the tube to the other. The mercury vapours give off both visible and ultra violet light. The ultra violet light strikes the fluorescent coating on the inside surface of the glass tube and causes it to glow brilliantly. The colour of the light given off by the lamp depends upon the material used for the fluorescent coating. Fluorescent lamps produce a great deal of light with little heat. This is the reason why their efficiency is comparatively high.

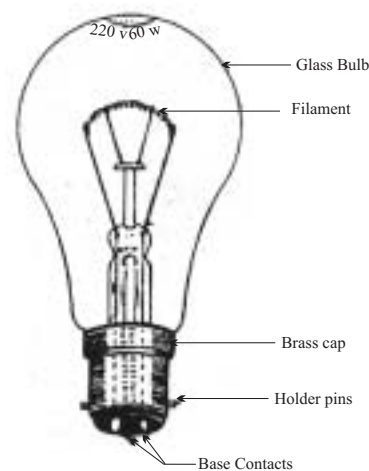


Fig. 13.14 Incandescent lamp

#### b) Electric iron or electric press

An electric iron basically has four parts:

- base plate,
- heating element,
- pressure plate, and
- upper cover with handle of insulating material such as bakelite.

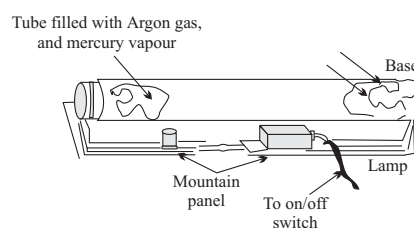


Fig. 13.15 Fluorescent lamp

The heating element consists of fine nichrome strip wound on a mica sheet, which is further enclosed, between thin strips of mica. In electric irons, mica is used for electrical insulation. Mica has a special property that it acts as an insulator for electricity but as a conductor for heat.

The heating element is placed between the base plate and the pressure plate. The pressure plate protects the heating element and does not allow it to move from its position. When an electric current passes through the heating element, heat is generated in it that is transferred to the base plate by conduction. The heated base plate can now be used to iron clothes.

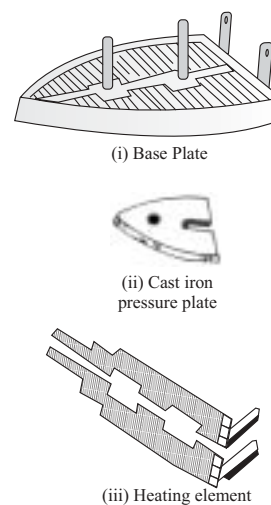
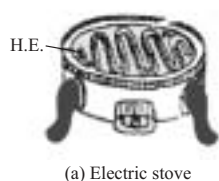
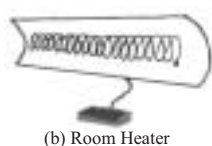


Fig. 13.16 Electric iron

### c) Electric heater and electric heat radiators



(a) Electric stove



(b) Room Heater

Fig. 13.17 (a) Electric stove (b) Room heater

These devices have heating elements made of nichrome wire in the form of spiral arranged in the grooves of ceramic plate or rod. The electric stove and room heaters are two such devices (Fig. 13.17).

In heat radiators, the heating element is mounted in a frame having a highly polished concave reflector at its back. When electric current is passed through the heating element, it gets heated and starts radiating heat. The heat radiation falling on the concave polished reflector are also reflected in the forward direction.

### d) Electric kettle

It is an electrical device in which heating effect of electric current is used (Fig. 13.18). You might have seen electric kettles of different shapes and sizes being used in houses, offices and restaurants. In an electric kettle, the heating element is fitted at the bottom of the vessel in such a way that maximum heat from the heating element is conducted to the vessel.

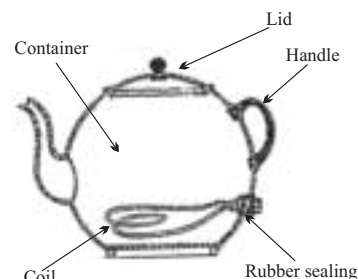


Fig. 13.18 Electric kettle

### e) Electric immersion heater

An immersion heater consists of a heating element made of nichrome wire housed in a metallic tube. The nichrome wire is separated from the metallic tube by filling the intervening space with magnesium oxide powder that is an electrical insulator and a reasonably good conductor of heat. The metallic tube is coiled in a few turns so that its long length may be accommodated in a smaller space and as such may remain in contact with the liquid to be heated. The design of an electrical immersion heater is shown in Fig. 13.19.

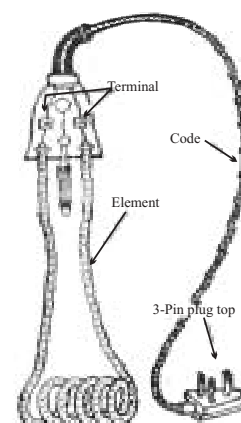


Fig. 13.19 Electric immersion heater



### 13.5.2 Electrical appliances based on magnetic effect of electric current

All the devices based on magnetic effect of electric current such as electric bell, electric fan, mixer-grinder and ammeter, voltmeter etc. make use of an electromagnet and/or the motor described in section of this lesson. Below is given a brief description of two of these devices, viz. electric bell and electric fan.

#### (a) Electric bell

If you closely examine an electric bell you will see that it has a U-shaped electromagnet as shown in Fig. 13.20. The two ends of the windings of the electromagnet are connected to the power supply (battery or the mains) through a make and break arrangement and a push button called the bell push (a kind of switch).

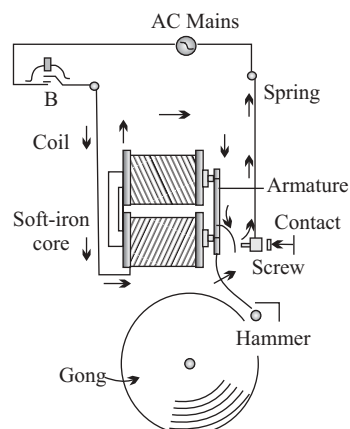


Fig. 13.20 Electric bell

When the bell push (B) is pressed the electric current flows through the coils of the electromagnet and the soft iron core of the electromagnet becomes magnetized. This magnetized iron core attracts the armature, consequently the hammer attached to the armature hits the gong and a loud sound is produced.

But as soon as the armature is attracted by the electromagnet the circuit is broken at the contact screw. The electromagnet no more remains magnet. The armature due to spring action returns back to original position. The process is repeated again and again. The hammer periodically keeps on hitting the gong till the push button is not released.

#### (b) Electric fan

Electric fans are used to circulate air in a room. Mostly a fan uses a permanent capacitor type motor. Three blades are symmetrically attached to the rotor shaft of the motor. As soon as the switch is made an electric current flowing through the motor rotates the blades which circulate air of the room. Fig. 13.21 shows the various parts of a ceiling fan.

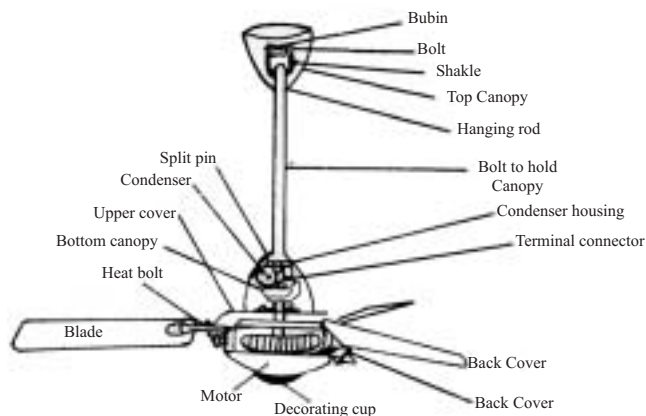


Fig. 13.21 Parts of a ceiling fan

### CHECK YOUR PROGRESS 13.5

1. Which material is the filament of an incandescent lamp made of?
2. Name a substance that is good conductor of heat but a bad conductor of electricity.
3. What is the role of a polished concave surface behind the element of a room heater?
4. Is fluorescent tube based on heating effect of electric current?
5. Name the energy transformation that takes place in an electric fan.



### LET US REVISE

- A current-carrying coil behaves as a magnet, one end of which behaves as the north pole and the other as the south pole. The polarity of the coil is determined by using the Right Hand Thumb Rule.
- The strength of an electromagnet depends on (i) strength of current flowing through the coil, (ii) number of turns per unit length of the coil, and (iii) the nature of the core material.
- A current-carrying conductor placed in magnetic field experiences a force. The magnitude of the force depends on (i) strength of the magnetic field, (ii) current flowing through the conductor, (iii) length of the conductor, and (iv) orientation of the coil with respect to the field.
- The direction of the force experienced by a current carrying conductor placed in a magnetic field is given by Fleming's Left Hand Rule.
- An electric motor is a device, which converts electrical energy into magnetic field.
- When magnetic field associated with a closed coil is changed a current is induced in the coil, which lasts, so long as the change in magnetic field is continued. This observation first made by Faraday is called electromagnetic induction.
- Electric generator is a device, which converts mechanical energy into electrical energy. The device is based on the phenomenon of electromagnetic induction.
- Long distance transmission of a.c. power has become possible by the use of devices called transformers. There are two types of transformer (i) step-up transformers, which increase the level of voltage (ii) step-down transformers, which decrease the level of voltage.
- In domestic wiring circuits, fuse and earthing are very important safety provisions. Careless use of electric power may be dangerous. Therefore, we must take proper precaution in the use of electricity.
- Electric bulb, electric heater, electric iron, electric kettle, etc. are examples of appliances based on thermal effect of electric current.
- Electric bell, electric crane, electric fan, electric mixer-juicer-grinder are appliances based on magnetic effect of electric current.

### TERMINAL EXERCISES

#### A. Objective type questions.

1. Name the device which converts
    - i) electrical energy into mechanical energy
    - ii) mechanical energy into electrical energy
    - iii) high voltage into low voltage
-

- iv) low voltage into high voltage
  - v) electrical energy into light energy
2. Fill in the blanks.
- i) The electricity in our home has voltage \_\_\_\_\_ volts, frequency \_\_\_\_\_ Hz and it provides \_\_\_\_\_ current.
  - ii) The power plant in which \_\_\_\_\_ or \_\_\_\_\_ is used as basic fuel is called thermal power plant, whereas Uranium-235 is used in \_\_\_\_\_ power plant.
  - iii) In a hydroelectric power plant \_\_\_\_\_ of water stored in a dam is converted into \_\_\_\_\_ of rotation of a turbine, which in turn changes into \_\_\_\_\_ energy.
  - iv) In the statement for Fleming's Left Hand Rule central finger points in the direction of \_\_\_\_\_, forefinger points in the direction of \_\_\_\_\_, and thumb points in the direction of \_\_\_\_\_.
  - v) \_\_\_\_\_, \_\_\_\_\_ and/or \_\_\_\_\_ are at the root of all electrical hazards.

**B. Descriptive type questions.**

1. A circuit has a fuse of 5A. What is the maximum number of 100 W (220V) bulbs that can be safely used in the circuit?
  2. Explain the principle and working of an a.c. generator.
  3. Explain the construction and working of the following:
    - i) Electric motor
    - ii) Electric iron
    - iii) Electric bulb
    - iv) Electric fan
    - v) Electric bell
  4. Distinguish between the following:
    - i) Permanent magnet and electromagnet
    - ii) Electric generator and electric motor
  5. Explain the role of earthing and fuse in electric circuits.
  6. With the help of suitable diagrams show how electrical energy is
    - i) Transmitted from generating station to town substation.
    - ii) Distributed from town substation to the consumer site.
-

7. Draw a domestic electric wiring diagram from electric pole to one room of the house having a bulb, a socket and a fan. Provide separate fuse for each room and separate switch for each device.
8. Describe an experiment to demonstrate:
  - i) Force experienced by a current-carrying conductor placed in a magnetic field
  - ii) Phenomenon of electromagnetic industries
9. Enlist the precautions one must observe in the use of electrical energy.

### **ANSWERS TO CHECK YOUR PROGRESS**

#### **13.1**

1. Fleming's Left Hand Rule is used to find the direction of force experienced by a current carrying conductor placed in a magnetic field. According to this rule, stretch the forefinger, the central finger and thumb of your left hand at right angles to each other and hold them in such a way that the forefinger points in the direction of the magnetic field, central finger points in the direction of electric current, then thumb will point in the direction of motion of (or force) in the conductor.
2. The direction of magnetic field due to a current-carrying loop can be determined using Right Hand Thumb Rule. According to the rule, hold the right hand above the coil with the curling fingers pointing in the direction of current, then the stretched thumb will indicate the direction of magnetic field.
3.
  - i) An electromagnet is much stronger than permanent magnet.
  - ii) The strength and polarity of an electromagnet can be changed but that of a permanent magnet is fixed.
4. The strength of electromagnet depends on (i) the current flowing through the conductor, and (ii) number of turns in the coil.
5. When a current-carrying coil is placed in a uniform magnetic field it experiences a pair of equal, opposite and parallel forces due to which the coil rotates.

#### **13.2**

1. The phenomenon of setting up electric current in a coil by changing magnetic field associated with it is called electromagnetic induction.
  2. When a coil of wire is rotated in a uniform magnetic field, the magnetic field associated with the coil is changed due to which current is set up in the coil.
  3. We use Fleming's Right Hand Rule to determine the direction of the current induced in a conductor when the conductor moves in a magnetic field crossing the field lines. The law states, stretch the forefinger, the central finger and the thumb of your right hand at right angles to each other, and hold it in such a way that forefinger points in the direction of field, thumb points in the direction of motion of the conductor, then, the central finger will point in the direction of induced current.
-

4. When the magnet moves towards the coil, the magnetic field threading the coil increases inducing a current in it. Due to the induced current the LED glows.
5. Michael Faraday

### 13.3

1. Live wire
2. Thermal effect
3. So that different appliances may draw different currents needed by them.
4. Transformer; No it cannot be used with d.c.
5. Transmission at high voltage provides for low current due to which the power losses and voltage drop in lead wires substantially decreases and transmission can be done at low cost.
6. Because all the lamps are connected in parallel.

### 13.4

1. The insulating rubber shoes or gloves do not let the current flow through the body of the electrician to earth and he is saved from getting any shock.
2.
  - i) Electricity may give shock to the careless operator.
  - ii) Short circuiting or over loading may cause fire.
3. Tin-lead alloy has low melting point and high resistance, hence blows off much before the rest of the circuit wiring is heated appreciably.
4.
  - i) Light circuit 5 A
  - ii) Power circuit 15 A
5. We will switch off the main switch and try to insulate the body of the person (so that he does not remain in contact with earth) without directly touching him/her.
6. The third wire is earth wire. It is a safety device to protect the operator from electric shock in case of current leakage from the body of the appliance.

### 13.5

1. Tungsten
  2. Mica
  3. It reflects the heat falling on it and sends it in forward direction.
  4. No
  5. Electrical energy into mechanical energy
-

## GLOSSARY

**Earth wire:** Green-coloured wire, which at one end is connected to the metallic body of an appliance and the other end is connected to a copper plate, buried deep in the ground.

**Electric fuse:** A short piece of thin wire made of lead-tin alloy, placed in series with the main supply on the live wire, that acts as a safety device.

**Electric generator:** A device that converts mechanical energy into electrical energy.

**Electric motor:** A device that converts electrical energy into mechanical energy.

**Electromagnet:** A current-carrying solenoid with a soft core inside it.

**Electromagnetic induction:** Phenomenon of producing electric current in a coil by changing the magnetic field associated with it.

**Live wire:** Red-coloured wire that carries electricity at high potential of 220V.

**Neutral wire:** A wire that is at ground potential of zero volts may be of any colour except red or green.

**Step-down transformer:** A device, which decreases the magnitude of alternating voltage.

**Step-up transformer:** A device, which increases the magnitude of alternating voltage.

**Transformer:** A device which can increase or decrease the magnitude of alternating voltage.

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