Magnetic Effects of Electric Current

Magnetic field :- The region around a magnet in which the force of attraction or repulsion can be detected is called a magnetic field.

S.I. Unit :- Tesla.

Properties of Magnetic field lines

- Strength of magnetic field lines in a unit space, more strength with more greater no. of magnetic field lines.
- Strength of magnetic field is a quantity that has both magnitude & direction.
- As we go away from the pole of the magnet, strength decreases.

Magnetic field lines :- Curved path along which the iron filings arrange themselves due to the force acting on them in the magnetic field are known as magnetic field lines.

Properties

- It has both magnitude and direction.
- Outside the bar magnet, magnetic field lines start from north pole
- end at south pole.
- Magnetic field lines are closed and continuous curves.
- Regions where lines are closer, denote a strong magnetic field.
- Regions where lines are farther denote a weaker magnetic field.
- The two magnetic field lines never cut each other.

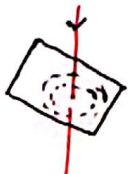
Magnetic field due to a current-carrying conductor →

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

Pattern of magnetic field produced by a current-carrying conductor depends on its shape.

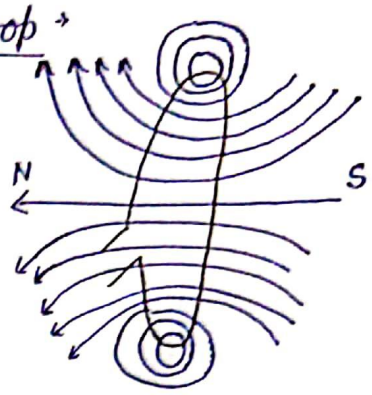
Magnetic field due to current through a Straight Conductor

The magnetic lines of force around a straight current carrying conductor are concentric circles with their centres on the wire.



Right-Hand Thumb Rule → Imagine a straight current-carrying conductor in your right hand in such a way that your thumb points in the direction of electric current. Now, the direction of your right hand's fingers will give the direction of magnetic field lines.

Magnetic field due to a current through a circular loop →



- Circular and Concentric field near the coil.
- Near the centre field lines are straight & parallel.
- At the centre field is perpendicular to the plane of the coil.

Magnetic field depends upon : ⊙ Amount of current ($B \propto I$)

⊙ Number of turns in the wire ($B \propto N$).

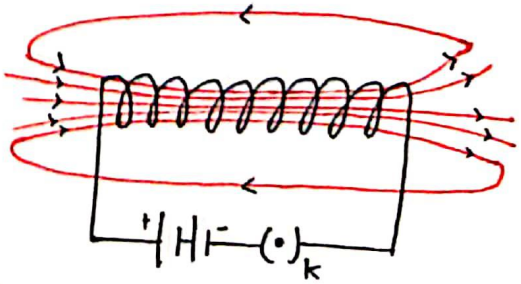
⊙ Radius of coil.

Direction of Magnetic field →	Direction of coil current	Pole created
	Clockwise	South pole
	Anticlockwise	North pole
	at the centre	⊥ᵏ to the plane.

Magnetic Field Produced by a Current-Carrying Solenoid →

When a coil of an insulated copper wire is wrapped closly in the shape of a cylinder, it is called a Solenoid.

Pattern of field of solenoid is compared with the magnetic field around a bar magnet it looks similar. The field inside the solenoid are in the form of parallel straight lines.



One end of solenoid behaves as north pole while the other end behaves as South pole.

It has uniform magnetic field inside it.

Electromagnet :- It refers to a magnetised solenoid which works on the principle of magnetic effect of current.

An electromagnet consists of a long insulated copper wire wound around a soft iron core.

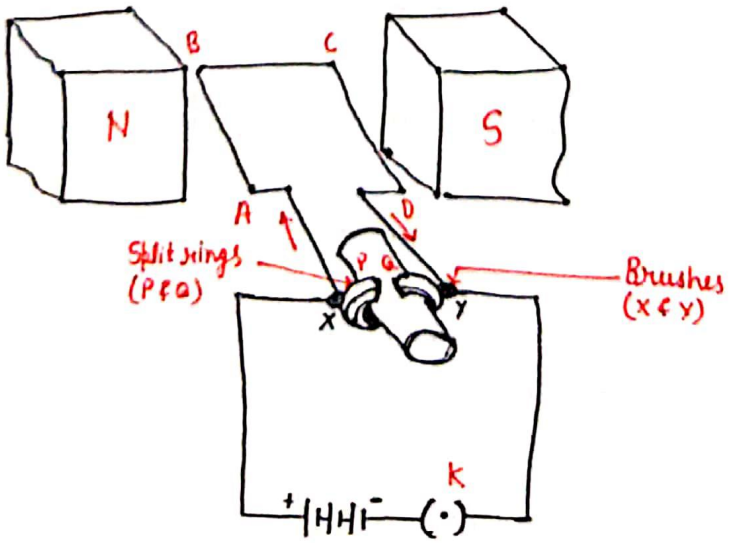
Force On A Current-Carrying Conductor in a magnetic field →

When a current-carrying wire is held near a magnetic needle (or compass) the magnetic needle gets deflected. This is because the magnetic field around the current carrying conductor (wire) exerts a mechanical force on the magnetic needle and produces a motion in it.

It depends on :-
- Current ($F \propto I$)
- Length of conductor in magnetic field ($F \propto l$).
- Magnetic field strength ($F \propto B$).
- Angle between Conductor & magnetic field ($F \propto \sin\theta$)

Fleming's left Hand Rule → It states that, "Stretch the thumb, forefinger & middle finger of your left hand such that they are mutually perpendicular to each other. Where the first finger points in the direction of magnetic field and the second in the direction of current, then thumb will point in the direction of motion of force acting on the conductor."

Electric Motor :-



Principle – It works on the principle of magnetic effect of current. When a current carrying conductor is placed perpendicular to the magnetic field, it experiences a force.

Construction – It consists of a rectangular coil PQRS of insulated copper wire suspended in a uniform magnetic field. The ends of rectangular coil are connected to the two copper metallic split ring 'C' and 'D' called split ring commutator. It rotates along with the coil. The external source such as battery sends the current to the coil through key and conducting stationary carbon brushes 'x' and 'y' which slides over the split ring 'C' and 'D' respectively.

Working – The current I flows in the coil ABCD, it will exert an equal & opposite force separated by a perpendicular distance. This causes the coil to rotate about its axis. After 180° rotation, the arms of the coil change their sides. At this position, the commutator reverses the direction of current and ensures the flow of current in the same direction. Therefore, the motor continues to rotate the coil. During this rotation, some amount of induced current is obtained which flows in the opposite direction. As a result of it, the current flowing through the coil is reduced as the speed of the motor increases.

Role of Split ring Commutator – The two carbon brushes provide the path to the induced current to flow from the armature and the slip rings to the external circuit containing load resistance.

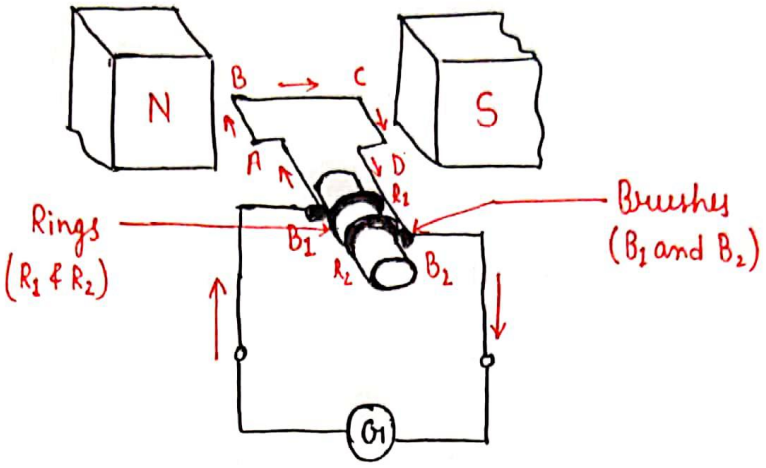
Electromagnetic Induction :- The phenomenon of producing electric current in a conductor by moving it perpendicular to a magnetic field or vice-versa is called Electromagnetic induction.

Induced Current :- The alternating current produced in a conductor or a closed coil, when magnetic lines of force rapidly change in it, is called induced current.

Fleming's Right Hand Rule [Dynamo Rule] :- It states that, "Stretch the thumb, forefinger middle finger of your right hand, so that they are perpendicular to each other

If the forefinger indicates the direction of magnetic field and the thumb shows the direction of motion of conductor, then the middle finger will show the direction of induced current."

Electric Generator :



Principle : It is based on the principle of electromagnetic induction which is the process of producing induced current in a coil by changing its orientation i.e. by rotating it in a uniform magnetic field.

Working of an AC Generator → When the armature coil ABCD rotates in the magnetic field, with the help of some mechanical work in clockwise direction. i.e. arm AB moves up and CD moves down, due to change in magnetic flux, induce current sets up in the coil. Then according to Fleming's right hand rule, the current flows in the direction ABCD. Then, the current in external circuit flows from B_2 to B_1. After half rotation, CD starts moving up & AB moves down. Hence, net induced current in the direction DCBA. Hence the current in the external circuit flows from B_1 to B_2.

Thus, after every half rotation the polarity of the induced emf thereby induced current across the load resistance changes. Therefore, in the external circuit, we get alternating current.

Function of Brushes → The two carbon brushes provide the path to the induced current to flow from the armature and the slip rings to the external circuit containing load resistance.

Direct Current
Continuously flows in the same direction

Alternating Current
Periodically change its direction.

Domestic Electric Circuits :- The electricity supplied to our houses by the electricity board is Alternating Current (AC) at 220V at 500 Hz frequency.

- Each home is fitted with two different supplies.

Domestic Light
Current rating 5A.
Used for bulbs, fans, TVs etc.

Domestic Power.
Current rating 15A.
Used for heaters, coolers, ACs, geysers etc.

- We connect all the domestic electrical circuits in parallel because :
  - → When two or more appliances are used at the same time, each appliances will be able to draw current as per the requirement.
  - → When distribution circuits are in parallel, then each circuit operates seperately. So if one, of the distribution circuits get overloaded, only the fuse in that circuit will be blown off.

- Live wire, red insulation at 220 V.
- Neutral wire, black or blue insulation at zero volt.
- Earth wire, green or yellow insulation.

The Overloading of electric wiring in any circuit, due to the flow of large current through it, is called Overloading of the electrical circuit.

Short Circuiting A sudden flow of very large current due to direct contact of a live and a neutral wire is called short Circuiting.

Electric Fuse A wire is a piece of thin wire made up of a material having a low melting point and high resistance. • It is made of alloy of lead & tin.

Earthing Connecting the metallic body of an electrical appliances to the earth by a conducting wire is called the earthing of an appliances.

- Maintain the metallic body at zero potential.
- User gets protected from electric shock.