Chapter 11

ELECTRICITY

STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Design an experiment to generate electricity.
- ☑ Explain the working of a model generator.
- ☑ Identify the simple devices that generate electricity in daily life.
- ☑ Design and demonstrate the working of a power station.
- ☑ List types of energy being used in power stations.
- ☑ Relate problems involved in generating electricity.
- ☑ Describe basic components of an electronic system.
- ☑ List components that would be needed to turn A.C to D.C.
- ☑ State how output component in various devices could be used in their schools and surroundings.

Although electricity and magnetism were well known for centuries but Hans Christian Oersted a Danish Scientist in 1820 discovered a connection between them. He observed that current flowing through a coil of wire produces a magnetic field around it (Figure 11.1). In this way, he proved that a magnetic field can be produced by an electric current. In 1831, a British Scientist Michael Faraday discovered that the reverse of this phenomenon is also possible. He observed that when a loop of wire was moved quickly between the two opposite poles of a magnet, an electric current was produced

The physicist and philosopher Hans Christian Oersted (1772-1851)

in it. This fascinating discovery changed this world into a magic world. Today, it is hard to imagine our lives without electricity.

This chapter discusses the ways to generate electricity from traditional fuels and some other sources of energy, the working of a power station and the problems involved in generating electricity.

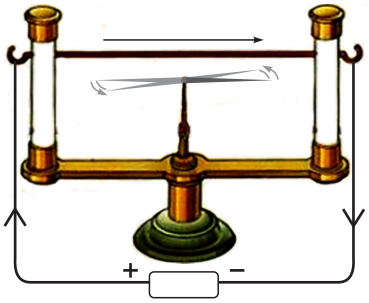


Figure 11.1: Compass needle near a wire, showing the effect discovered by Oersted

11.1 How Electricity is produced?

No fans, computers, refrigerators and other electrical appliances in our homes can be run without electricity. Electricity can be generated from many different sources by different methods. For example, dry cells and batteries produce electricity by chemical reactions of compounds.

Activity 11.1

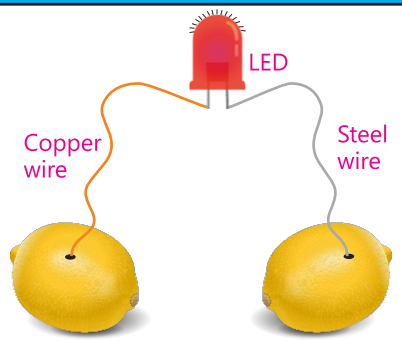
Material required

Copper wire, steel wire, 2 lemons, LED.

Procedure

- Take two small pieces of steel and copper wires.
- Push the wires into the lemons as shown in the figure.
- Connect other ends of the wires to the terminals of a LED.

What do you observe?



For your information

Lemon produces a very small current of about one milliampere. This current is very weak to light up a bulb. However, this current is sufficient to run a calculator.

Electricity can also be produced by some mechanical ways. Just as we can make magnets from electricity, we can also use magnets to produce electricity. We know that if a magnet is moved quickly through a coil of copper wire, electrons move in the wire and thus electricity is produced. Electricity can also be produced by rotating a coil between the opposite poles of a magnet (Figure 11.2). The mechanical system to produce electricity in this way is called electric generator or dynamo . Thus, due to relative motion between a coil and magnet, electric current starts to flow through the coil which can be connected to an external circuit. The current produced by electric

generators is not unidirectional. Its direction changes again and again after an equal interval of time. Such a current is called alternating current (A.C). For the production of electricity of higher voltage, a generator should have:

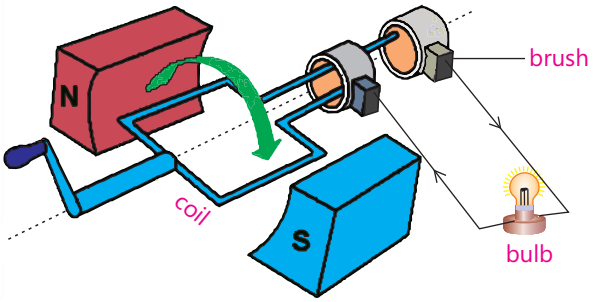
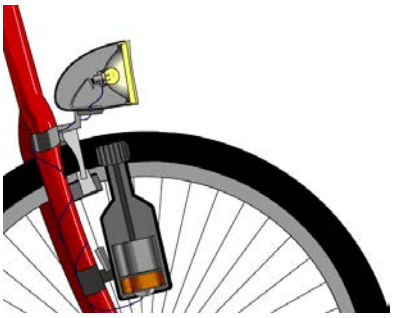


Figure 11.2: Working of a generator

- stronger magnets
- more turns in its coil
- quick relative motion between the magnet and coil

11.1.1 Bicycle Dynamo - a Small Generator

Your bicycle may have a dynamo to light up its lamp. The dynamo is a small portable generator which produces electricity from the energy of your body when you pedal a bicycle.



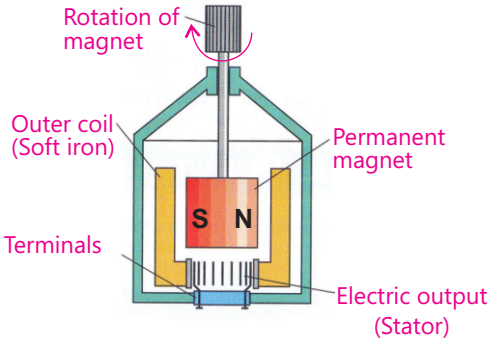


Figure 11.3: Working of a dynamo

Figure 11.3 shows a bicycle dynamo. The working principle of this small generator is the same as that of a big generator. In a dynamo the coil is held stationary while the magnet rotates inside the coil with the rotating wheel of the bicycle.

? Point to ponder

It is economical to have lights lit by dynamo and not by batteries. Can you tell its reason?

11.1.2 Power Plant Generators

The development of a country highly depends on the availability of the power resources. We need large amount of electricity for our domestic and commercial use. For these purposes, electricity is mostly generated in places called power stations.

In a power plant generator, the coils are kept stationary while magnet is rotated inside the coil. The stationary coil is called stator while the moving magnet is called rotor

(Figure 11.4). The running water of a stream or a river is used to run generator for producing electricity. Similarly, fuels like coal, oil or gas are also used to run generators. For example, in coal-fired electricity generation, the burning coal heats water in a boiler, producing steam. The steam pushes the blades of a turbine fixed at the lower end of the rotor shaft. As the rotor spins inside the stator, electric power is generated (Figure 11.5).

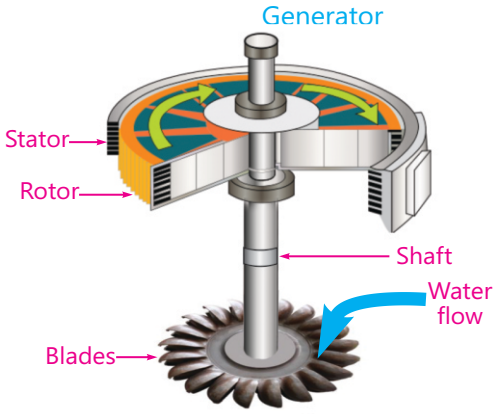


Figure 11.4: Turbine

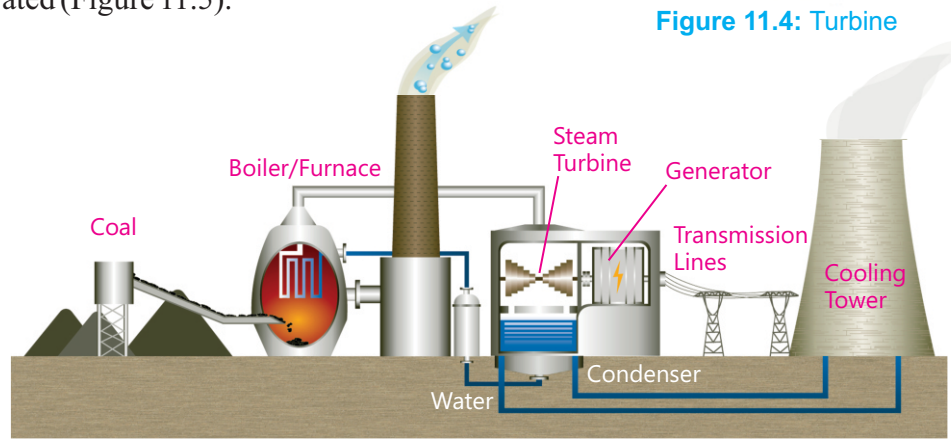


Figure 11.5: Generation of coal-fired electricity

In a hydro power station, water falls down from a high reservoir (lake) through the tunnels. The falling water turns the blades of a turbine fixed to the lower end of the rotor

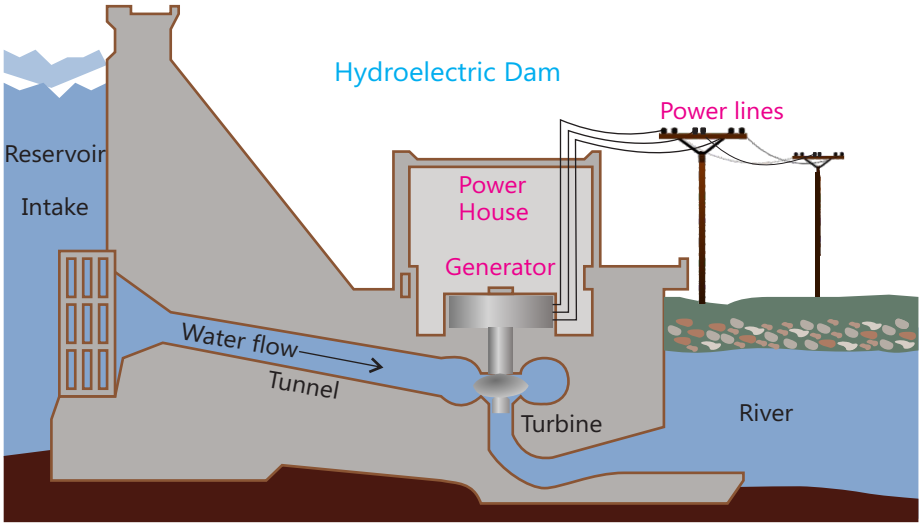


Figure 11.6: Hydro power generation

shaft. The rotating shaft turns the rotor, which generates electricity in the stator coils (Figure 11.6). The electricity is transmitted to various parts of the country through power transmission system. Hydro power generation is very economical and environmental friendly.

11.2 Energy Sources to Generate Electricity

Electricity is not only generated by mechanical generators but there are some other ways as well to generate electricity. But due to the continuous increase in prices of gas, oil and coal the cost of electricity is becoming unaffordable for people. Scientists are now searching the most cheaper ways to generate electricity. Sources used most often in the modern technology are solar, nuclear, wind and biomass energy to generate electricity.

1. Solar Energy

Solar energy is used through solar panels which are an inter-connected assembly of photo voltaic cells that produce electricity in the brighter sunlight (Figure 11.7). During daytime, this electricity can be used directly to run appliances. It can also be stored in batteries for use during night. Solar electricity is environmental friendly. The trend to generate electricity by solar penals is increasing day by day in Pakistan due to the increase in prices of traditional thermal electricity.

Figure 11.7: Solar panels

2. Wind energy

The kinetic energy of wind in coastal areas is used to turn huge blades mounted on high poles. The turning blades run the generator to produce electricity (Figure 11.8).

Figure 11.8: Wind power

3. Nuclear energy

When nuclei of heavy elements are broken by a special process called 'fission' a large amount of heat energy is released. This heat is used to make steam that rotates the turbine which runs the electric generator (Figure 11.9).

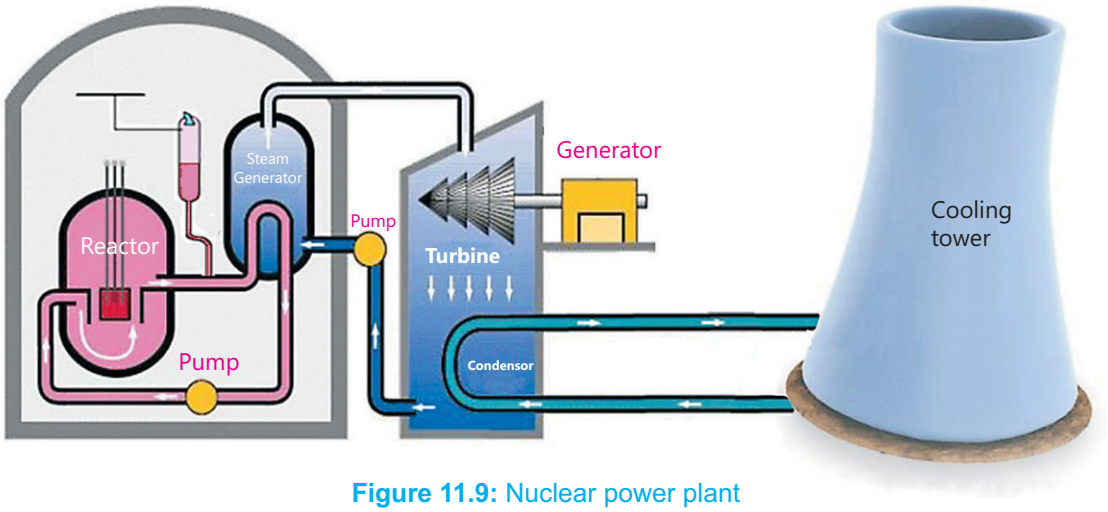


Figure 11.9: Nuclear power plant

11.3 Problems Involved in Generating Electricity

Various types of problems are involved in generating electricity. Some of these problems are described below:

1. Hydroelectric power is one of the commonly used methods of producing electricity. It is the cheapest way of getting electricity, but some problems are there in this method. For hydroelectric power generation dams are constructed. The water table in the nearby areas of a dam rises which causes water logging and land becomes uncultivable. In winter due to the shortage of water, electricity cannot be generated on large scale. Moreover, the population of area is shifted to some other places if a dam is to be constructed in that area.
2. Electricity production by thermal energy needs fossil fuels (oil, gas, coal). These are non-renewable energy sources. That is why are running short day by day and their prices are shooting up. Moreover, fossil fuels release smoke and other harmful gases in the atmosphere.
3. Many advanced countries use nuclear energy for production of electricity. Although it is not very expensive but sometimes it becomes very risky. The danger of harmful radiation leakage is always there. Another problem with this method is the proper disposal of waste material which is also highly radioactive.
4. Solar power is becoming very popular these days. Solar energy is renewable source of energy and is available to everyone free of cost. Production of electricity by using solar energy is safe and causes no pollution, but still has certain problems. The major problem is the high initial cost of solar panels and storage batteries.
5. Wind energy is also a renewable source of energy. It does not produce pollution.

The initial cost is very high. Moreover, wind farms cover large areas of expensive land and are very noisy.

11.4 Electronic Systems

We are living in an electronic age. Radio, television, computer, amplifiers, hi-fi sound system, worldwide communication systems, mobile phones, artificial satellites etc., are common electronic systems. They use electricity to perform their functions like processing input data and obtaining, altering, transmitting or storing information. All these functions are done by controlling the motion of electrons. The branch of physics that concerns with the behaviour and control of motion of electrons is called **electronics**. Electronic systems use short pulses of electric current to carry information in the form of signals. Later on, these signals can be changed into sounds, pictures or other information.

A well-known example of an electronic system is television. Without going through the details of internal working of its different parts, we can describe its functions by a block diagram as shown in Figure 11.10.

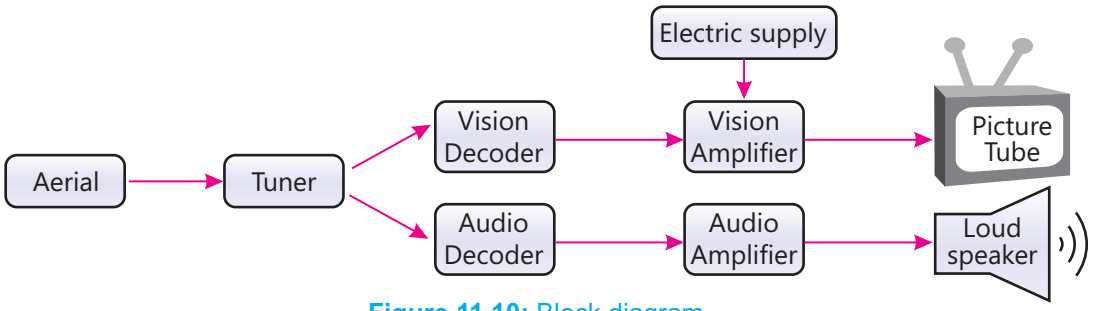


Figure 11.10: Block diagram

The following steps will explain how the system operates:

1. A camera converts picture and a microphone converts sound into electronical signals at the TV station.
2. These signals are mixed with carrier waves and are transmitted through transmitter antenna or cable.
3. Signals are received by TV in the form of a weak alternating current.
4. These signals are amplified by the amplifiers already installed in the TV.
5. The circuits inside the TV separate video and audio signals.
6. Video signals go to the picture tube that displays motion picture on the screen.
7. Audio signals go to the speaker that converts them back into sound.

11.4.1 Basic Components of an Electronic System

Resistors, semiconductor diodes, transistors, silicone chips and integrated circuits (ICs) are some basic components of an electronic system.

Semiconductors

Semiconductors are materials in which motion of electrons can be controlled. The most common semiconductor material is silicone. The devices made from semiconductor materials are widely used in electronic systems to amplify and process electronic signals.

Two most common semiconductor devices are semiconductor diode and transistor.

Semiconductor Diodes

Semiconductor diode is a device in which electric current can flow in one direction (Figure 11.11). A semiconductor diode has two terminals P and N. Current can flow from P to N but not in opposite direction. For this reason, semiconductor diodes are often used for converting alternating current into direct current.

Figure 11.11: Semiconductor diode

Transistors

A transistor is a semiconductor device with three terminals. Transistors are used as switches. Some types of transistors are shown in Figure 11.12.

Figure 11.12: Transistors

Integrated Circuits

Very tiny electronic circuits are called integrated circuits. These are commonly called as Ics (Figure 11.13). An integrated circuit consists of a tiny silicone chip with many components incorporated on it. In some ICs, about 1000 components are constructed on just a 3 mm square silicone chip. Before the advent of ICs, components in an electronic circuit were connected to one another by connecting wires that took too much space. ICs eliminated the need of such clumsy wiring.

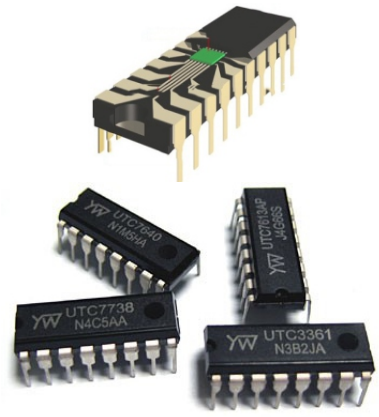


Figure 11.13: Integrated chips

11.5 Uses of Various Devices (Input, Processor, Output)

Electronic devices are mainly of three types.

(i) Input devices (ii) Processors (iii) Output devices

11.5.1 Input Devices

Any device that changes non-electronical energy into electrical energy in an electronic system is called an input device. A microphone is an input device. It converts sound into electrical signal. Similarly, an electronic camera also converts a picture to electrical

signals. Both are input devices (Figure 11.14). Other examples of input devices are the 'keyboard' and 'mouse' which are used to enter information into a computer. Scanner is also an input device. These devices feed information, pictures and documents etc. to the computer in the form of electrical signals.

Microphone Camera Keyboard and mouse Scanner

Figure 11.14: Input devices

11.5.2 Processors

A processor is the main component in an electronic system that converts the 'input' into 'output'. Amplifier, tape recorder, television etc. are also common processors (Figure 11.15). The amplifier increases the energy of electrical signals of sound fed by the microphone and sends them to the loudspeaker. The television converts the electrical signals fed to it through antenna or cable, into picture and sound (Figure 11.16).

Figure 11.15: Processor

The microprocessor of a computer is a very good example of it. It controls different parts of the computer to display output result on the screen of monitor.

Amplifier

Television

Figure 11.16: Some common processors

11.5.3 Output Devices

An output device converts electrical energy into other forms of energy. For example, a

loudspeaker converts electrical signals into sound, so it is an output device. The screen of a TV is also an output device. It converts electrical signals into a picture. The output devices of computer system are the monitor and printer (Figure 11.17).

Monitor Printer Speakers

11.17: Output devices

The output component of various devices are widely used in our schools and surrounding. Electrical appliances such as tape recorder, TV, computers, electric meters, and electric bells are commonly used in homes and schools. Loudspeakers are used in masajid, halls, cinemas and theaters. Robots are used in the factories for mega projects.

KEY POINTS

- When a magnet is moved quickly through a coil of copper wire, electrons move in the wire and electricity is produced. The mechanical system to produce electricity in this way is called generator.
- In power plant generators, the coils are kept stationary while magnet is turned inside the coil. The stationary coil is called stator while the moving magnet is called rotor.
- Because of modern technologies, new sources of energy to run power generators are now being used everyday instead of traditional sources.
- The branch of physics that concerns with the behaviour and control of motion of electrons is called electronics.
- Resistors, semiconductor diodes, transistors, silicone chips and integrated circuits (ICs) are some basic components of electronic system.
- Semiconductor diodes has the ability to control current mainly in one direction.
- A transistor is a semiconductor device with three terminals. Transistors are used as switches and amplifiers.
- Any device that changes non-electronical energy into electrical energy in an electronic system is called an input transducer or input device.
- An output device converts electrical energy into other forms of energy.

QUESTIONS

11.1 Encircle the correct option.

(i) Which power plant is almost free from environmental pollution problems?

a. Thermal power plant b. Nuclear power plant
c. Hydro power plant d. Solar power plant

(ii) Which is the cheapest source of energy to produce electricity?

a. Hydel b. Atomic c. Solar d. Thermal

(iii) Electronics is the branch of physics that concerns with the behaviour and control of motion of:

a. protons b. electrons c. neutrons d. atoms

(iv) Which of the following is an input device?

a. Mouse b. Monitor c. Printer d. Hard disc

(v) Which of the following is an output device?

a. Printer b. Mouse c. Scanner d. Hard disc

(vi) The component which converts A.C into D.C is called:

a. amplifier b. semiconductor diode
c. transformer d. semiconductor

(vii) Which of the following is a processor?

a. Mouse b. Tape recorder c. Keyboard d. Monitor

11.2 Give short answers.

(i) State the principle of power generator.
(ii) What are input devices? Give at least three examples.
(iii) What are output devices? Give at least three examples.
(iv) What is difference between A.C and D.C?
(v) Name some basic components of electronic system.
(vi) What is the function of a solar panel?

11.3 Sketch an electrical generator and its important parts.

11.4 Describe the working of power generator.

11.5 Discuss the problems involved in:

(i) Hydel power generation (ii) Thermal power generation
(iii) Solar power generation

11.6 What is an electronic system? Draw the block diagram to show the functions of different stages of television.

Project

Using internet, library and other resources, write a time line of discovery of electricity.