UNIT 3

Magnetism and Electromagnetism

Learning Objectives

After studying this chapter, students will be able to

- understand the concept of magnetic field
- know the properties of magnetic field lines
- calculate the force exerted on a current carrying conductor in a magnetic field
- understand the force between two parallel current carrying conductors
- know the concept of electromagnetic induction and apply it in the case of generators.
- appreciate how voltage can be increased or decreased using transformers
- understand the applications of electromagnet and apply the knowledge in constructing devices using electromagnets

BH6RTD

Introduction

Have you ever played with magnets? Do you wonder why it attracts iron? Magnets are always very attractive objects for the humans. In fact famous scientist Einstein mentioned that he was always attracted by magnets in his childhood. In the olden days magnets were used in the ships. Captains of the ships effectively used the magnets to identify the direction of the ship in the sea.

There are two kinds of magnets that we can see around us: Natural magnet and Artificial magnet. Natural magnets exist in the nature. These kind of magnets can be found in rocks and sandy deposits in various parts of the world. The strangest natural magnet is lodestone magnetite (Fig. 3.1)

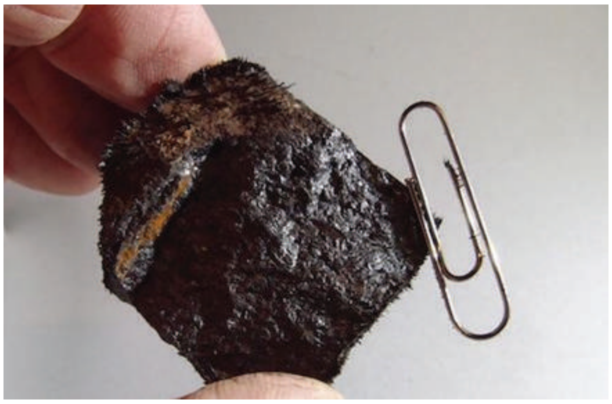


Figure 3.1 Natural magnets

The magnetic property in the natural magnets is permanent. It never gets destroyed. The lodestone are used to make compasses in the olden days. Artificial magnets are made by us. The magnets available in the shops are basically artificial magnets (Fig. 3.2) In this lesson we shall study about magnetic properties and how it is effectively used in day to day life.

Figure 3.2 Artificial magnets

3.1 Magnetic field (B)

Activity 1

Put a magnet on a table and place some paper clips nearby. If you push the magnet slowly towards the paper clips, there will be a point at which the paper clips jump across and stick to the magnet. What do you understand from this?

The interesting question is how the magnet attracts the paper clip? From the above activity we notice that magnets have an invisible field all around them which attracts magnetic materials. In this space we can feel the force of attraction or repulsion due to the magnet. Thus, magnetic field is the region around the magnet where its magnetic influence can be felt. It is denoted by B and its unit is Tesla.

DO YOU KNOW? The broad spectrum of magnetic-field strengths is very interesting to know:

Human Brain's magnetic field
= 1 pT = 1 pico tesla

Magnetic field in a galaxy
= 0.5 nT = 0.5 nano tesla

Magnetic field due to microwave oven
(at 1 foot distance)
= 8 μT = 8 micro tesla

Earth's magnetic field at Chennai (13^{o} latitude) = 42 μT = 42 micro tesla

Magnetic field of MRI scanner = 2 T

The direction of the magnetic field around a magnet can be found by placing a small compass in the magnetic field as shown in the Fig 3.3

Figure 3.3 Compass showing direction of magnetic field

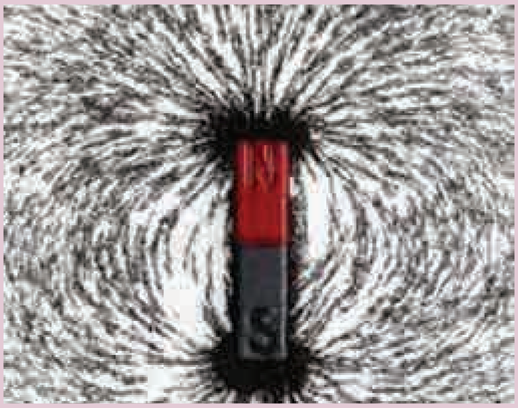
Magnetic field can penetrate through all kinds of materials, not just air. The Earth produces its own magnetic field, which shields the earth's ozone layer from the solar wind and is important in navigation using a compass.

DO YOU KNOW? Some sea turtles (loggerhead sea turtle) return to their birth beach many decades after they were born, to nest and lay eggs. In a research, it is suggested that the turtles learnt their home beach's location through what is called "geomagnetic imprinting". The turtles, it seems, can perceive variations in magnetic parameters of Earth such as magnetic field intensity and remember them. This memory is what helps them in returning to their homeland.

3.2 Magnetic Field Lines

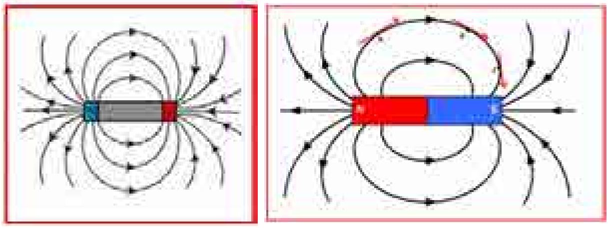
Activity 2

Place a magnet over a cardboard. Sprinkle some iron-filings on the cardboard. Tap the card board gently. We observe that the iron filings align themselves in definite pattern. These patterns are called magnetic lines of force.



Activity 2 shows that magnets have some curved lines around them and these lines are called magnetic field lines. This can also be inferred by placing a test magnet in the magnetic field of another magnet. Through the direction the test magnet moves, magnetic field lines can be identified. The magnetic field lines start at north pole and ends at south pole as shown in the Figure 3.4(a)

A magnetic field line is defined as a curve drawn in the magnetic field in such a way that the tangent to the curve at any point gives the direction of the magnetic field as shown in the Figure 3.4 (b). In the Figure 3.4 (b), the arrow mark indicates the direction of magnetic field at points A, B and C. Note carefully that the magnetic field at a point is tangential to the magnetic field lines.



a b

Figure 3.4 Magnetic field lines

We all know that earth also behaves like a magnet and the magnetic field lines of earth's is shown in the figure 3.5

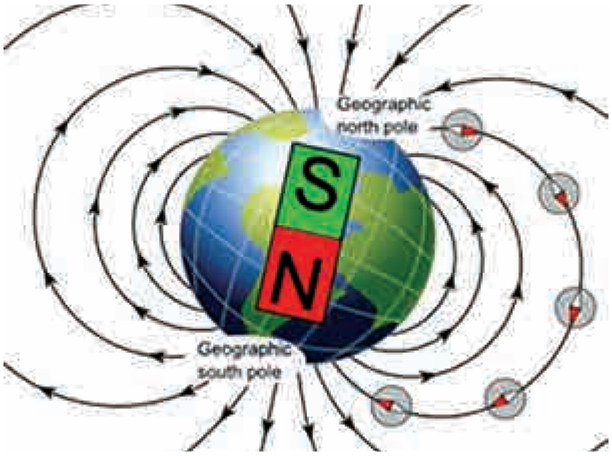


Figure 3.5 Earth's magnetic field lines

3.2.1 Magnetic flux

Magnetic flux is the number of magnetic field lines passing through a given area as shown in the figure 3.6. It is denoted by ϕ and its unit is weber (Wb).

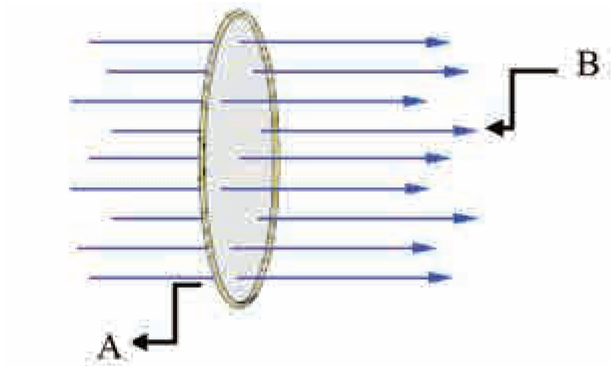


Figure 3.6 Magnetic flux

The number of magnetic field lines crossing unit area kept normal to the direction of field lines is called magnetic flux density. It is shown in the figure 3.7. Its unit is Wb/m2

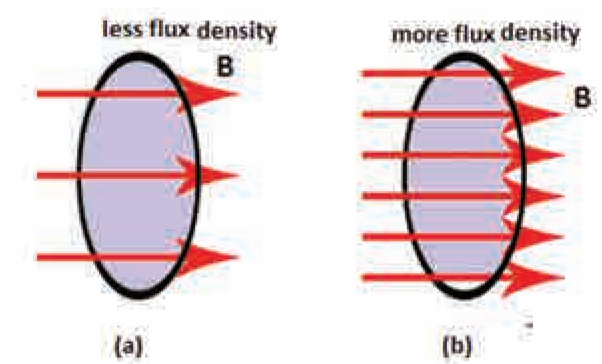


Figure 3.7 Magnetic flux density

3.2.2 Properties of magnetic lines of force

- Magnetic lines of force are closed continuous curves, extending through the body of the magnet.
- Magnetic lines of force start from the North Pole and end at the South Pole.
- Magnetic lines of force never intersect.
- They will be maximum at the poles than at the equator.
- The tangent drawn at any point on the curved line gives the direction of magnetic field.

More to Know

Magnetic Shielding

The computer hard disk stores information using magnetism. Therefore if the hard disk comes near a powerful magnet the data may get corrupted because of the strong magnetic field. Hence we may have to shield computer hard disk, MRI and other such sensitive equipments from such magnetic effects. Stopping the magnetic field from entering into a region is called magnetic shielding. It is known that soft magnetic materials like iron or nickel-iron alloy have the ability to choke up magnetic lines. Magnetic lines coming out of a magnet prefer to pass within the soft metals rather than through air.

3.2.3 Magnetic field lines between two magnets

What does happen when two magnets are placed near each other? There are four ways we can keep them. They are shown in Fig 3.8

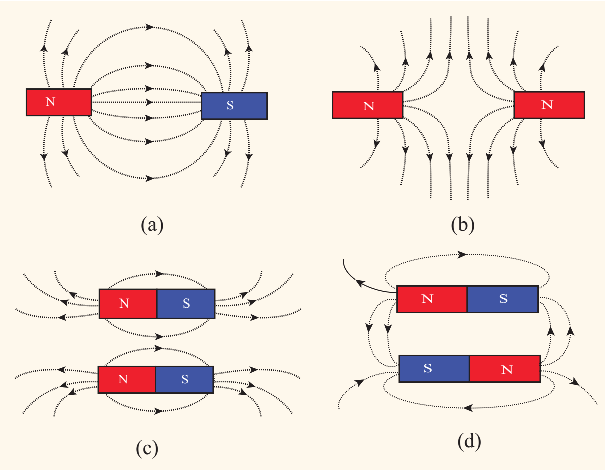


Figure 3.8 Magnets placed together in different directions

(a) two unlike poles facing each other, (b) two like poles facing each other, (c) parallel magnets with same poles facing same side and (d) parallel magnets with opposite poles facing same side. All these positions are.

3.3 Magnetic effect of current

It was on 21st April 1820, Hans Christian Oersted, a Danish Physicist was giving a lecture. He was demonstrating electrical circuits in that class. He had to often switch on and off the circuit during the lecture. Accidentally, he noticed the needle of the magnetic compass that was on the table. It deflected whenever he switched on and the current was flowing through the wire. The compass needle moved only slightly, so that the audience didn't even notice. But it was clear to Oersted that something significant was happening. Intrigued, he conducted experiments to find out a startling effect, the magnetic effect of current.

Oersted aligned a wire XY such that they were exactly along the North-South direction. He kept one magnetic compass above the wire at A and another under the wire at B. When the circuit was open and no current was flowing through it, the needle of both the compass was pointing to north. Once the circuit was closed and electric current was flowing, the needle at A pointed to east and the needle at B to the west as shown in Figure 3.9. This showed that current carrying conductor produces magnetic field around it.

The direction of the magnetic lines around a current carrying conductor can be easily understood using the right hand thumb rule. Hold the wire with four fingers of your right hand with thumbs-up position. If the direction of the current is towards the thumb then the magnetic lines curl in the same direction as your other four fingers as shown in Figure 3.10. This shows that the magnetic field is always perpendicular to the direction of current.

The strength of the magnetic field at a point due to current carrying wire depends on: (i) the current in the wire, (ii) distance of the point from the wire, (iii) the orientation of the point from the wire and (iv) the magnetic nature of the medium. The magnetic field lines are stronger near the current carrying wire and it diminishes as you go away from it. This is represented by drawing magnetic field lines closer together near the wire and farther away from the wire.

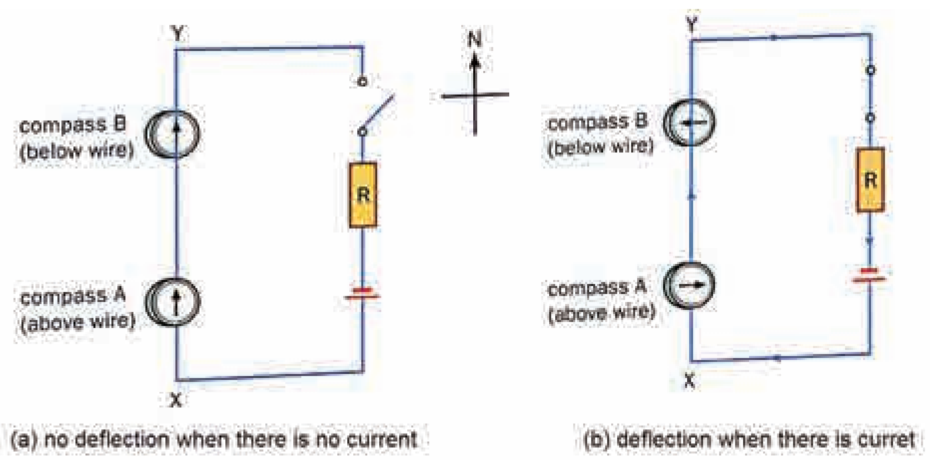


Figure 3.9 Current produces magnetic field

Know Your Scientist

Hans Christian Oersted, (14th August 1777 – 9th March 1851) was a Danish Physicist and Chemist who discovered that electric currents create magnetic fields, which was the first connection found between electricity and magnetism. In 1824, Oersted founded Selskabet for Naturlærens Udbredelse (SNU), a society to disseminate knowledge of the natural sciences.

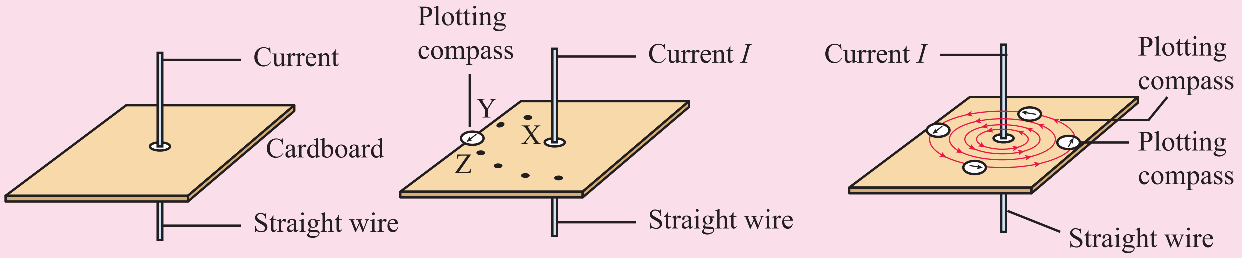
3.4 Force on a current carrying conductor in a magnetic field

H.A.Lorentz found that a charge moving in a magnetic field, in a direction other than the direction of magnetic field, experiences a force. It is called the magnetic Lorentz force. Since charge in motion constitutes a current, a conductor carrying moving charges, placed in magnetic field other than the direction of magnetic field, will also experience a force and can produce motion in the conductor.

In activity 3, we saw that a current carrying wire has a magnetic field perpendicular to the

Activity 3

Take a cardboard and thread a wire perpendicular through it. Connect the wire such that current flows up the wire. Switch on the circuit. Let the current flow. Place a magnetic compass on the cardboard. Mark S and N point of the compass as X and Y respectively on the cardboard. Move the compass such that S end touches Y. Now mark the N end as Z. In the next step move the compass such that S end touch Z. Repeat the steps. Now if you join all the points you will find that it is a circle. Start again, but now keep the compass away from the center or towards the center. If you follow the above steps, you can see that you can draw another magnetic line and the magnetic lines are concentric circles. Also you will find the magnetic lines are anti-clockwise.



Reverse the direction of the current, you will find the magnetic circles are clockwise. Note: The flow of current here means conventional current and not the direction of the flow of electrons.

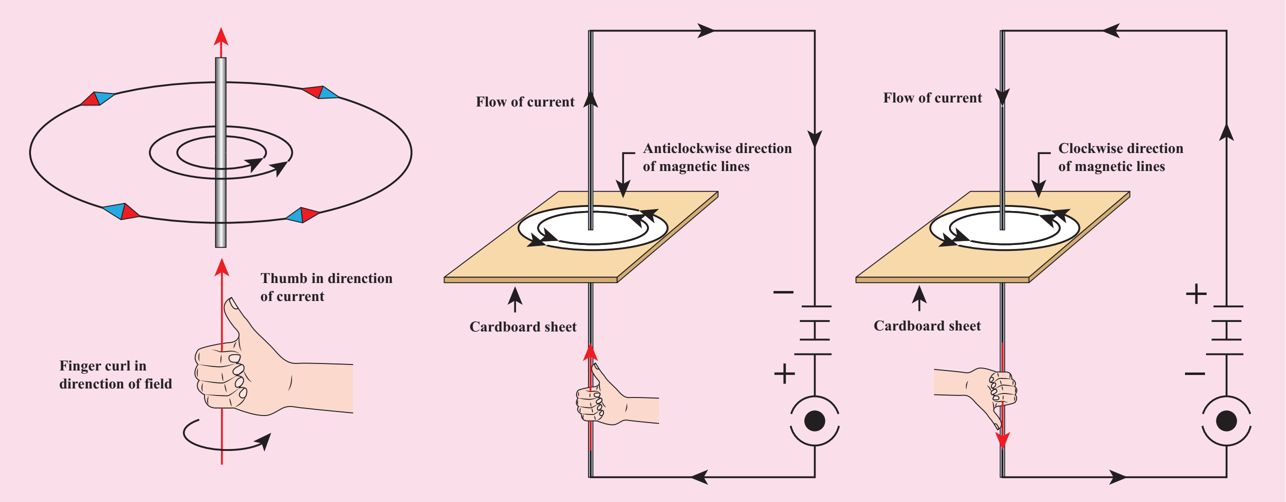


Figure 3.10 Right hand thumb rule

wire, by looking at the deflection of the compass needle in the vicinity of a current carrying conductor. The deflection of the needle implies that the current carrying conductor exerts a force on the compass needle. In 1821, Michael Faraday discovered that a current carrying conductor also gets deflected when it is placed in a magnetic field. In Figure 3.11, we can see that the magnetic field of the permanent magnet and the magnetic field produced by the current carrying conductor interact and produce a force on the conductor. The view perpendicular to the direction of current is shown in Figure 3.12.

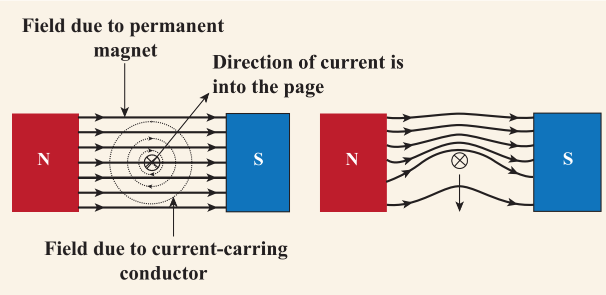


Figure 3.12 Force on current carrying conductor kept in magnetic field

If a current I is flowing through a conductor of length L kept perpendicular to the magnetic field B, then the force F experienced by it is given by the equation,

Activity 4

Stand near the TV screen (The old CRT type TV). Do you feel any sensation on your skin? Take a bar magnet and bring it near the TV Screen. What do you observe? You can observe that the picture on the screen is distorted. Move the bar magnet away from the screen. Now you will get a clear picture. Repeat this to confirm that the motion of electrons is affected by the field produced by the bar magnet. This must be due to the fact that the magnetic field exerts force on the moving charges. This force is called magnetic force.

$$F = I\,L\,B$$

The above equation indicates that the force is proportional to current through the conductor, length of the conductor and the magnetic field in which the current carrying conductor is kept.

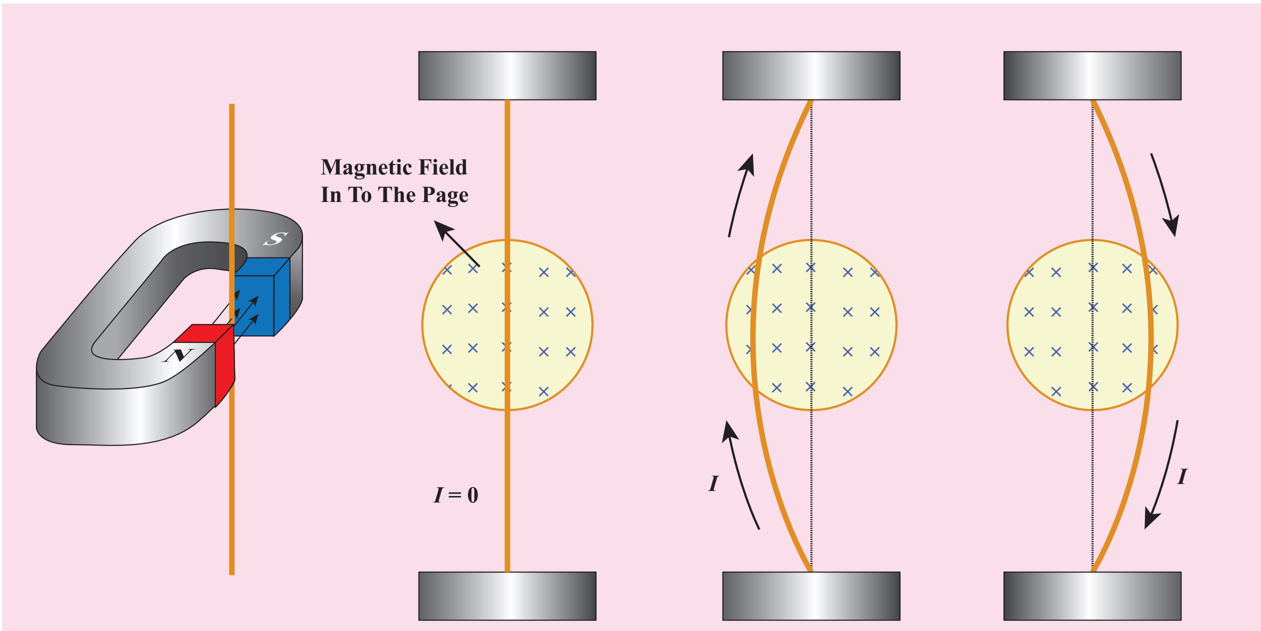


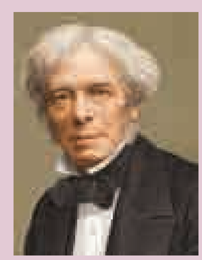
Figure 3.11 Deflection of current carrying wire in magnetic field

Note : The angle of inclination between the current and magnetic field also affects the magnetic force. When the conductor is perpendicular to the magnetic field, the force will be the maximum (=BIL). When it is parallel to the magnetic field, the force will be zero.

The force is always a vector quantity. A vector quantity has both magnitude and direction. It means we should know the direction in which the force would act. The direction is often found using what is known as Fleming's Left hand Rule (formulated by the scientist John Ambrose Fleming).

The law states that while stretching the three fingers of left hand in perpendicular manner with each other, if the direction of the current is denoted by middle finger of the left hand and the second finger is for direction of the magnetic field then the thumb of the left hand denotes the direction of the force or movement of the conductor (Fig. 3.13)

Know Your Scientist



Michael Faraday (22 September 1791 – 25 August 1867) was a British Scientist who contributed to the study of electromagnetism and electrochemistry. His main discoveries include the principles underlying electromagnetic induction, diamagnetism and electrolysis.

Although Faraday received little formal education, he was one of the most influential scientists in history. Faraday was an excellent experimentalist who conveyed his ideas in clear and simple language. The SI unit of capacitance is named in his honour: the farad. Albert Einstein kept a picture of Faraday on his study wall, alongside pictures of Isaac Newton and James Clerk Maxwell. Faraday is one of the greatest scientific discoverers of all time.

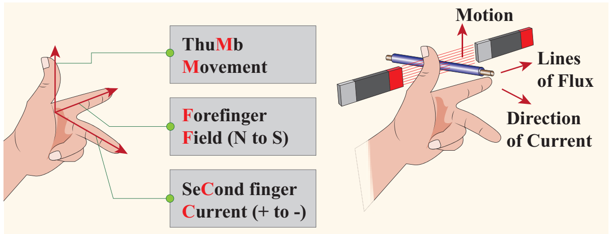


Figure 3.13 Fleming's left hand rule

Exercise 1

A conductor of length 50 cm carrying a current of 5 A is placed perpendicular to a magnetic field of induction 2×10^{-3} T. Find the force on the conductor.

Solution:

Force on the conductor = ILB

$$= 5\times50\times10^{-2}\times2\times10^{-3}$$

$$= 5\times10^{-3}\text{ N}$$

Exercise 2

A current carrying conductor of certain length, kept perpendicular to the magnetic field experiences a force F. What will be the force if the current is increased four times, length is halved and magnetic field is tripled?

Solution:

Let the current be I, length be L, and magnetic field be B. Therefore, F = I L B.

When current is increased four times, length is halved and magnetic field tripled then, force, $F_1 = (4I) \times (L/2) \times (3B)$

$F_1 = 6F$

Therefore, the force increases six times.

3.5 Force on parallel current carrying conductors

We have seen that a current carrying conductor has a magnetic field around it. If we place another conductor carrying current parallel to the first one, the second conductor will experience a force due to the magnetic field of the first conductor. Similarly, the first conductor will experience a force due to the magnetic field of the second conductor. These two forces will be equal in magnitude and opposite in direction. This is shown in Fig. 3.14.

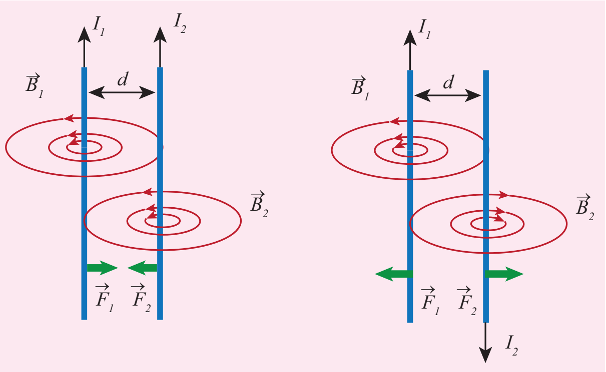


Figure 3.14 Attractive and repulsive force on current carrying wires

Using Fleming's left hand rule we can find that the direction of the force on each wire would be towards each other when the current in both of them are flowing in the same direction. That is the wires would experience an attractive force. However, if the direction of the flow of current is in opposite direction, then the force on each of the wire will also be in opposite direction. These are shown in Figure 3.14. The perpendicular view of the same is shown in Figure 3.15.

Connection between Electricity and magnetism:

Before 18th century people thought that magnetism and electricity were separate subjects of study. After Oersted experiment the electricity and magnetism were united and became a single subject called "Electromagnetism".

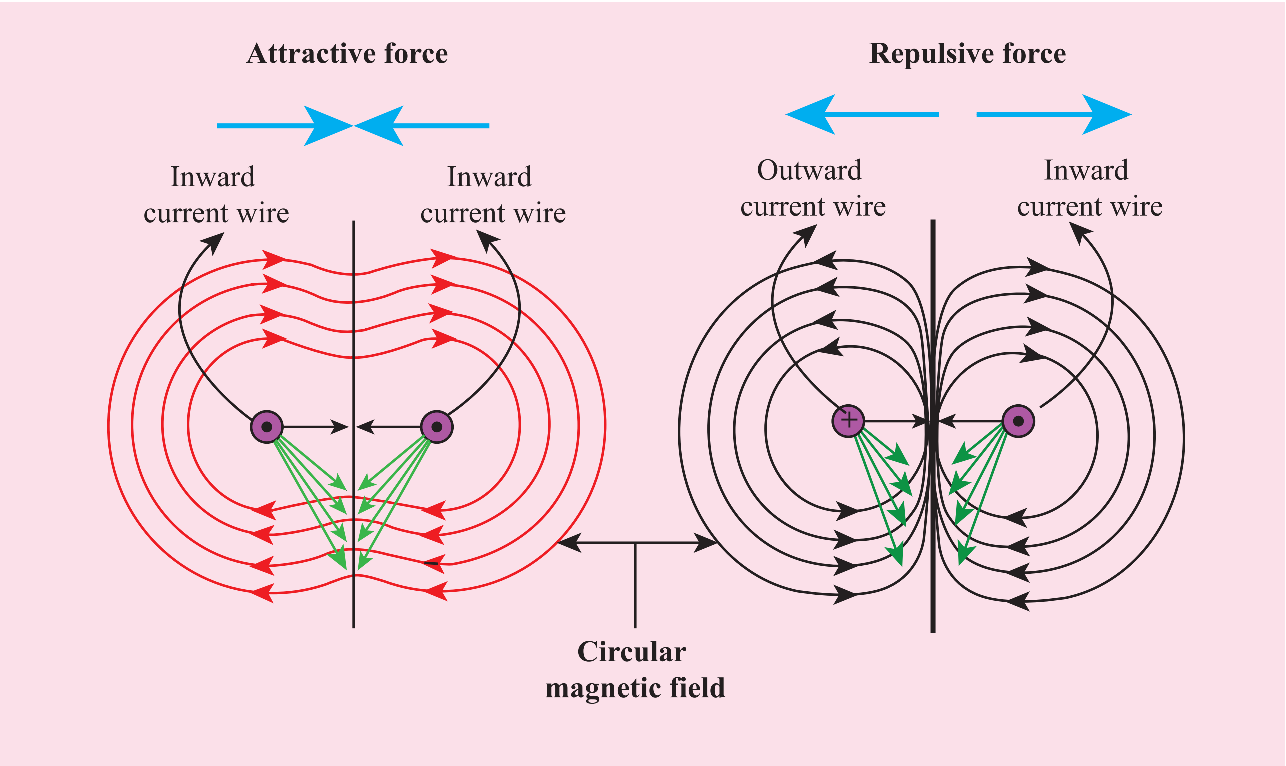


Figure 3.15 Force on current carrying conductors when viewed perpendicular to the direction of current

When there is current, the magnetic field is produced and the current carrying conductor behaves like a magnet. You may now wonder how was it possible for a lodestone to behave like a magnet when there was no current passing through it. In the twentieth century only we understood that the magnetic property arises due to the motion of electrons in the lodestone. In the circuit the electrons flow from negative of the battery to positive of the battery and constitutes current. As a result it produces magnetic field. In natural magnets and artificial magnets we buy in shops, the electrons move around the nucleus constitutes current which leads to magnetic property. Here, every orbiting electron in its orbit is like a current carrying loop. Even though in all materials the electron orbits around the nucleus, only for certain special type of material called magnetic material the motion of electrons around the nucleus gets added up and as a result we have permanent magnetic field.

3.6 Electric motor

BMFMV1

An electric motor is a device which converts electrical energy into mechanical energy. Electric motors are crucial in modern life. They are used in water pump, fan, washing machine, juicer, mixer, grinder etc. We have already seen that when electric current is passed through a conductor placed normally in a magnetic field, a force is acting on the conductor and this force makes the conductor to move. This is harnessed to construct an electric motor.

To understand how a motor works, we need to understand how a current carrying coil experiences a turning effect when placed inside a permanent magnetic field and it is shown in Figure 3.16.

In Fig. 3.16, a simple coil is placed inside two poles of a magnet. Now look at the current carrying conductor segment AB. The direction of the current is towards B, whereas in the conductor segment CD the direction is opposite. As the current is flowing in opposite directions in the segments AB and CD, the direction of the motion of the segments would be in opposite directions according to Fleming's left hand rule. When two ends of the coil experience force in opposite direction, they rotate.

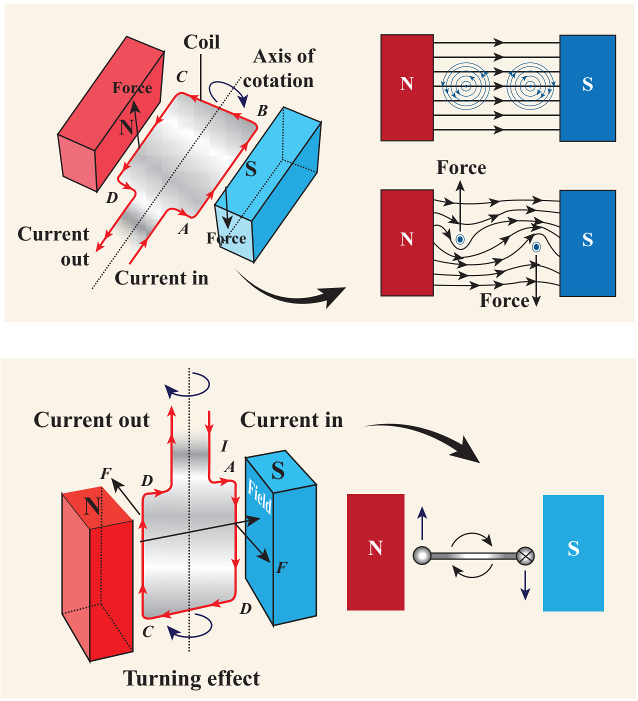


Figure 3.16 Turning effect in a coil

If the current flow is along the line ABCD, then the coil will rotate in clockwise direction first and then in anticlockwise direction. If we want to make the coil rotate in any one

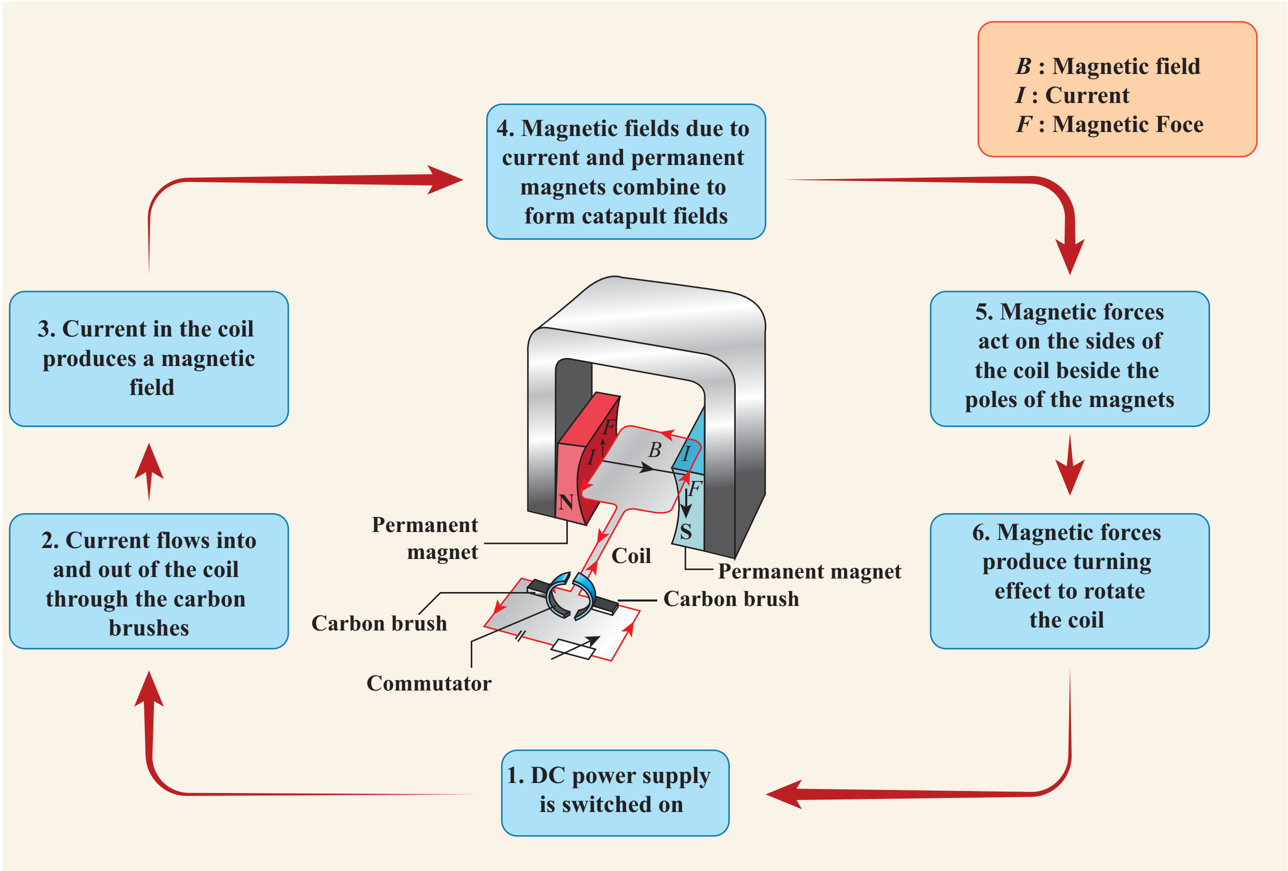


Figure 3.17 Principle of electric motor

direction, say clockwise, then the direction of the current should be along ABCD in the first half of the rotation and along DCBA in the second half of the rotation. To change the direction of the current, a small device called split ring commutator is used (Fig. 3.18).

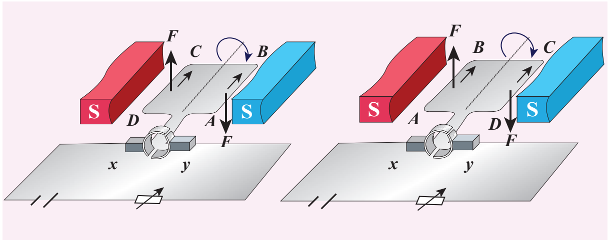


Figure 3.18 Split ring as commutator to produce rotation in same direction.

When the gap in the split ring commutator is aligned with terminals X and Y there is no flow of current in the coil. But, as the coil is moving, it continues to move forward bringing one of the split ring commutator in contact with the carbon brushes X and Y. The reversing of the current is repeated at each half rotation, giving rise to a continuous rotation of the coil.

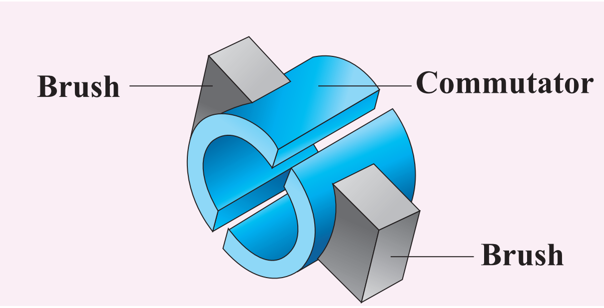


Figure 3.19 Close view of split ring and carbon brushes

The speed of rotation of coil can be increased by:

i. increasing the strength of current in the coil.
ii. increasing the number of turns in the coil.
iii. increasing the area of the coil and
iv. increasing the strength of the magnetic field.

3.7 Electromagnetic Induction

When it was shown by Oersted that magnetic field is produced around a conductor carrying current, the reverse effect was also attempted. In 1831, Michael Faraday explained the possibility of producing an e.m.f across the conductor when the magnetic flux linked with the conductor is changed. In order to demonstrate this Faraday conducted the following experiments.

3.7.1 Faraday's experiments

Experiment 1

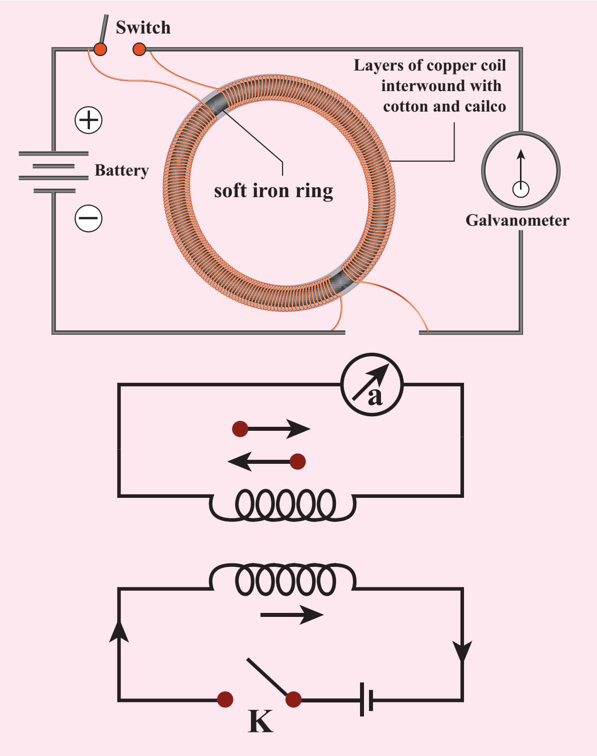


Figure 3.20 Faraday's experiment

In this experiment, two coils were wound on a soft iron ring (separated from each other). The coil on the left is connected to a battery and a switch K. A galvanometer is attached to the coil on the right. When the switch is put 'on', at that instant, there is a deflection in the galvanometer. Likewise, when the switch is put 'off', again there is a deflection – but in the opposite direction. This proves the generation of current.

Experiment 2

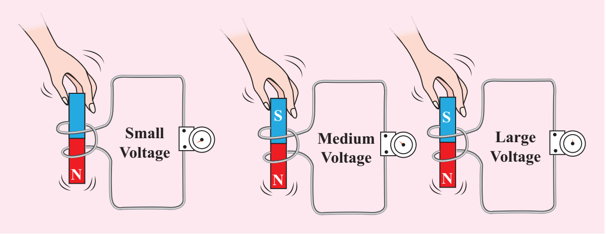


Figure 3.21 Electromagnetic induction by moving the magnet

In this experiment, current (or voltage) is generated by the movement of the magnet in and out of the coil. The greater the number of turns, the higher is the voltage generated.

Experiment 3

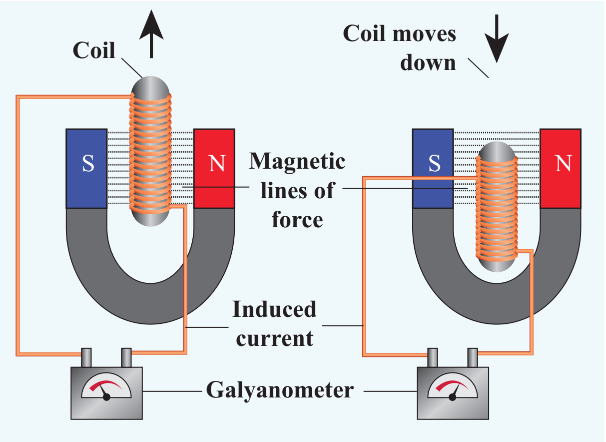


Figure 3.22 Electromagnetic induction by moving the coil

In this experiment, the magnet is stationary, but the coil is moved in and out of the magnetic field (indicated by the magnetic lines of force). Here also, current is induced.

All these observations made Faraday to conclude that whenever there is a change in the magnetic flux linked with a closed circuit an emf is produced and the amount of emf induced varies directly as the rate at which the flux changes. This emf is known as induced emf and the phenomenon of producing an induced emf due to change in the magnetic flux linked with a closed circuit is known as electromagnetic induction.

Note:

The direction of the induced current was given by Lenz's law, which states that the induced current in the coil flows in such a direction as to oppose the change that causes it. The direction of induced current can also be given by another rule called Fleming's Right Hand Rule.

Activity 5

Create your own electromagnet

You are given with a long iron nail, insulation coated copper wire and a battery. Can you make your own electromagnet?

3.7.2 Fleming's Right Hand Rule

Fleming formulated Right Hand Rule to find the direction of flow of current when a conductor is placed in a changing magnetic field as he formulated Left Hand Rule to find the direction of the force in a current carrying conductor placed in a magnetic field.

Stretch the thumb, fore finger and middle finger of your right hand mutually perpendicular to each other. If the fore finger indicates the direction of magnetic field and the thumb indicates the direction of motion of the conductor, then the middle finger will indicate the direction of induced current. Fleming's Right hand rule is also called "generator rule".

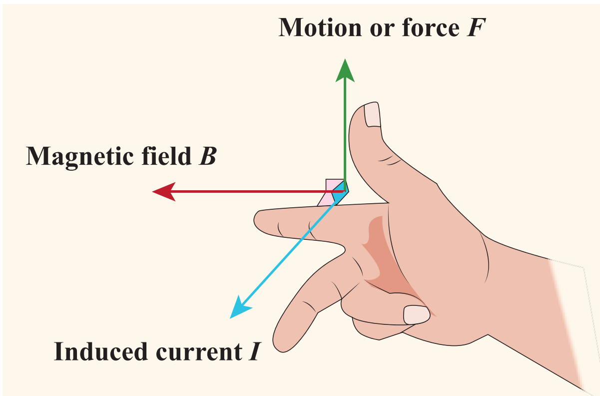


Figure 3.23 Fleming's right hand rule

3.8 Electric generator

An alternating current (AC) generator, as shown in Figure 3.24, consists of a rotating rectangular coil ABCD called armature placed between the two poles of a permanent magnet. The two ends of this coil are connected to the two slip rings S_1 and S_2. The inner sides of these rings are insulated. Two conducting stationary brushes B_1 and B_2 are kept separately on the rings S_1 and S_2 respectively. The two rings S_1 and S_2 are internally attached to an axle. The axle may be mechanically rotated from outside to rotate the coil inside the magnetic field. Outer ends of the two brushes are connected to the external circuit.

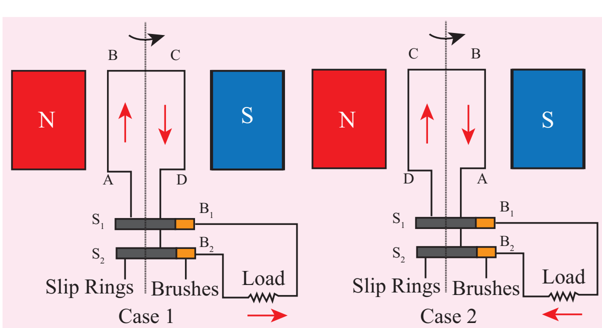


Figure 3.24 AC generator

When the coil is rotated, the magnetic flux linked with the coil changes. This change in magnetic flux will lead to generation of induced current. The direction of the induced current, as given by Fleming's Right Hand Rule, is along ABCD in the coil and in the outer circuit it flows from B_2 to B_1. During the second half of rotation, the direction of current is along DCBA in the coil and in the outer circuit it flows from B1 to B2. As the rotation of the coil continues, the induced current in the external circuit is changing its direction for every half a rotation of the coil.

To get a direct current (DC), a split ring type commutator must be used. With this arrangement, one brush is at all times in contact with the arm moving up in the field while the other is in contact with the arm moving down. Thus a unidirectional current is produced. The generator is thus called a DC generator (Figure 3.25).

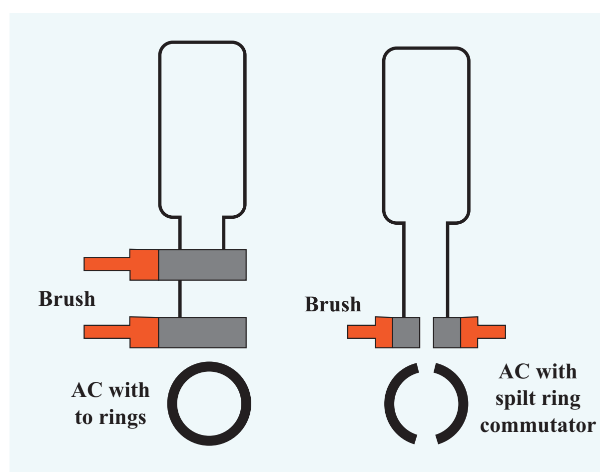


Figure 3.25 Comparison of AC and DC generators

3.9 Transformer

Transformer is a device used for converting low voltage into high voltage and high voltage into low voltage. It works on the principle of electromagnetic induction. It consists of primary and secondary coil insulated from each other. In Figure 3.26, the alternating current flowing through the primary coil induces magnetic field in the iron ring. The magnetic field of the iron ring induces a varying emf in the secondary coil.

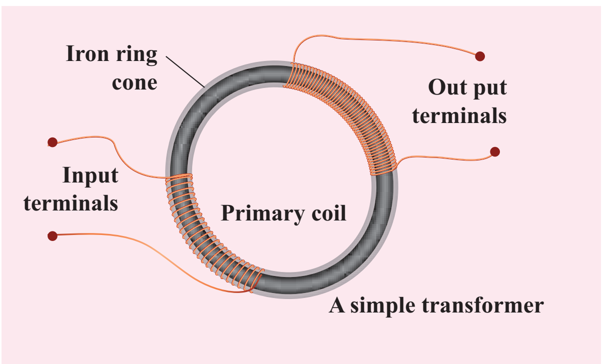


Figure 3.26 Principle of transformer

Depending upon the number of turns in the primary and secondary coils, we can step-up or step-down the voltage in the secondary coil as shown in Figure 3.27.

Step up transformer: The transformer used to change a low alternative voltage to a high alternating voltage is called a step up transformer. ie (Vs > Vp) . In a step up transformer, the number of turns in the secondary coil is more than the number of turns in the primary coil (Ns > Np).

Step down transformer: The transformer used to change a high alternating voltage to a low alternating voltage is called a step down transformer (Vs < Vp). In a step down transformer, the number of turns in the secondary coils are less than the number of turns in the primary coil (Ns < Np).

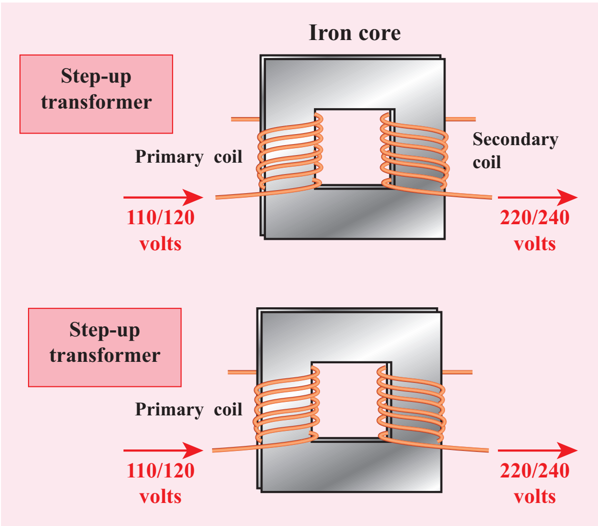


Figure 3.27 Step up and Step down transformers

DO YOU KNOW?

A step up transformer increases the voltage but it decreases the current and vice versa. Basically there will be loss of energy in a transformer in the form of heat, sound etc.

The formulae pertaining to the transformers are given in the following equations.

$$\frac{\text{The number of primary turns } N_p}{\text{The number of secondary turns } N_s} = \frac{\text{The primary voltage } V_p}{\text{The secondary voltage } V_s}$$

$$\frac{\text{The number of secondary turns } N_s}{\text{The number of primary turns } N_p} = \frac{\text{The primary current } I_p}{\text{The secondary current } I_s}$$

A transformer cannot be used with the direct current (DC) source because of current in primary coil is constant (ie. DC). Then there will be no change in the number of magnetic field lines linked with the secondary coil and hence no emf will be induced in the secondary coil.

Exercise 3

The primary coil of a transformer has 800 turns and the secondary coil has 8 turns. It is connected to a 220 V ac supply. What will be the output voltage?

Solution:

In a transformer, $E_s / E_p = N_s / N_p$

$E_s = N_s / N_p \times E_p$

$= 8/800 \times 220$

$= 220/100$

$E_s = 2.2$ volt

Exercise 4

A transformer is designed to give a supply of 8 V to ring a house bell from 240 V ac mains. The primary coil has 4800 turns. How many turns will be in the secondary coil.

Solution:

In a transformer, $E_s / E_p = N_s / N_p$

$N_s = E_s / E_p \times N_p$

$= 8/240 \times 4800$

$N_s = 4800/30 = 160$ turns

3.10 Applications of Electromagnets

Electromagnetism has created a great revolution in the field of engineering applications. In addition, this has caused a great impact on various fields such as medicine, industries, space etc.

3.10.1 Speaker

Inside the speaker, the electromagnet is placed in front of a permanent magnet. The permanent magnet is fixed firmly in position whereas the electromagnet is mobile. As pulses of electricity pass through the coil of the electromagnet, the direction of its magnetic field is rapidly changed. This means that it is in turn attracted to and repelled from the permanent magnet vibrating back and forth. The electromagnet is attached to a cone made of a flexible material such as paper or plastic which amplifies these vibrations, pumping sound waves into the surrounding air towards our ears.

DO YOU KNOW?

An electric bell contains an electromagnet, consisting of coils of insulated wire wound around iron rods. When an electric current flows though the coils, the rods become magnetic and attract a piece of iron attached to a clapper. The clapper hits the bell and makes it ring.

3.10.2 Magnetic Levitation Trains

Magnetic levitation (Maglev) is a method by which an object is suspended with no support other than magnetic fields. In maglev trains two sets of magnets are used, one set to repel and push the train up off the track, then another set to move the floating train ahead at great speed without friction. In this technology, there is no moving part. The train travels along a guideway of magnets which controls the train's stability and speed using the basic principles of magnets.

3.10.3 Medical System

Nowadays electromagnetic fields play a key role in advanced medical equipments such as hyperthermia treatments for cancer, implants and magnetic resonance imaging (MRI). In a, sophisticated equipments working based on the electromagnetism can scan minute details of the human body.

MRI Scanner

Many of the medical equipments such as scanners, x-ray equipments and other equipments also use principle of electromagnetism for their functioning.

Points to Remember:

- When current passes through a wire a magnetic field is set up around the wire. This effect of current is called magnetic effect of current.
- The space surrounding a bar magnet in which its influence in the form of magnetic force can be detected, is called magnetic field.
- The path along which a free magnetic north pole will move in a magnetic field is called magnetic field lines.
- Magnetic field lines do not intersect.
- The magnetic field set up by a current carrying conductor is always at right angles to the direction of flow of current.
- Two parallel wires carrying current in the same directions attract each other.
- Two parallel wires carrying current in the opposite directions repel each other.
- Direction of the force in a current carrying conductor is determined by Fleming's Left Hand Rule.
- Electric motor is a device which converts electrical energy into mechanical energy.
- The phenomenon of producing induced current in a closed circuit due to the change in magnetic field in the circuit is known as electromagnetic induction.
- Direction of induced current in a conductor is determined by Fleming's Right Hand Rule.
- Electric generator is a device used to convert mechanical energy into electrical energy.
- Electric generator works on the principle of electromagnetic induction.
- Transformer is a device which converts low alternating current to high alternating current and vice versa.
- Transformer transfers electric power from one circuit to another.

A-Z GLOSSARY

Magnetic field	The region surrounding a magnet in which the force of the magnet can be detected.
Magnetic line of force	The path followed by a magnetic needle in a magnetic field.
Dynamo	Device which converts mechanical energy into electrical energy.
Motor	Device which converts electrical energy into mechanical energy.
Electromagnetic induction	The phenomenon of producing an induced emf due to the changes in the magnetic lines of forces associated with a conductor.
Transformer	Device which converts low alternating current to high alternating current and vice versa.
MRI	Magnetic Resonance Imaging which is used to obtain images of the internal parts of our body.

TEXT BOOK EXERCISES

BHYEYB

I. Choose the correct answer.

1. Which of the following converts electrical energy into mechanical energy.
   a) motor b) battery
   c) generator d) switch

2. An electric generator converts
   a) electrical energy into mechanical energy
   b) mechanical energy into heat energy
   c) electrical energy into electrical energy
   d) mechanical energy into electrical energy.

3. The part of the AC generator that passes the current from the armature coil to the external circuit is
   a) field magnet b) split rings
   c) slip rings d) brushes

4. Transformer works on
   a) AC only
   b) DC only
   c) both AC and DC
   d) Ac nor effectively than DC

5. The unit of magnetic flux density is
   a) Weber b) weber/metre
   c) weber/meter^2 d) weber . meter^2

II. Fill in the blanks.

1. The SI Unit of magnetic field induction is ________.

2. No force acts in a current carrying conductor when it is ________ to the magnetic field.

3. Devices which is used to convert high alternating current to low alternating current ________.
4. An electric motor converts ________.
5. A device for producing electric current is ________.

III. Match the following.

1. Magnetic material	(a) Oersted
2. Non-magnetic material	(b) iron
3. Current and magnetism	(c) induction
4. Electromagnetic induction	(d) wood
5. Electric generator	(e) Faraday

IV. True or False:

1. A generator converts mechanical energy into electrical energy.
2. Magnetic field lines always repels each other and do not intersect.
3. Fleming's Left hand rule is also known as Dynamo rule.
4. The speed of rotation of an electric motor can be increased by decreasing the area of the coil.
5. A transformer can step up direct current.
6. In a step down transformer the number turns in primary coil is greater than that of the number of turns in the secondary coil.

V. Answer in brief.

1. State Fleming's Left Hand Rule.
2. Define magnetic flux density.
3. List the main parts of an electric motor.
4. Draw and label the diagram of an AC generator.
5. State an important advantage of ac over dc.
6. Differentiate step up and step down transformer.
7. A portable radio has a built in transformer so that if can work from the mains instead of batteries. Is this a step up or step down transformer?
8. Two coils A and B of insulated wire are kept close to each other. Coil A is connected to a galvanometer. While coil B is connected to a battery through a key. What would happen if
   (i) a current is passed through coil B by plugging the key?
   (ii) the current is stopped by removing the plug from the key?
9. State Faraday's laws of electromagnetic induction.

VI. Answer in detail.

1. Explain the principle, construction and working of a dc motor.
2. Explain two types of transformer.
3. Draw a neat diagram of an AC generator.

REFERENCE BOOKS

Advanced Physics by Keith Gibbs – Cambridge University Press.

Principles of physics (Extended) – Halliday Resnick and Walker. Wiley publication, New Delhi.

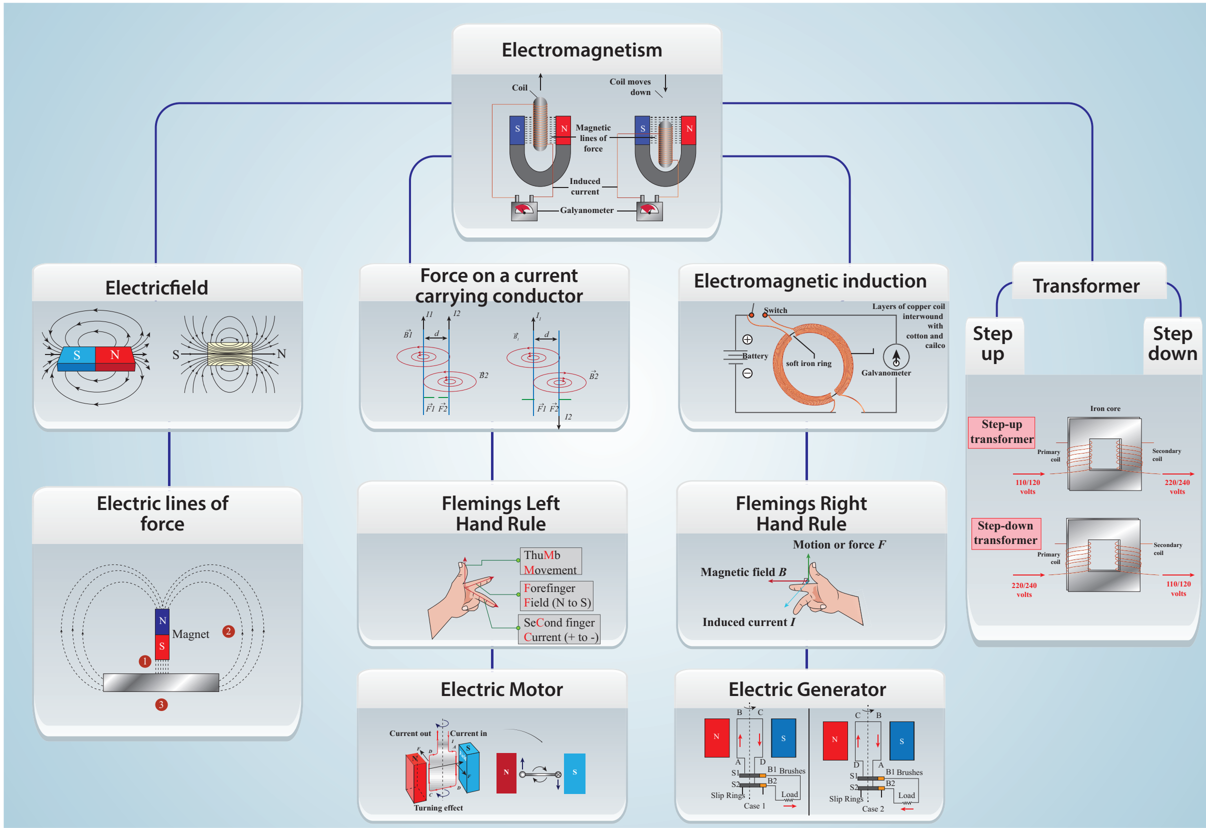
Fundamental University Physics – M. Alonso, E. J. Finn Addimon Wesley (1967)

INTERNET RESOURCES

www.physicsabout.com

https://science.howstuffworks.com

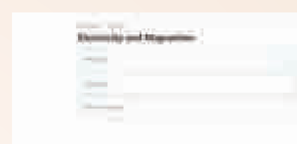
http://arvindguptatoys.com/films.html



ICT CORNER

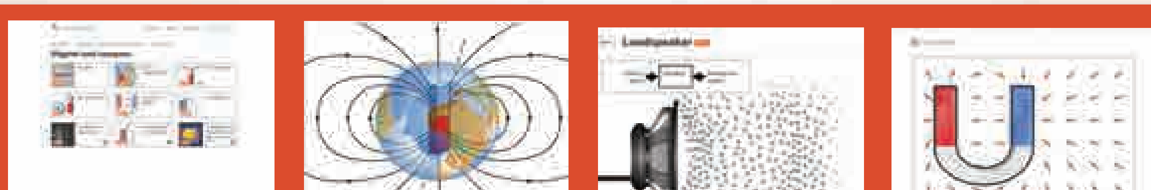
Magnetism and Electromagnetism

Explore this activity to know about the various properties in magnetism



Steps

- Copy and paste the link given below or type the URL in the browser. Click the option **Magnet and Compass**.
- You can find six activities and three videos related to magnets and loudspeaker.
- Click any one of the six activities to simulate and understand the process.
- Click any one of the three videos to understand the concepts related to loudspeaker and magnets. Try all the other activities and videos as well.



Step1 Step2 Step3 Step4

Browse in the link:

URL: http://www.edumedia-sciences.com/en/node/75-magnetism

*Pictures are indicative only

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