Module 8
Magnetism

What this module is about

Everybody is familiar with a toy magnet, that mysterious little U-shaped device that picks up needles or pins and holds them indefinitely in what seems to be like magic. As a child you probably played with small magnets. But magnet is far from being a mere toy. It is an essential part of machines, tools and some measuring devices. You have heard of a magnetic compass that helps navigators keep their course at sea. When you hold a phone receiver to your ear, a magnet records the vibrations set up by the voice of the person talking at the other end. Electric motors also contain magnets to function. Particle accelerators like cyclotron contain thousand of magnets as well.

Electricity and magnetism cannot be separated. Magnetism plays an important role in the study of electricity. Whenever electric current appears, there is magnetism. The operation of many electrical devices such as radios, TV sets, motors and other devices depends on the magnetic effects of electric current.

This module presents the discovery of magnetism and some of the fundamental experiments and laws showing the relationship between electricity and magnetism. In reading this module, you should pay attention to the nature of the force exerted on moving charges by a magnetic field. In addition, you need to understand the way in which an electric current produces a magnetic field. You will also learn how two important current-carrying shapes of wire: a long straight wire and a circular loop or solenoid produce magnetic field.

This module discusses the following topics:

- **Lesson 1 - Discovery of Magnetism**
- **Lesson 2 - Magnets and Magnetic Field**
- **Lesson 3 - Electromagnetism**

Read this module and see the wonders of electricity and magnetism and their contributions to the world of technology.

So, start and enjoy.

What you are expected to learn

After going through this module, you are expected to:

1. discuss the history of magnetism;
2. describe the different kinds of magnets and their properties;
3. list some uses of permanent magnets;
4. explain what is meant by magnetic field and how it is detected;
5. describe magnetic field;
6. show how magnetic fields and electric currents are related;
7. describe the way an electromagnet is made and the kind of magnetic field it produces;
8. state the effect that a magnetic field has on electric current;
9. recognize the conditions under which a magnetic field can be used to produce electric current;
10. explain how the interaction of magnetic fields produces movement in a motor;
11. illustrate the components of a typical household electrical circuit;
12. describe the functions of fuses and circuit breakers and tell how they work;
13. describe a generator and the way it produces electric energy; and
14. describe a transformer and explain how it works.

How to learn from this module

Here's a simple guide for you in going about the module:

1. Read and follow instructions carefully.
2. Answer the pretest in order to determine how much you know about the lessons in this module.
3. Check your answers with the given answer key at the end of this module.
4. Read each lesson and do activities that are provided for you.
5. Perform all the activities diligently to help and guide you in understanding the topic.
6. Take the self-tests after each lesson to determine how much you understood the topic.
7. Answer the posttest to measure how much you have gained from the lessons.

What to do before (Pretest)

I. Choose the letter(s) of the BEST ANSWER. Write your answers on a separate sheet of paper

1. The N pole of a compass needle points to the north magnetic pole of the earth because that pole is
   a. an S pole
   b. an N pole
   c. a large iron deposit
   d. near the north geographic pole

2. If the poles of two magnets repel each other
   a. both poles must be S poles.
   b. both poles must be N poles.
   c. one pole is an S and the other is an N.
   d. both poles are of the same kind.

3. Magnetizing a piece of iron is a process by which
   a. magnetic atoms are added to the iron.
   b. magnetic lines of force are brought into line.
   c. existing atomic magnets are brought into line.
   d. each atom in the iron is converted into a magnet.

4. A magnetic field can make a compass needle turn because the field
   a. attracts N poles.
   b. is produced by a magnet.
   c. comes from the center of the earth.
   d. exerts forces on the atomic currents in the compass needle.

5. A primary solenoid connected to a battery is inside a secondary solenoid. It is not possible to induce a current into the secondary coil by
   a. turning the primary current off.
   b. moving a core into the primary coil.
   c. pulling the primary out of the secondary coil
   d. running a steady current through the primary coil.

6. A magnet will attract a wire if
   a. the wire is long.
   b. the wire has a small mass.
   c. the wire exerts an electric force.
   d. the wire has current flowing through it.

7. The iron atom acts as a magnet because
   a. it has an equal number of protons and electrons.
   b. the electrons have a spinning motion.
   c. the electrons have negative charge.
   d. the neutrons have no charge.

8. A steel sewing needle can be made into a magnet by
   a. banging it on a table.
   b. soaking it in mercury.
   c. placing it near a compass.
   d. stroking it with a magnet in one direction only.

9. A piece of copper cannot be made into a magnet because
   a. copper cannot be charged.
   b. the domains are already aligned.
   c. the copper atoms have no charge.
   d. electrons spinning in opposite directions in copper cancel each other.

10. To increase the strength of an electromagnet,
    a. increase the current in the coil.
    b. add an iron center in the coil.
    c. increase the number of loops in the wire.
    d. all of the above

11. If a magnet is brought near a magnet suspended on a string, the
    a. N poles attract each other.
    b. N poles attract the S poles.
    c. S poles attract each other.
    d. N poles repel the S poles.

12. A device that turns electric energy into sound energy is
    a. a speaker . b. a generator.
    c. a VCD player. d. a transformer.

13. Substances that are slightly attracted by strong magnets are said to be
    a. diamagnetic. b. ferromagnetic.
    c. paramagnetic. d. none of these.

14. The lines of force of unlike poles placed near each other
    a. curve away from each other.
    b. connect the poles.
    c. cancel each other.
    d. none of these.

15. The scientist who discovered that an electric current can affect the action of a magnetic needle was
    a. Ampere.
    b. Oersted.
    c. Faraday.
    d. Gilbert.

II. Complete each statement by supplying the correct term or phrase.

1. The N pole of a magnet will be attracted to the _____ pole of another magnet.
2. Alloys and ceramics are used to make _______magnets.
3. The S pole of the earth's magnetic field is located in ________.
4. Many magnetic lines of force go into a magnet at its ________.
5. A suspended solenoid will rotate until it is lined up with the earth's ______.
6. Regions containing groups of atoms that act like small magnets are called _________.
7. The relationship and interaction between electricity and magnetism is called ___________.
8. Like poles of magnets ________each other.
9. ______ are objects that attract material containing iron and they always face the same direction when moving freely.
10. Natural magnets are made of iron ore called ________.

Key to answers on page 32

Lesson 1 Discovery of Magnetism

Have you ever used a compass to find a direction? If you have, you are doing something that was first done by the Chinese in the twelfth century. Historians believe that the Chinese were the first to build compasses to help them navigate. They made use of a property of certain materials that had been discovered centuries before – magnetism.

To know more about the discovery of magnetism, do this activity.

What you will do
Activity 1.1

Read the history of magnetism and answer the questions after the selection:

MAGNETS: KNOWN SINCE ANTIQUITY

Magnetism, the natural force that causes magnets to function as they do, became known to people many centuries ago. They knew that the black metallic ore are called *loadstone*. It has the property of drawing particles of iron to it.

Pins, needles and nails are attracted to the lodestone

The Greek philosopher named Thales, who lived during the sixth century B.C., is said to have been the first to observe this property. After his time, the lodestone was often mentioned in ancient writings. It was given the name "magnet" after Magnesia, a district in the Asia Minor where large magnetic deposits are found. Years later, they found out that the thing they called magnet does not only attract iron rings but also attract other rings suspended from one another forming a long chain.

The Roman Lucretius, who lived in the first century B.B., tried to explain magnetism in terms of his atomic theory.

There are many legendary accounts of the properties of magnet. The *Arabian Nights* contains the story of ship that approached an island made of magnetic rock. The ship fell completely to pieces because all the iron nails were pulled out of it through the attraction of the rock.

Another tale was based on the story of a shepherd named *Magnes*. One day when he was tending his flock of sheep on the slopes of Mount Ida in Asia Minor, he noticed that the iron tip of his staff was being pulled toward the ground. He dug up the ground and found out that the large deposit of lodestone was attracting his staff. Thereafter the lodestone was called magnet in honor of the shepherd who had discovered it, and later was called magnetite. Scholars have pointed out that this story originated long after the word "magnet" was commonly used.

What you will do

Self-Test 1.1

Test your understanding by completing the blanks.

1. The black metallic ore that has the property of attracting pieces of iron are called _____________.
2. The natural force of attracting pieces of iron is called ___________.
3. The word magnet was believed to have been derived from the name of a shepherd named ______________.
4. Lodestone was later called ____________ for its magnetic property.
5. _________ was a Greek philosopher who first discovered the magnetic property of lodestone.

Key to answers on page 32

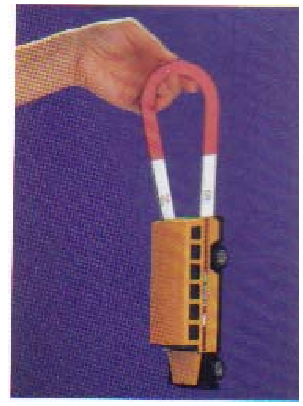
Lesson 2 Magnets and Magnetic Fields

In the course of the centuries, much of the mystery that once surrounded magnetism has been dispelled. Today, the lodestone or the natural magnet is no longer familiar in the study of magnetism because practically all magnets nowadays are artificial. This lesson dicusses the different types of magnets, their properties and magnetic fields.

A. Magnetic Substances

A substance that possesses magnetic properties is a **magnet**. It attracts iron and faces the same direction when moving freely. All materials have the property of being attracted or repelled. Substances like iron and steel are strongly attracted to magnets. These substances are called ***ferromagnetic.*** Nickel and cobalt are also ferromagnetic. These materials are often called magnetic materials.

Some substances, such as wood, aluminum, platinum and oxygen, are just slightly attracted by strong magnets. These substances are called ***paramagnetic.*** Substances that are slightly repelled by magnets are ***diamagnetic.*** Table salt, mercury, zinc and gold are diamagnetic substances.



Substances that are already magnetized are called magnetite. These are called natural or ***permanent magnets***. Lodestones are permanent magnets. Materials that can be made into magnets are called ***artificial magnets***. Artificial magnets are made by ***induced magnetism***. This is done by stroking ferromagnetic materials in the same direction several times with a magnet. This process is called **magnetization. ALNICO** magnet is permanent magnet containing **al**uminum, **ni**ckel and **co**balt. Temporary magnets are those of soft iron that are easy to magnetize and loses their magnetic property very easily. Electromagnet is an example of temporary magnet. It is a magnet that can be switched on and off. It is used to lift heavy objects in industrial sites and forwarding businesses. Permanet magnets are used in radio speakers, audio-video devices and other electrical appliances.

What you will do

Activity 2.1 Making an artificial magnet by induced magnetism

Problem: How to make an artificial magnet

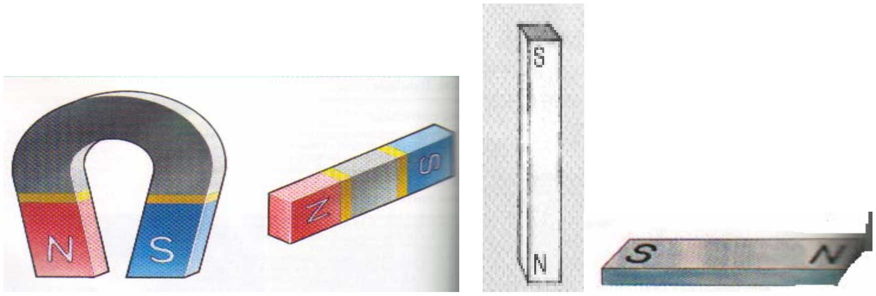
Materials: screw driver,
magnet (circular magnet from defective radio speaker)
pins, clips and nails

Procedure:

1. Gather all the materials needed.
2. Stroke the end of a screwdriver with the magnet. (Do it in one direction only)
3. Place the screwdriver near pieces of paper clips, pins or nails. Observe what happens. ____
____

Key to answers on page 32

B. Magnets and Magnetic Forces



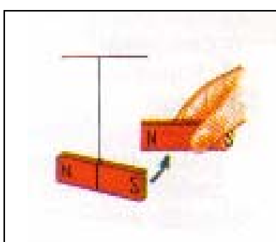
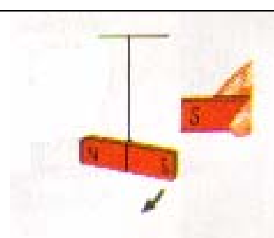
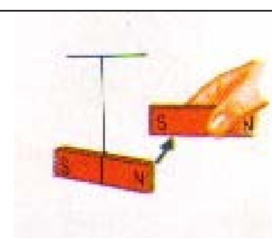
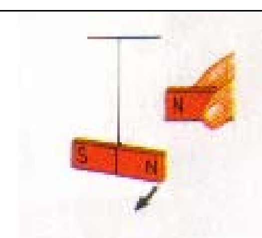
Look at the pictures above. The areas of greatest magnetic force are called magnetic poles. Every magnet has two poles. You cannot produce a magnet with only one pole.

The end of the magnet that points north is called the ***north magnetic pole,*** (N pole), and the end that points south is the ***south magnetic pole,*** (S pole).

What you will do

Activity 2.2

The diagram below illustrates a bar magnet that is suspended by a string. Another bar magnet is brought near it. Study the arrows in the diagram and answer the questions below.

			
The N pole of a magnet is brought near the S pole of the suspended magnet	The S pole of a magnet is brought near the S pole of the suspended magnet	The S pole of a magnet is brought near the N pole of the suspended magnet	The N pole of a magnet is brought near the N pole of the suspended magnet

Answer the following questions:

1. What happens to the suspended magnet when the S pole of the other magnet is brought near its N pole?

   ____

2. What happens to the suspended magnet when the N pole of the other magnet is brought near its N pole?

   ____

3. What happens to the suspended magnet when the N pole of the other magnet is brought near its S pole?

   ____

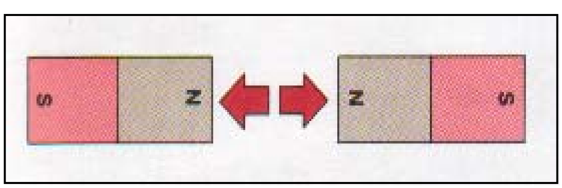
4. What happens to the suspended magnet when the S pole of the other magnet is brought near its S pole?

   ____

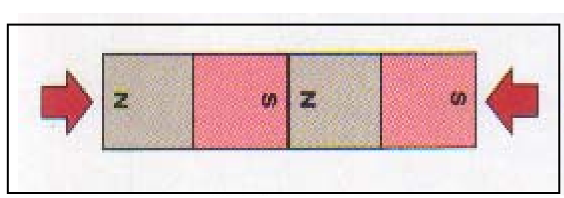
Key to answers on page 32

Rules of Magnets

You're right in your observations regarding the magnets. The diagrams below illustrate the rules of magnets. Refer to the diagrams below:



Like poles repel.



Opposite poles attract.

Uses of Magnets

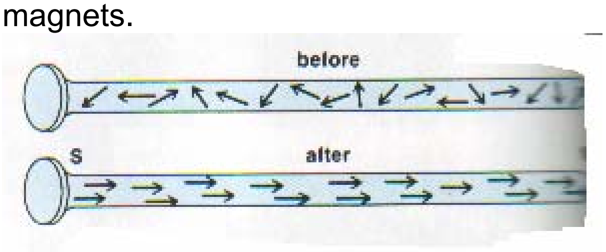
There are also five elements that can be made into magnets: iron, cobalt, nickel, aluminum, gadolimium and dysprosium. None of these elements can be magnetized permanently. To make a permanent magnet, you need an alloy. An alloy is a mixture of two or more metals. The classic material for making a permanent magnet is steel, an alloy of carbon and iron. The best material for permanent magnet is *magnequench*, which was invented in 1985. This material is mostly iron, with a little neodynmium and boron added.

Ships use compasses to find the correct course through vast areas of oceans where no land is in sight. A ship's compass is a permanent magnet attached to a card marked in degrees that floats in alcohol.

Magnets are made in many sizes and shapes. There are several magnets hidden in your home. Electric clocks, motors, stereos, loudspeakers and television sets all contain magnets. One magnet that is easy to find is the magnet found on the door of your refrigerator.

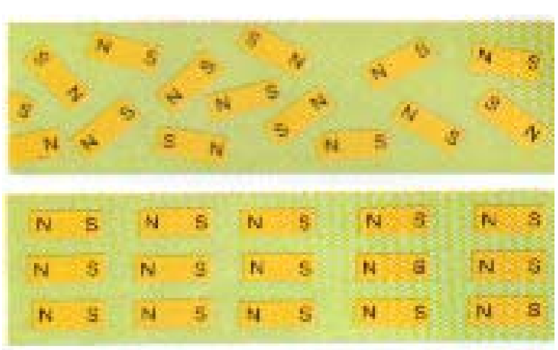
C. Magnetic Domains, Magnetic Fields and Magnetic Lines of Force

Most materials cannot be magnetized. Iron and a few other materials such as steel, nickel and cobalt can be magnetized. These materials have regions called ***magnetic domains***. Magnetic domains, which are clusters of many atoms, can be thought of as tiny magnets.



Substances that can be magnetized can be thought of as consisting of many tiny magnets. How does the arrangement of the "tiny magnets" differ between the unmagnetized and magnetized substances?

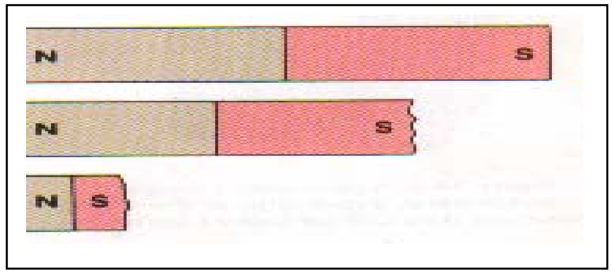
Look at this!



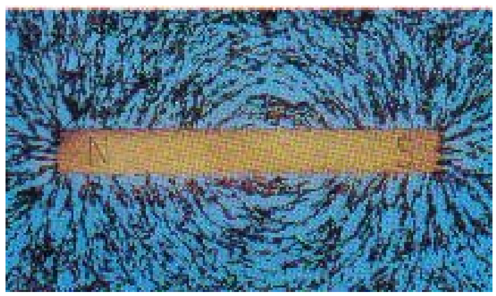
BEFORE: When the material is unmagnetized, the domains are not lined up in a definite way. They are randomly arranged.

AFTER: When the material is magnetized, the domains line up in a definite pattern. All the north poles point in one direction, and the south poles in the other.

So, if you cut a magnet in half, the cut ends become poles. You then have two similar magnets, each with an N pole and an S pole. Breaking a magnet does not greatly affect the alignment of domains in the pieces, so each piece is still a magnet.



The closer you bring two magnets together, the stronger the force between them becomes. Move them apart and the force gets weaker. If you move them apart farther, you will eventually feel no force. The force changes strength as you move within the magnet's magnetic field. A ***magnetic field*** is the space around a magnet in which its force affects objects. A good picture of a magnetic field can be made by sprinkling iron filings around a magnet. (See figure below.)



What you will do

Activity 2.3 Drawing Magnetic Lines of Force

Materials:

bar magnet (2)
iron filings
plain sheet of paper

Procedure:

1. Place two bar magnets flat on the table with the N poles about 2 cm apart.
2. Cover the magnets with a thin sheet of plain paper.
3. Sprinkle the iron filings on the paper gently until the filings line up.
4. Make a sketch showing how the magnetic lines of force are arranged.
5. Where is the magnetic field strongest?

If the materials are not available at home, refer to the following figures:

Figure A:

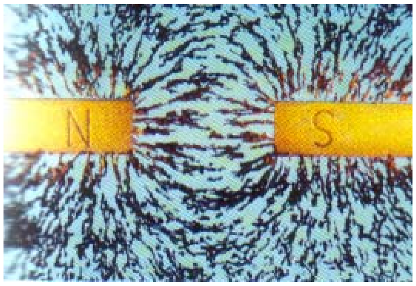
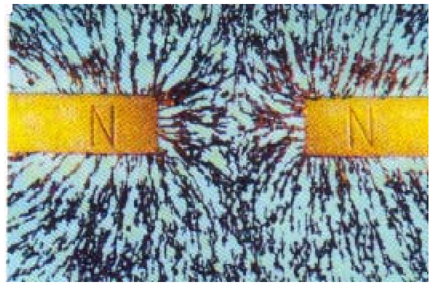


Figure B:



1. Trace the path of the iron filings in each figure.
2. What do you observe?_______________________________________

Discussion:

The magnetic field changes the filings into little magnets that attract one another. This makes the filings form long and thin chains. The chains line up in the shape of the magnetic field.

Analysis:

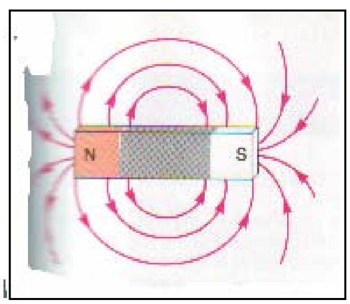


Fig. A: Bar Magnet

Figure A shows the magnetic field around a bar magnet. The arrowheads show the direction of the magnetic lines of force, which come out of the N pole and enter the S pole. The concentration of lines of force at the poles shows that the field is strongest there.

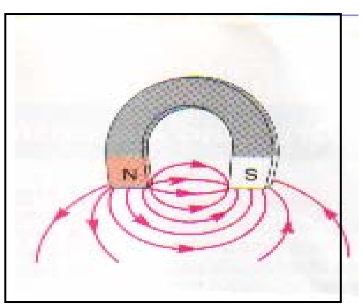


Fig. B: U-shaped magnet

Figure B shows the magnetic field around a U-shaped magnet. The shape crowds the lines of force together in between the two poles. This means that the magnetic force between the poles becomes very strong. This is also the reason why a horseshoe magnet can lift greater weights than a bar magnet.

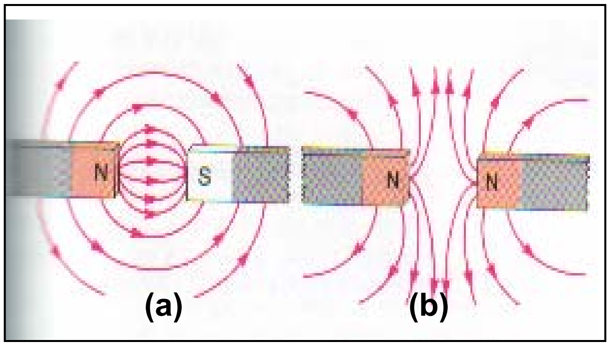


Fig. C: Magnetic Lines of Force
(a) between two unlike poles
(b) between like poles

In studying magnets in 1820s, Michael Faraday described magnetic fields through **magnetic lines of force** (Fig. C)

Magnetic lines of force never overlap even when the poles of the two magnets are brought close to one another.

What you will do

Self-Test 2.1

Arrange the jumbled letters to form the word(s), that best fits the statement.

1. Natural magnets **COILAN**
2. Clusters of many atoms that act as tiny magnets in a material **MAINODS**
3. A region around a magnet **SFILEDGENAMICT**
4. Imaginary lines that represent magnetic field **SLIENSOFGENTMICFOECR**
5. Materials that are strongly attracted to magnet **GENTAMICORREF**
6. Materials that are repelled by magnet **GENTAMICIAD**
7. Materials that are slightly attracted by magnet **GENTAMICARAP**
8. A substance that possesses magnetic properties **NETGAM**
9. Iron and other elements can become strongly magnetized **NETGAMITAZIONT**
10. A magnet has two **SLOPES**

Key to answers on page 33

Lesson 3   Electromagnetism

What did you do today? Did you listen to a recorder? Did you use or hear a motor at work in a mixer, blender, refrigerator, washing machine, hair dryer, fan, and vacuum cleaner? Did you hear a buzzer or doorbell sound? What about a cellular phone?

If you saw or heard these devices or machines, you observed the combined effects of electricity and magnetism at work. Scientists learned how to use the relationship between electricity and magnetism to produce electric currents and to make machines that would make these devices function. These scientists and inventors have made amazing changes in the way you live.

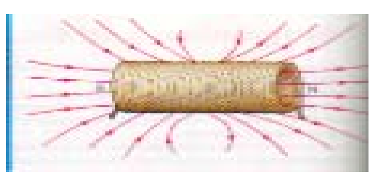
Read this lesson and you will appreciate the convenience of life because of electricity and magnetism.

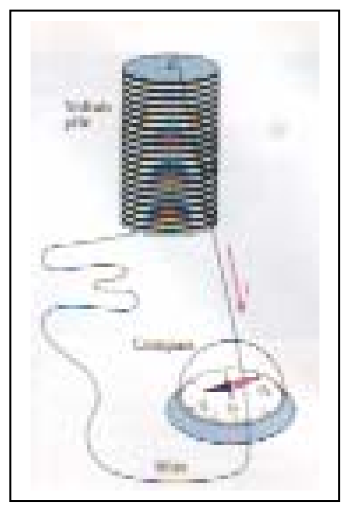
A. Electricity Makes Magnetism

Hans Christian Oersted

On the morning of February 16, 1820, an important discovery was made by accident. Professor ***Hans Christian Oersted*** in Denmark was giving a lecture on electricity to his students. He closed a switch to demonstrate the flow of current. There happened to be a compass nearby. Every time the professor closed the switch, the compass needle turned. Oersted had discovered that an electric current is surrounded by a magnetic field.

His discovery made him conclude that a ***current-carrying wire produces a magnetic field***. This led to the principle of electromagnet.
An **electromagnet** is a magnet that can be switched on and off. It is a solenoid with a core. The strength of an electromagnet can be made stronger by increasing the number of turns on the core.



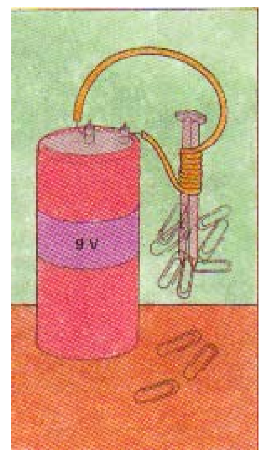


B. Magnetic Field and Electric Current

Shortly after Oersted's discovery that electricity produces magnetic field, scientists experimented with the opposite possibility. In 1831, **Michael Faraday**, an English scientist, discovered that a moving wire through a magnetic field could cause an electric current. At about the same time, an American scientist named **Joseph Henry** made a similar discovery. A current produced by a magnetic field is an induced current.

What you will do

Activity 3.1 Make your own electromagnet



Materials: Large nail, copper wire, dry cell and paper clips

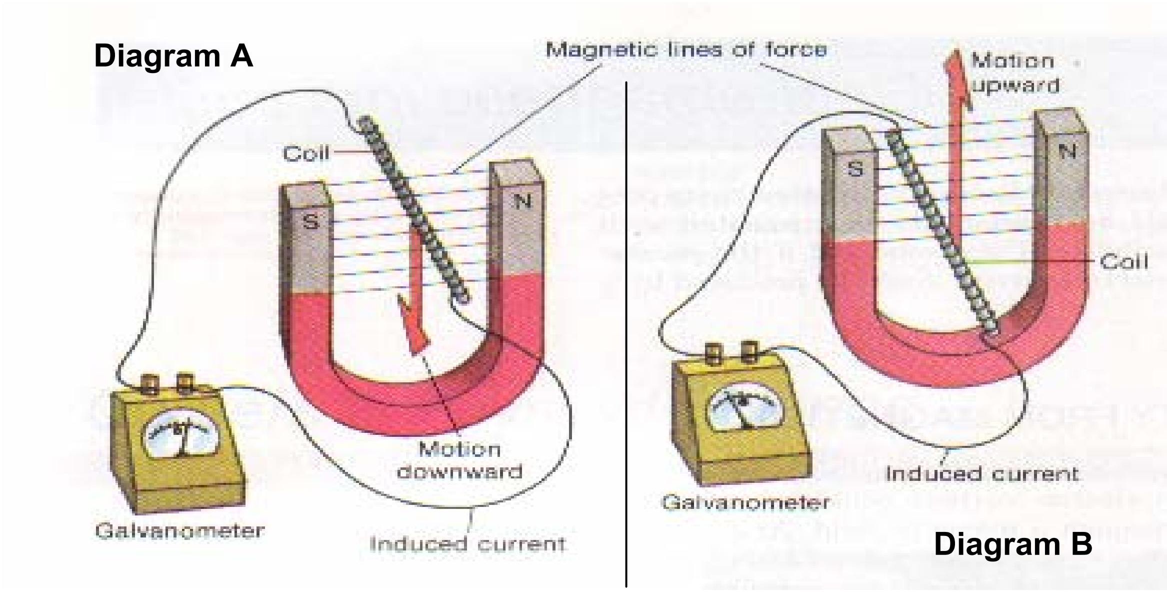
Procedure:

1. Gather all the materials needed.
2. Wrap the copper wire around the large nail.
3. Connect the free ends of the wire to a dry cell.
4. Place the iron nail coil near pieces of nail, paper clips and pins.
5. Observe what happens. ______________________________
6. Disconnect the wire from the dry cell. What happens? ________________

Key to answers on page 33

What you will do
Activity 3.2 Diagram Analysis

The set up shows a wire that is bent and the ends were attached to a galvanometer.



In diagram A, the coil is moved down the space between the north and south poles (see arrow) of the two magnets. What happens to the galvanometer needle?

___

In diagram B, the coil is moved up the space between the north and south poles (see arrow) of the two magnets. What happens to the galvanometer needle?___

If a galvanometer is an instrument used to measure very small electric currents, what is produced by the coil of wire inserted between the poles of the magnet?

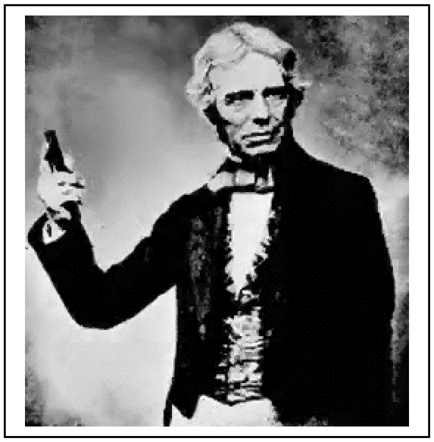
___

Discussion

This experiment showed that electricity is produced in a wire as it moves through a magnetic field. It also shows that the direction in which the coil moves affects the direction of the current. The conducting material like the coil cuts the magnetic lines of force that produce electric current.

If we moved the magnet in and out of the magnetic field, is there a current produced? Yes, the effect is the same, but if the magnet does not move, no current is produced, because no magnetic lines of force exist.

Key to answers on page 33



<u>Michael Faraday</u> concluded ***<u>that when a wire is moved through a magnetic field, a current is generated in the wire.</u>*** This process of generating current by the relative motion between a wire and magnetic field is called ***electromagnetic induction.***

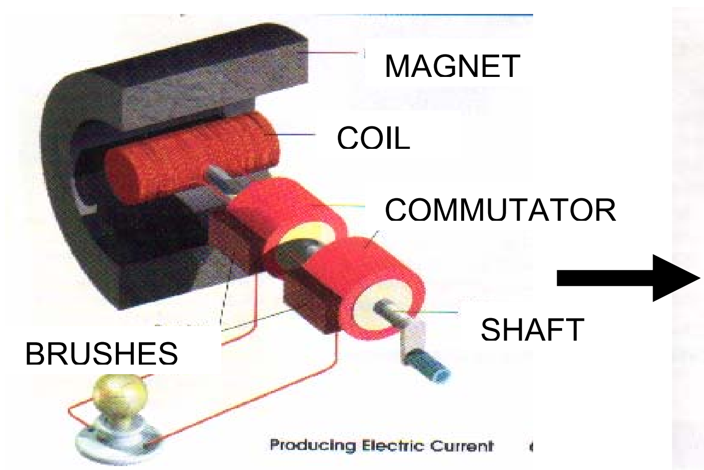
Michael Faraday

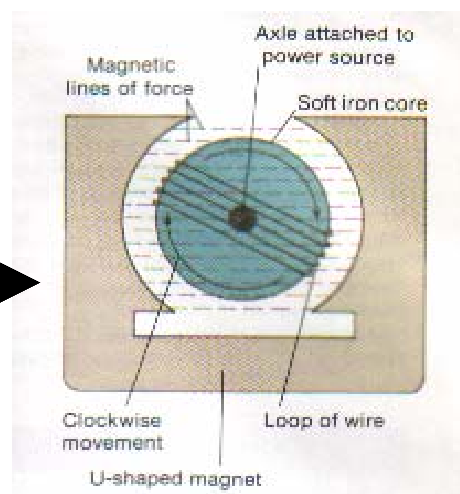
Applications of Electromagnetic Induction

What is the difference between the generator and a motor?

1. What is a generator?

A generator operates on the principle of electromagnetic induction. A ***generato***r is a ***device that converts mechanical energy to electrical energy***. It consists of a u-shaped magnet that produces magnetic field, and insulated loop of wire. The wire loop is attached to a power source placed between the magnetic poles. The power source slowly begins to rotate the wire clockwise. As the wire loop moves, it cuts through the magnetic lines of force that induce current. As the rotation of the wire loop continues, it moves parallel to the magnetic lines of force. When the wire is in this position, no lines of force are cut, therefore, there is no electricity. As it moves further clockwise, the lines of force are cut again producing electricity. The alternate movement of the wire causes alternating current. A rectifier changes alternating current into direct current.





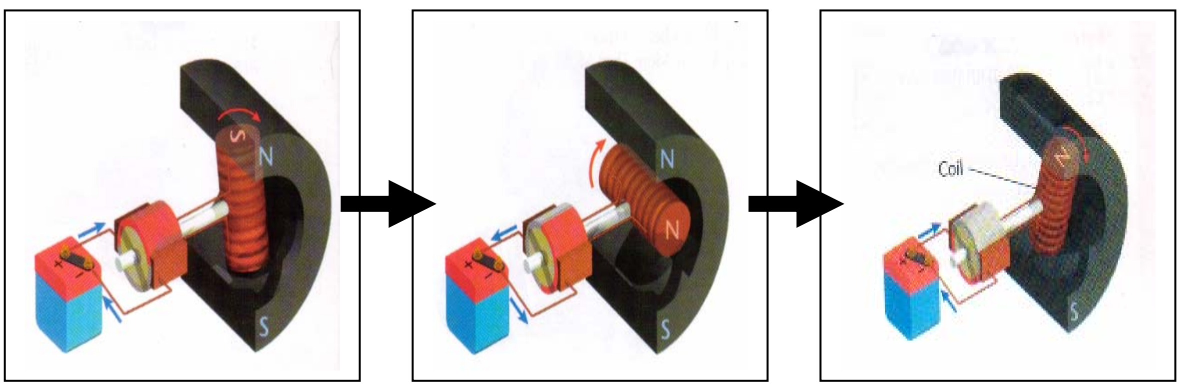
A moving loop cuts through a magnetic field, which generates current in the wire.

Types of Generators

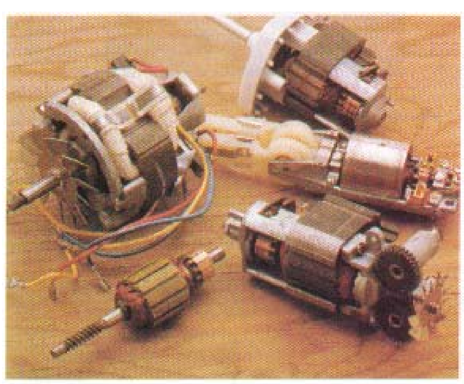
- An **a.c.** generator is a rotating loop in a magnetic field which generates current that fluctuates in value and changes direction every half-rotation of the loop. The current produced is called alternating current (a.c.).
- A simple **d.c.** generator is a rotating loop in a magnetic field which generates current that fluctuates in value but does not change direction.
- The only difference between the simple a.c. and simple d.c. generator is the commutator used. An a.c. generator makes use of two slip rings while a d.c. generator makes use of a split ring commutator.

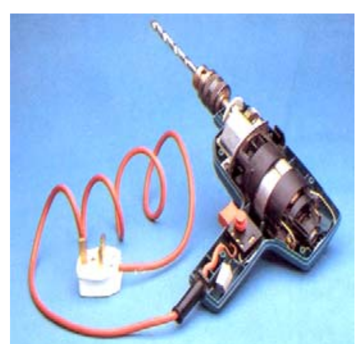
2. What is a motor?

One of the most important uses of electromagnetism is in the electric motor. An ***electric motor*** is a ***device that converts electrical energy to mechanical energy***. A motor contains a movable electromagnet. If an alternating current is supplied to the electromagnet, its poles are reversed. Where it was once attracted by the opposite pole of fixed magnet, it will next be repelled. This process is repeated many times each second.



There are many types of electric motors. Each is designed for a particular purpose or use. They all operate on the principle of electromagnetism.



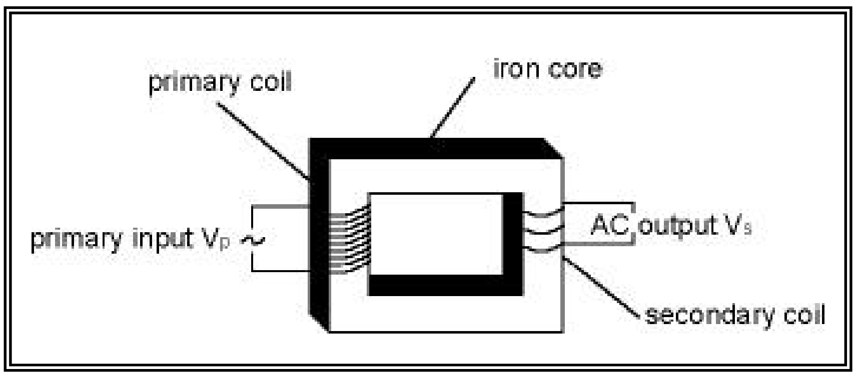


3. What is a transformer?

The alternating current through power lines is at an extremely high voltage. Before alternating current from the power plant can enter your home, its voltage must be decreased. The current must flow through a device called a transformer to decrease the voltage. The transformer regulates the voltage that enters the system. The operation of a transformer operates on the principle of both electromagnetism and electromagnetic induction.

A simple transformer is made of two coils of wire called the primary and the secondary coils. These coils are wrapped around an iron core. As an alternating current passes through the primary coil, the iron core becomes an electromagnet. Because the current changes direction many times each second, the magnetic field also changes its direction and induces an alternating current in the secondary coil.

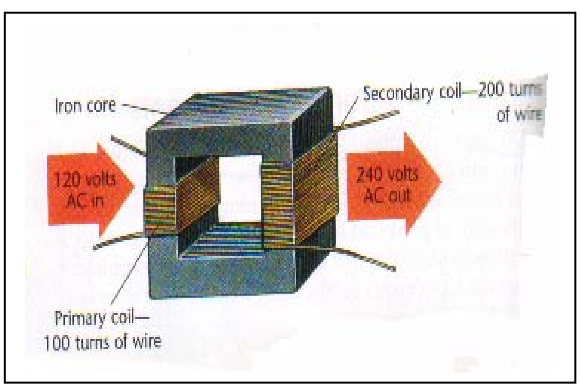
Schematic Diagram of the Parts of a Transformer

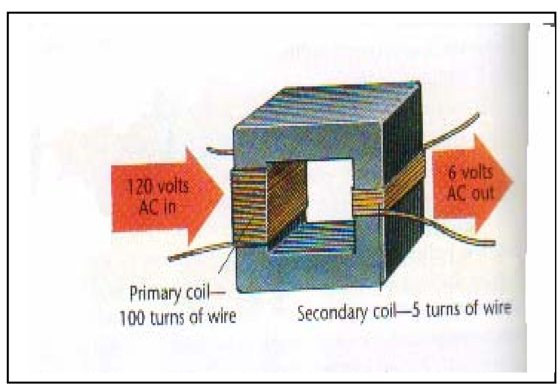


What you will do

Activity 3.3 Diagram Analysis

Examine the pictures of the two types of transformers, the step up and the step down transformers. Differentiate a step-up transformer and the step-down transformer in terms of the number of turns in the coil.





Step-up Transformer | **Step-down Transformer**

You're right! The number of turns in the iron core determines the type of transformer. In a step-up transformer, the number of turns in the primary core is less than in the secondary coil, while in the step-down transformer, the number of turns in the primary core is greater than in the secondary coil. A step-up transformer increases the voltage while a step-down transformer decreases the voltage.

What will you do?

You want to use the appliance that was given to you by your Japanese friend. It is said that its voltage is 100 volts. What will you do? Why?

Key to answers on page 33

What you will do

Self-Test 3.1

Match the phrase in COLUMN A with the term being described in COLUMN B

COLUMN A

1. a small region in a piece of iron where atomic magnetic line up in the same direction
2. ends of bar magnet
3. rotating coil in an electric motor
4. a device that converts mechanical energy into electric energy
5. a device that converts electrical energy into mechanical energy
6. the production of current in a wire that

COLUMN B

a. electromagnetism
b. armature
c. circuit breaker
d. commutator
e. electromagnet
f. electromagnetic induction
g. generator
h. magnetic domain

is moving across a magnetic field
7. a device that regulates or controls the flow of current
8. current that reverses the direction of flow
9. increase the voltage supply
10. measures small amounts of electric current
11. a property of some materials in which there is a force of repulsion or attraction between like or unlike poles
12. a temporary magnet made of a wire coil through which an electric current passes
13. current that flows in only one direction
14. the branch of physical science that involves the combined effects of electricity and magnetism
15. induced magnetism

i. magnetic field
j. rectifier
k. transformer
l. magnetic
m. transistor
n. temporary magnetism
o. motor
p. magnetic poles
q. generator
r. galvanometer
s. alternating current
t. direct current
u. step down transformer
v. step-up transformer

Key to answers on page 33

Lesson 4 Electricity at Home

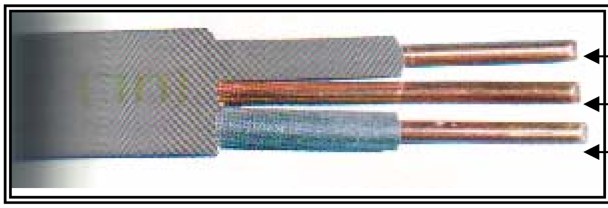
Human lifestyles have changed. Years ago, most people thought of electricity as little more than a curiosity for amusing people. To many scientists, however, it was a phenomenon to be studied in the laboratory. Today giant towers across the country carry electricity to every corner of the land. Electricity has become indispensable to our way of life.

Look around your home. You will find electric outlets in nearly every wall. This is where electrical appliances are plugged in order to function. You use electricity in many ways.

Read this lesson and see how important electricity is in our daily life.

A. Household Circuits

When a house is built, an electrician must install electric outlets, wall switches, fuses, and circuit breakers. All of these devices must be connected by wires inside the walls. In one kind of installation, the wirings in the walls consist of plastic-insulated cable. This type of cable is a group of three wires enclosed in a plastic casing. One wire, insulated with its own black cover, is the “hot” wire. This carries the alternating current to the outlet of 220 volts. *Caution:* DON’T TOUCH THIS WIRE! When touched, it would produce a potential difference of 220 volts that would be very dangerous. This could send enough current through your body to stop your heart from beating. The white insulated wire has no potential but it carries the AC (*alternating current*) back out of the appliances and it might be dangerous to touch. The third wire has no insulation. This wire is connected directly to the ground and it carries no current. This wire is a safety feature.



BLACK "HOT"WIRE

THIRD WIRE

WHITE WIRE – (grounding)

Electric Cable

Electric Outlet

The electric cable is used to carry electric current to homes and other buildings. The electric outlet, the figure at the left side, is where you insert a plug. The flat prongs are connected to the black and white wires of the cable inside the wall. Current flows in one prong, through the appliance, and back into the wall through the other prong. The potential difference between the prongs causes current to flow, delivering energy to the appliance.

The round outlet is a provision for the round prong that serves as the ground wire. If you live in an older type of house, the outlets may not have the grounding terminals.

B. Short Circuits

The 220-volt "hot" wire is very dangerous. Worn insulation or a poor connection can create a short circuit. A short circuit is any accidental connection that allows the current to go directly to the ground instead of passing through an appliance. A 220-volt potential difference can provide any enormous current if there is no appliance in the circuit to provide resistance. A short circuit can cause wires to carry more current than they were designed to carry. The wires can overheat and cause fires.

In modern homes, the ground wire in the cable protects people against short circuits. The metal shell of an appliance is connected to the ground wire through the round, third terminal of the plug. If the "hot" wire touches the shell, the current goes directly to the ground through this lowest –resistance path. If you touch the shell of the grounded appliance, very little of the current will go through your body. Appliances that have plastic shell insulate the user from the current. Such appliances do not need to be connected to the ground.

C. Overloads

Have you ever plugged several appliances into the same outlet? If you have, you may have overloaded the circuit. Wires may contain too much current when they are overloaded. An overload may cause the circuit to heat up and melt the wires, much as a short circuit would. Often, this kind of overload occurs in the kitchen. For this reason, kitchens are usually wired with thicker wires that carry more current without over heating. Why are kitchens likely places for circuit overload?

D. Protecting the Circuits

What you will do

Activity 4.1 Locating and Examining a Fuse Box

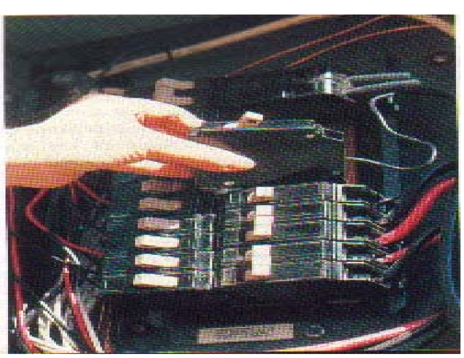
Have a parent or an adult help you locate and examine the fuse box or circuit breaker in your home. Answer the following questions:

1. Describe the appearance of the fuse.
2. How are these fuses rated?
3. How many are rated 15 Ampere, 30 Ampere and 60 Ampere?
4. If you have a circuit breaker at home, describe the set-up.

Key to answers on page 34

Read this!

To prevent wire from overheating, circuits are protected against overloads and short circuits. This protection is often provided by a fuse. A ***fuse*** is a device containing a short strip of metal with a low melting point. If too much current passes through the metal, it melts, or "blows", and breaks the circuit. This is your signal to find and correct the overload and to replace the fuse.



Circuit Breaker

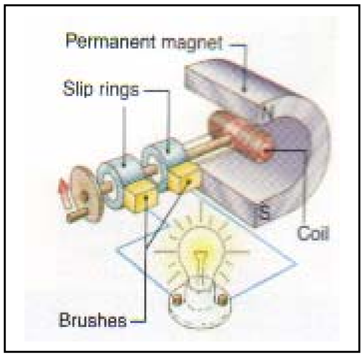
Another device that protects circuit from overloads is a ***circuit breaker***. One type of circuit breaker is a switch attached to a bimetallic strip of metal. When the metal gets hot, it bends, which opens, or "trips", the circuit. This action does not harm the circuit breaker. After the problem has been corrected, the circuit breaker can be reset.

E. Power Transmission

Thousands of powerful generators across the country produce electricity for use in houses and businesses. This energy is fed through a network of transmission lines called power grid.

All these generators supplying you with electricity work on the basis of Faraday's law of induction.

Let's recall:



Faraday's law of electromagnetic induction states that current can be induced in a loop by changing magnetic field that is passing through the loop.

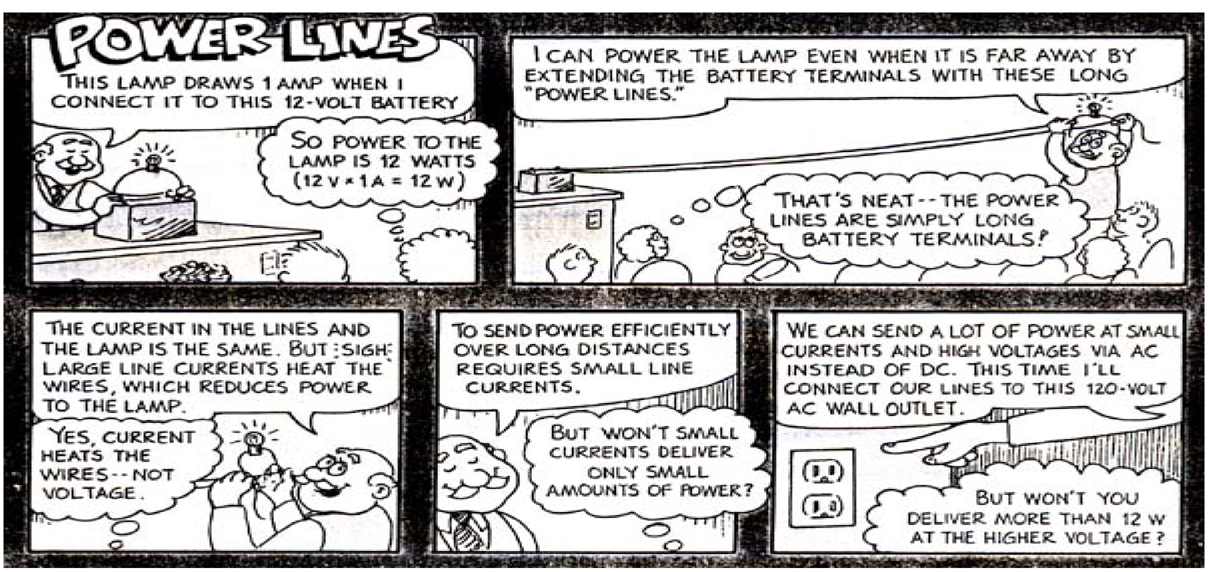
A power plant like an electric lamp works in the principle of electromagnetic induction. When a loop of wire spin within a magnetic field, current is induced in the wire.

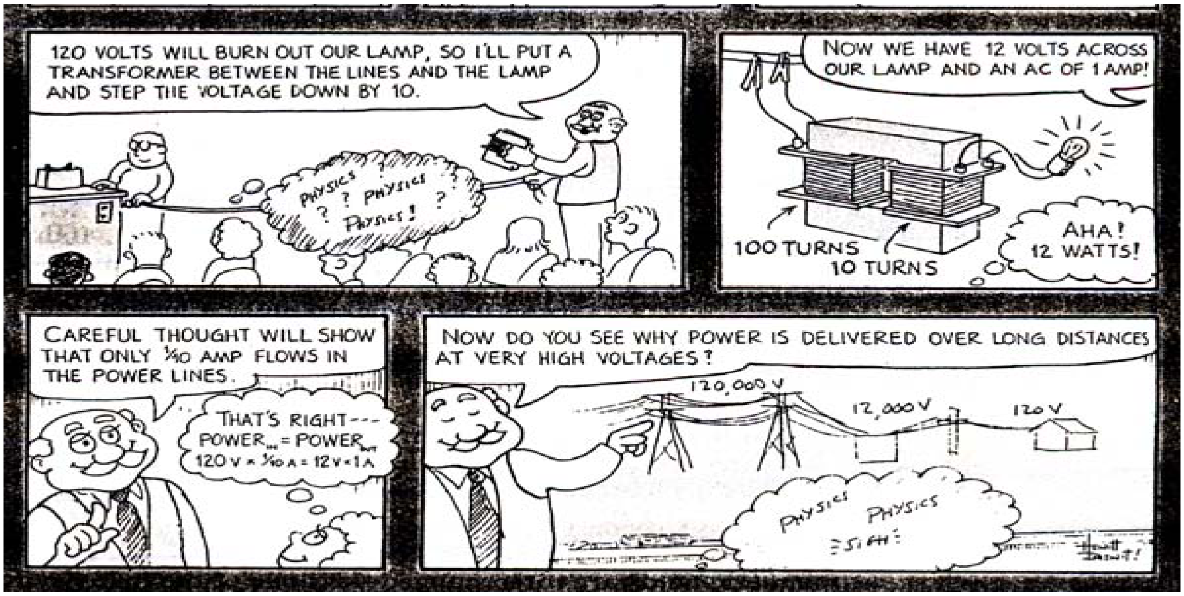
What you will do

Activity 4.2

Read the comic strips below. Answer the following questions:

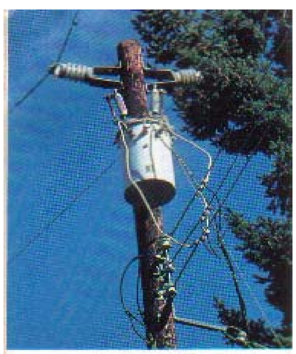
1. How is power distributed from the power plant to the consumer?
2. Why is power transmitted at high voltage and low current through long distance?
3. To decrease power loss, transmission lines must have low resistance. What materials are used as transmission lines?
4. Transmission lines are large diameter wires made of several stranded thinner wires. Why are they made this way?



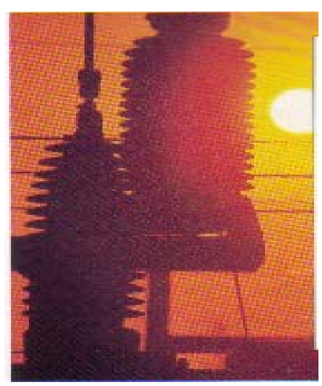


Source: Conceptual Physics by Paul Hewitt

Key to answers on page 34



This common sight is a transformer. This transformer lowers the voltage of electric current from power plants of about 30,0000 volts to 220 volts that are received in your houses.



Large white ceramic insulators prevent high voltage from arching to the ground.

What you will do

Self-Test 4.1

Match the function in COLUMN A with the parts in COLUMN B

COLUMN A

1. part of a transformer
2. prevents short circuiting
3. voltage transmitted to houses
4. used as ground wire
5. Increases voltage
6. decreases voltage
7. wire that supplies the voltage
8. network of transmission lines
9. assembly of fuse in a fuse box that help avoid overloading
10. ends of a bar magnet

COLUMN B

A. electromagnet
B. primary coil
C. magnetic fields
D. black wire
E. magnetic north
F. step-up transformer
G. 220 volts
H. step-down transformer
I. white wire
J. magnetic poles
K. circuit breaker
L. fuse
M. power grid

Key to answers on page 34

Let's summarize

1. Magnets are objects that attract materials containing iron and that always face the same direction when moving freely

2. Natural magnets are made of an iron ore called magnetite, or lodestone. They are permanent magnets. Artificial magnets, which are made by induced magnetism, are either permanent or temporary, depending upon the material they are made of. Materials such as iron that are strongly attracted by magnets are called ferromagnetic substances. Paramagnetic substances are only slightly attracted by magnets. Diamagnetic substances are slightly repelled by magnets.

3. Magnetic lines of force indicate the presence and strength of magnetic force field. They extend from the magnetic north pole to the magnetic South Pole. Like poles of

magnet repel, unlike poles attract. The cause of magnetism is explained by the idea of magnetic domains.

4. Magnetic and electric fields may induce one another. Coiling a conductor around an iron core makes electromagnets.

5. Motors used electromagnetism to convert electrical energy to mechanical energy.

6. Transformers and generators are based on electromagnetic induction. A conductor cutting magnetic lines of force induces a current. A step-up transformer increases the voltage. A step-down transformer decreases the voltage.

7. Generators used electromagnetism to convert mechanical energy into electrical energy.

8. A coil of wire with a current through it is an electromagnet that reverses when the current reverses direction. Alternating current and direct current are two types of current.

9. A fuse and a circuit breaker are two devices that protect household circuits.

10. Most electronic devices run on direct current. Rectifiers change alternating current into direct current.

11. In all power plants, a large generator is connected to a turbine through a drive shaft. As the turbine rotates, it brings the generator with it, which generates electrical energy. Electrical energy from the power plant is transmitted at high voltage and low current to minimize power losses. Step-up transformers raise output voltage from generators before transmission.

12. Electrical energy distribution begins at the first substation where the transmission voltage is initially reduced. At subsequent substations, voltage is further cut down. The final reduction of the voltage to 220 volts occurs at distribution transformers found on electric poles. From there, power is brought to houses through service wires.

Posttest

I. Encircle the letter of the BEST ANSWER.

1. Materials that are strongly attracted to magnets are
   a. diamagnetic
   b. ferromagnetic
   c. paramagnetic
   d. All of the above

2. According to Michael Faraday,
   a. magnetic field produces current
   b. current produces magnetic field
   c. current is always present in a magnetic field
   d. wire carrying current produces magnetic field

3. How do you weaken a magnet?
   a. By heating it
   b. By banging it on a table
   c. By soaking it on a mercury
   d. By placing it near a compass

4. A piece of copper cannot be made into a magnet because
   a. copper cannot be charged.
   b. copper atoms have no charge.
   c. the domains are already aligned.
   d. electrons spinning in opposite direction in copper cancel each other.

5. To decrease the strength of an electromagnet
   a. add iron center to the coil.
   b. decrease the number of loops of wire in the coil.
   c. increase the number of loops of wire in the coil.
   d. All of the above

6. If the N pole of a magnet is brought near a magnet suspended on a string, the
   a. N poles attract each other
   b. N poles attract the S poles
   c. S poles attract each other
   d. N poles repel the S poles

7. In sending electric energy over long distance, the main cause of energy loss is
   a. the use of transformer.
   b. the size of the wires.
   c. the high current.
   d. the use of direct current.

8. A material that allows the electromagnet in a motor to move is the
   a. amplifier. c. commutator.
   b. armature. d. semiconductor.

9. A device that turns electric energy into a sound energy is
   a. a speaker. c. a CRT.
   b. a transformer. d. generator.

10. A material that is slightly repelled by a magnet is called
   a. diamagnetic. b. ferromagnetic.
   c. paramagnetic. d. all of these

11. In a magnet the regions of greatest magnetic force are the
   a. magnetic domains. b. magnetic poles.
   c. lodestones. d. magnetic field.

12. A compass needle points to the ________ pole.
   a. magnetic b. geographic c. closer d. at any point

13. Clusters of many atoms that can be thought of as tiny magnets are
   a. insulators. c. magnetic poles.
   b. magnetic domains. d. geographic poles.

14. In a household electric circuit, a short circuit occurs when
   a. two hot wires touch.
   b. a hot wire is grounded.
   c. a fuse blows or a circuit breaker trips the circuit.
   d. a ground wire touches the metal shell of an appliance.

15. High potentials are used in long-distance transmission of electricity because
   a. they are safer to use.
   b. there is no other way to make current flow.
   c. there is less loss of power when currents are small.
   d. generators produce high potentials with greater efficiency.

II. Match column A with column B

COLUMN A

1. the combined effects of electricity and magnetism
2. A magnet in which magnetism is produced by an electric current
3. The creation of a current by a changing magnetic field
4. A machine that changes kinetic energy into electric energy
5. A machine that changes electric energy into kinetic energy
6. A device that increases or decreases voltage
7. Tiny permanent magnets
8. Magnets made from alloys of aluminum, cobalt and nickel
9. Region in the space around a magnet in which a magnetic force acts on other magnet brought into the region
10. magnet made mostly of iron, with little neodynmium and boron

COLUMN B

a. electromagnetic induction
b. magnetic poles
c. battery
d. electromagnetism
e. electric motor
f. electromagnet
g. electric generator
h. voltage
i. Transformer
j. magnetism
k magnequench
l. magnetic field
m. temporary magnetism
n. magnetic lines of force
o. magnetites
p .permanent magnets
q. alnico magnet

Key to answers on page 21

Key to Answers

Pre-Test

I.

1. d	6. d	11. b
2. a, b, d	7. b	12. a
3. c	8. d	13. c
4. b	9. d	14. b
5. b	10. d	15. b

II.

1. South
2. permanent
3. south-seeking pole
4. poles
5. magnetic field
6. domains
7. electromagnetism
8. repel
9. ferromagnetic
10. lodestone

Lesson 1

Self-Test 1.1

1. lodestone
2. magnetic
3. Magnes
4. magnet
5. Thales

Lesson 2

Possible answers to:
Activity 2.1a:

3. The paper clips were attracted to the screw driver

Activity 2.2

1. The S pole of the suspended magnet is attracted to the N pole of the other magnet
2. The N pole of the suspended magnet repelled the N pole of the magnet
3. The N pole of the suspended magnet was attracted to the S pole of the other magnet
4. The S pole of the other magnet repelled the S pole of the suspended magnet.

Self-Test 2.1:

1. ALNICO
2. DOMAINS
3. MAGNETIC FIELD
4. MAGNETIC LINES OF FORCE
5. FERROMAGNETIC
6. DIAMAGNETIC
7. PARAMGANETIC
8. MAGNET
9. MAGNETIZATION
10. POLES

Lesson 3

Possible answers to Activity 3.1

1. The iron nails, paper clips and pins were attracted to the iron coil when the circuit is connected to the dry cell.
2. The iron nails, paper clips and pins dropped when the circuit is disconnected to the dry cell.

Possible answers to Activity 3.2

In diagram A, the pointer of the galvanometer deflected to the right
In diagram B, the pointer of the galvanometer deflected to the left
There is current when the magnet in placed in between the poles of the magnet.

What you will do?

Use a step-up transformer. Because the output here in the Philippines is 220 volts. So, to make the voltage 220, a step-up transformer is needed.

Self-Test 3.1

1. h	6. f	11. l
2. p	7. k	12. e
3. b	8. s	13. t
4. q	9. u	14. a
5. o	10. r	15. n

Lesson 4

The answers to ACTIVITY 4.1 are in the discussion.

Possible answers to Activity 4.2

1. Electric power is transmitted and distributed at high voltage and low current from the power plant to the consumer through transmission lines.
2. Output voltage from generators is first increased through step up transformer at the power plant before the electric power is transmitted. The voltage of the electric power is reduced to a value suited to the consumer's needs. Transformers are used to step up and step down the voltage in substation.)
3. Electric power is transmitted at high voltage and low current to minimize power loses. Copper wires are used as transmission lines.
4. The transmission lines need to be big diameter wires because they carry large current. But big solid wires are difficult to handle. Hence, thinner wires are stranded to have flexible strong diameter wires.)

Self-Test 4.1

1. B	5. F	9. K
2. L	6. H	10. J
3. G	7. D	
4. I	8. M	

Posttest

I. Multiple Choice

1. b	6. b	11. b
2. d	7. b	12. b
3. c	8. c	13. b
4. d	9. a	14. a
5. b	10. a	15. c

II. Matching Type:

1. d
2. f
3. a
4. g
5. e
6. i
7. o
8. q
9. b
10. k

-End of Module-

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