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Magnetic effects of Electric Current

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WHY THESE NOTES?

- TOUCHES EVERY CORNER OF NCERT
- INCLUDES NCERT ACTIVITIES (AKQ), BOXES(BKQ) & EXEMPLAR (EKQ)
- EACH LINE, FLOWCHART & DIAGRAM IS MOTIVATED FROM PYQs
- APPROVED BY 3 CBSE TOPPERS

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Magnetic field

The region around a magnet in which the force of attraction or repulsion can be felt is called its magnetic field.

Magnetic field line

The Imaginary line that are drawn to describe the magnetic field around a magnet are termed as magnetic field line.

Properties of magnetic field lines

- The magnetic field lines start from the north pole and terminate at the south pole of the magnet. Inside the magnet the direction of field line is from its south pole to its north pole.
- Magnetic field line do not intersect each other, if they, mean at the point of intersection, the compass needle point towards two direction, which is not possible.
- Stronger the field more crowded are the magnetic field lines.
- The magnetic field lines are closed curve.
- Magnetic field is a quantity that had both direction and magnitude.
- Magnetic field can be measured in Tesla or Weber/m^2.
- The unit of magnetic field strength is named the oersted.
- if current flowing from north to South in a conductor then compass deflect towards east.
- if current flowing from south to north in a conductor then the compass needle deflect towards west.

Magnetic field due to a current through a straight conductor

- Field lines pattern in straight wire is concentric circle.
- If the current is increased, the deflection also increase. It indicate that the magnitude of the magnetic field produced at a given point increase as the current through the wire Increase.
- The magnetic field produced by a given current in the conductor decrease as the distance from it Increase.
- Concentric circle representing the magnetic field around a current carrying Straight wire become larger and larger as we move away from it.

Magnet

Magnet is actually an ore of magnite. It's formula is Fe_3O_4.

Properties

- A magnet attract ferro magnetic Substance.
- Attraction between unlike poles and repulsion between like poles.
- An isolated pole does not exist.
- Induced of magnetic property.
- Directive property of magnet.

Box Wala

Hans Christan Oersted (1777-1851) Oersted Experiment in 1820

When an electric current flows through a conductor, a magnetic field is produced around it.

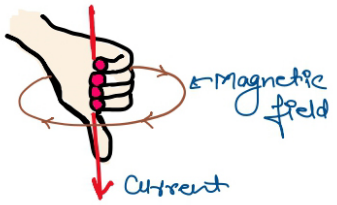
Electric current is the dynamic state of electric charge (free electron) hence it is clear that moving charge can produce magnetic field. This phenomena is known as magnetic effect of electric current.

activity 13.1

Answer: On passing the current, the compass needle is deflected. It means that the electric current through the copper wire produces a magnetic effect.

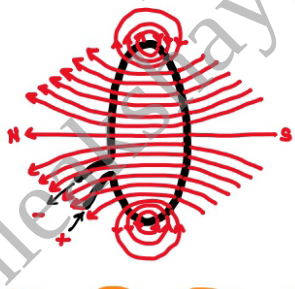
Right - Hand Thumb rule (Maxwell corkscrew Rule)

According to this rule if a current carrying conductor is imagined to held in our right hand such that the thumb point towards the current then the fingers will wrap and give the direction magnetic field around a conductor.



Magnetic field due to a current through a circular loop

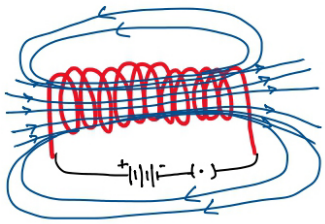
→ The magentic field line are circular near the current carrying loop. As we move away, the concentric circles representing magnetic field line become bigger and bigger.
→ The lines at the centre of loop are almost straight and parallel.
→ The direction of magnetic field produce at the center is at right angle to the place of the loop.
→ Circular loop can be considered to be made up of a large number of small straight element. Thus magnetic field line are in same direction. That is produced by each small element in the direction of the loop.



Magnetic field due to current in Solenoid

* A long cylindrical coil of insulated conducting wire is called Solenoid.

* The magnetic field around a current carrying solenoid is similar to magnetic field produce by a bar magnetic.
→ If 'i' clockwise -- South
→ If 'i' anticlockwise -- North



* The field is uniform inside the Solenoid (means parallel straight line) solenoid is same as bar magnet.

Electromagnet

A strong magnetic field produced inside a solenoid can be used to magnetise a piece of magnetic material like soft iron when placed inside the coil the magnet so formed is called electromagnet.

Use of electromagnet

→ For lifting heavy loads of iron
→ Removing iron insplinter from injered eyes.
→ Instrument like electric bell, telephone earpiece, radio ,T.V etc.
→ Garbage --- iron isolate

P.Y.Qs

Question: When a current carrying conductor is kept in magnetic field it experiences a force list the factors on which direction of this force depends.

Answer: It depends on

- The direction of current through the conductor.
- The direction of magnetic field in which the conductor is placed.

activity 13.2

Answer: Iron filings near the magnet align along the field lines.

Reason: The magnet exerts its influence in the surrounding region. So, the iron filings experience a force. It makes iron filings to arrange in a pattern.

activity 13.4

Answer: If the current flows from north to south, the north pole of the compass needle moves towards the east.

If the current flows from south to north, the needle moves in opposite direction (towards west).

It means that the direction of magnetic field produced by the electric current is also reversed.

activity 13.5

Answer: The direction of magnetic field lines is reversed if the direction of current through the copper wire is reversed.

activity 13.6

Answer: Concentric circle patterns of the iron filings emerge on the cardboard. At the centre, it appears as a straight line

Force on a current-carrying conductor in a magnetic field

→Electric current flowing through a conductor produces a magnetic field. The field so produce exert a force on a magnet placed near the conductor.

→French Scientist Andre Marie ampere Suggested that the magnet must also exert an equal and opposite force on the current carrying conductor.

→The direction of the force of the conductor depends upon the direction of current and the direction of magnetic fields.

P.Y.Qs

Question: Explain whether an alpha particle will experience any force in a magnetic field if

- it is placed in the field at rest
- it moves in the magnetic field parallel to field lines
- it moves in the magnetic field perpendicular to field lines

Answer:

- No, because, a charge particle at rest does not interact with magnetic field.
- No, because, the force is zero if current and field are in the same direction.
- Yes, because, the force is maximum when current and magnetic field are maximum.

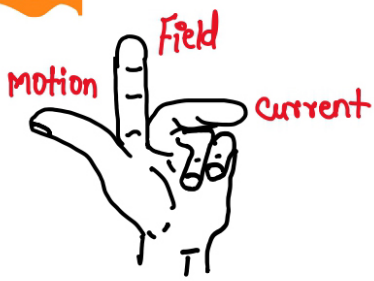
activity 13.7

Answer: The displacement of the rod (AB) suggests that A force is exerted on the current-carrying aluminium rod when it is placed in a magnetic field.

The direction of force is also reversed when the direction of current through the conductor is reversed.

Fleming's left hand rule

According to this "If we stretch out the thumb, the forefinger and middle finger of our left hand so that these are at right angle to each others then the fore finger gives the direction of magnetic field, thumb give the direction of motion (force), middle finger give the direction of current.



Box Wala

Magnetism in medicine

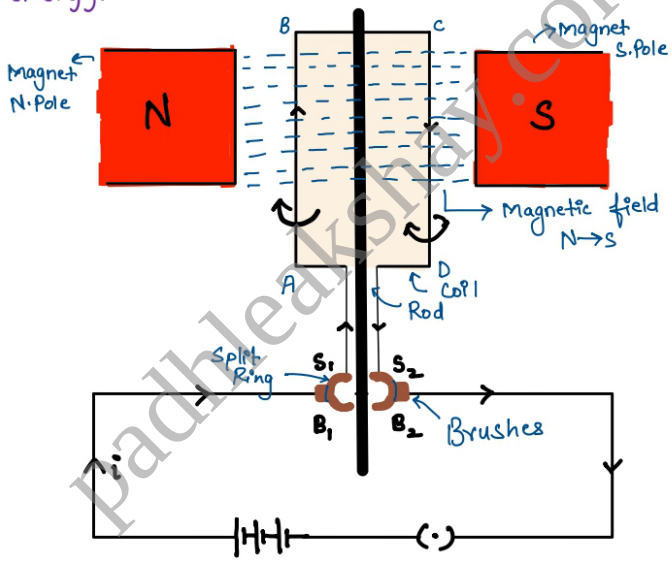
→ Even weak ion currents that travel along the nerve cells in our body produce magnetic fields.
→ When we touch something, our nerve carry an electric impulse to the muscle we need to use.
→ Two main organs in the human body when the magnetic fied produce is significant, heart and the brain.
→ The magnetic fied inside the body forms the basis of obtaining the "Image of different body parts". This is done using a technique called Magnetic Resonance Imaging (MRI).

Electric Motor

Principal

A current carrying Conductor experience a force when kept in a magnetic field and convert electrical energy into mechanical energy.

Construction



→ An electric motor consist of a coil ABCD of insulated copper wire.
→ Coil placed between the two poles of a magnetic field such that arms AB and CD are perpendicular to the direction of magnetic field.
→ The end of the coil connected with two split ring S1 and S2. The inner side of these halves are insulated and attach to an axle.
→ The external conducting edges of S1 and S2 touch two conducting stationary brushes b1 and b2.

Working

Current in the coil ABCD enters from the battery through brush B1 and flows back through Brush B2. In arm AB of the coil it flow from A to B and in arm CD it flows from C to D.

↓

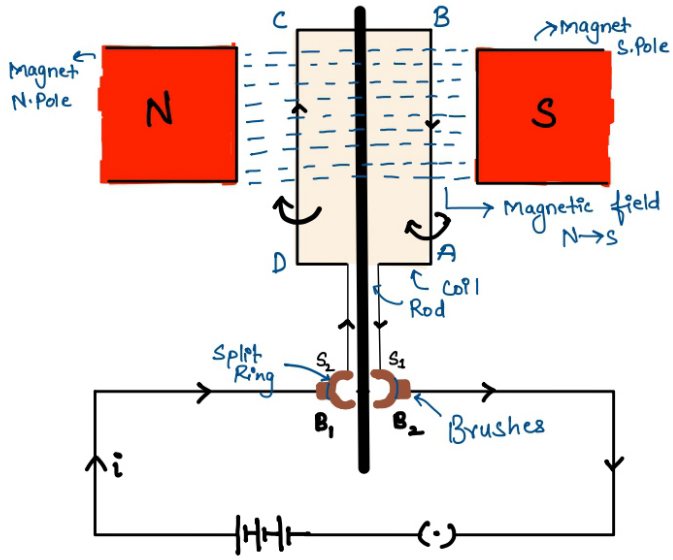
On applying fleming left hand rule. We find that the magnetic force acting on the arm AB pushes it in down ward direction while that on the arm CD pushes it upward.

↓

Thus the coil and the axle mount free to turn about on axis rotate anti clock wise.

↓

At half rotation split rings S1 makes contact with brushes B2 and split rings S2 with brushes B1. Therefore the current in the coil get reversed and flows along the path DCBA.



→ As a result the arm AB of the coil is now pussed up and the arm CD is now pussed down. Therefore the coil and the axle rotate half a turn more in the same direction.

→ This reversing of current is repeated at each half rotation giving rise to a continuous rotation of the coil and the axle.

Uses

→ electric cars, electric lift, computer, electric fans, drilling machines.

Electromagnetic Induction

The phenomena of producing electric current in a conductor due to relative motion between the conductor and the magnet is electromagnetic Induction.

*It was first Studied by Michael Faraday in 1831.
*The direction of induced current in a circuit is in such a way that it oppose the cause due to which it produced.

When the north pole of a bar magnet is move towards the coil the front face of the coil behave like a north pole. Hence force of repulsion comes into play between magnet and coil. And when the north pole of bar magnet is move away from the coil the front face of the coil behave like a south pole. Hence attraction come into play between magnet and coil.

Fleming Right hand rule

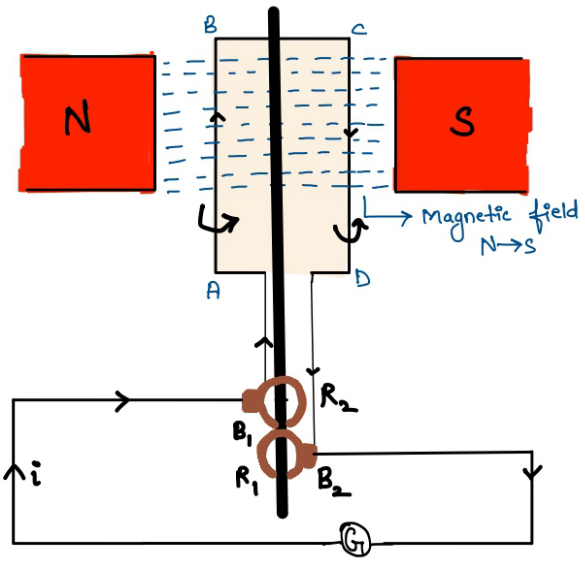
If we stretch the fore finger, central finger and thumb of the right hand in such a way that they are at right angle at each other then the fore finger gives the direction of magnetic field, thumbs give the direction of motion and central finger give the direction of induced current.

Electric generator

Principal

It is a device which converts mechanical energy into electrical energy, it is based on electromagnetic induction.

Construction



→An electric generator consist of a rotating rectangular coil ABCD placed between the two poles of permanet magnet.

→The two ends of this coil are connected to the two ring R1 and R2.

→The inner side of these rings are made Insulated. The two conducting Stationary brushes B1 and B2 are kept pressed seperately on the rings R1 and R2.

→The two rings R1 and R2 are internal attached to an axle.
Outer ends of the two brushes are connected to the galvanometer to show the flow of current in the given external circuit.

Working

The axle attached to the two ring is roateted, Such that the arem AB moves up and arm CD moves down In magnetic field.

↓

The coil ABCD rotates in clock wise direction then the change in magnetic field produce induced current in the coil. By applying fleming right hand rule the induced currents are set up in these arms along the direction AB and CD. Thus an induced current flows in the direction.

↓

This means that the current in the external circuit flows from B2 to B1.

↓

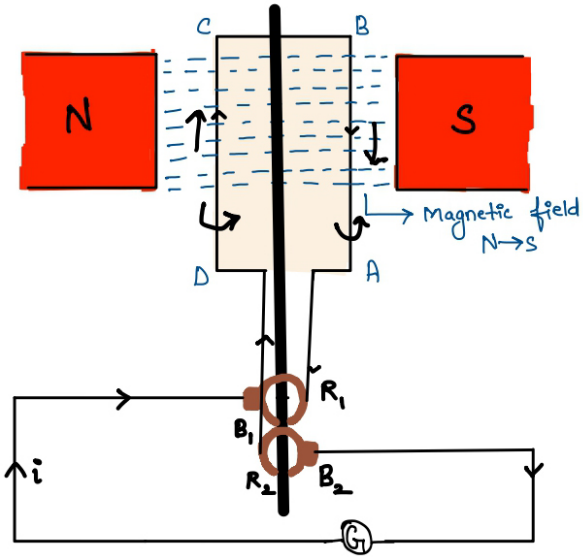
After half a rotation, arm CD starts moving up and AB moving down. As a result, the direction of the induced current in the direction DCBA.

↓

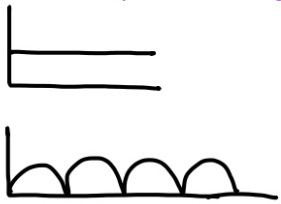
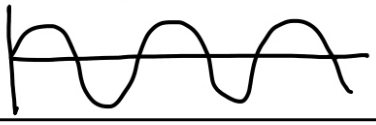
The current in the external circuit now flows from B1 to B2.

↓

This process is repeated so the induced current is in alternative nature.



Difference between Ac and DC current

D.C	A.C
• An electric current whose magnitude is either constant or variable but the direction always remain same. • D.C current is produced by electrochemical cell. 	• An electric current whose magnitude and direction change in equal interval of time. Most of the thermal power plant and hydroelectric power plant produce AC. • AC change direction after every 1/100 second. • Frequency of AC is 50Hz. 

Box Wala

Galvanometer

A galvanometer is an instrument that can detect the presence of a current in a circuit.

Commutator

A device that reverse the direction of flow of current through a circuit is called commutator.

Domestic electric circuit

- The wires in the supply, usually with red insulation, is called live wire (positive).
- The wire with black insulation is called neutral wire (negative).
- The earth wire, which has insulation of green colour is usually connected to a metal plate deep in the earth. This is used as safety measure. It provide low resistance path for current.

P.Y.Qs

Question: Explain the function of an earth wire. Why is it necessary to earth metallic appliances?

Answer: Earth wire is used as a safety measure especially for those appliances that have a metallic body, for example-electric press, toaster etc. The metallic body is connected to the earth wire, which provide a low resistance distance conducting path for the current. Thus it ensures that any leakage of current to the metallic body of the appliances keeps its potential to that of the earth and the user may not get a severe shock.

Fuse

A fuse in a circuit prevents damage to the appliance and the circuit due to overloading. It prevents the electric circuit and the appliance from a possible damage by stopping the flow of unduly high electric current.

Overloading /short circuit

Overloading can occur when the live wire and the neutral wire come into direct contact. In such a situation, the current in the circuit abruptly increase. This is called short circuit.

→Accidental hike in the supply voltage.
→Connecting too many appliance to a single socket.

Activity 13.8

Answer: If the south pole of the magnet is moved towards the end B, the deflections in the galvanometer would just be opposite to the previous case. When the coil & magnet are stationary, there is no deflection in the galvanometer.
Thus, this activity shows that the motion of a magnet with respect to the coil produces an induced potential difference, which sets up an induced electric current in the circuit.

activity 13.9

Answer: As soon as the current in coil-1 reaches either a steady value or zero, the galvanometer in coil-2 shows no deflection.

We conclude that a potential difference is induced in coil-2 whenever the electric current through the coil-1 is changing (starting or stopping). Coil-1 is called the primary coil and coil-2 is called the secondary coil. As the current in the first coil changes, the magnetic field associated with it also changes. Thus the magnetic field lines around the secondary coil also change. Hence the change in magnetic field lines associated with the secondary coil is the cause of induced electric current in it. This process, by which a changing magnetic field in a conductor induces a current in another conductor, is called electromagnetic induction.

Examplar

Question: An electric fuse of rating 3A is connected in a circuit in which an electric iron of power 1.5 kW is connected which operates at 220 V. What would happen? Explain.

Answer: $P = 1.5\,kW = 1.5 \times 1000\,W = 1500\,W$,

$V = 220\,V$

Electric current required

$$(I) = \frac{P}{V}$$

$$= \frac{1500}{220} = \frac{75}{11} = 6.8\,A$$

But electric fuse rating 3A, so electric fuse will blow up.

Question: List four important features of domestic electric circuits. Draw a schematic diagram of common domestic circuit showing life, neutral and earth wires.

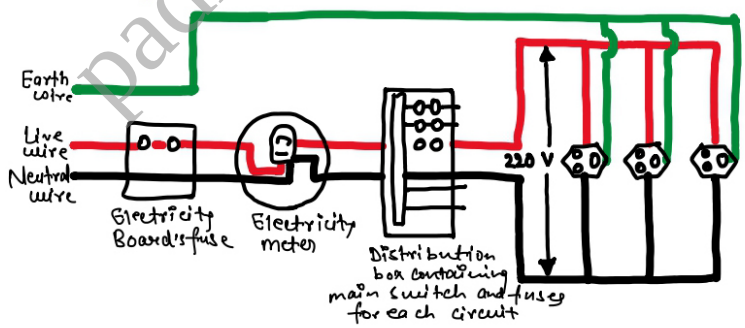
Answer: Four features are

(i) appliance to be connected in parallel.

(ii) each appliance has a separate switch to on/off the flow of current through it.

(iii) in each circuit different appliances can be connected across the live wire and the neutral wire.

(iv) Fuse connected to avoid damage.



Question: Write the values of the following physical quantities in connection with domestic power supply in our country

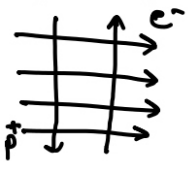
- potential difference between livewire and neutral Wire
- frequency of AC.

Answer:

- 220 V
- 50Hz

Question: A uniform magnetic field exists in the plane of paper pointing from left to right. In the field an electron and a proton move as shown. The electron and the proton experience

(a) forces both pointing into the plane of paper



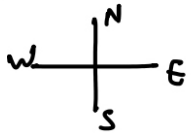
(b) forces both pointing out of the plane of paper
(c) forces pointing into the plane of paper and out of the plane of paper, respectively
(d) force pointing opposite and along the direction of the uniform magnetic field respectively

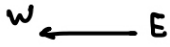
Answer: (a) forces both pointing into the plane of paper

Question: Commercial electric motors do not use
(a) an electromagnet to rotate the armature
(b) effectively large number of turns of conducting wire in the current carrying coil
(c) a permanent magnet to rotate the armature
(d) a soft iron core on which the coil is wound

Answer: (c) a permanent magnet to rotate the armature

Question: A constant current flows in a horizontal wire in the plane of the paper from east to west. The direction of magnetic field at a point will be North to South
(a) directly above the wire
(b) directly below the wire
(c) at a point located in the plane of the paper, on the north side of the wire
(d) at a point located in the plane of the paper, on the south side of the wire





Answer: (b) directly below the wire