MAGNETIC EFFECTS OF ELECTRIC CURRENT

To understand Magnetic effects of Electric current, first we should know **what is the Magnet?**

Magnet

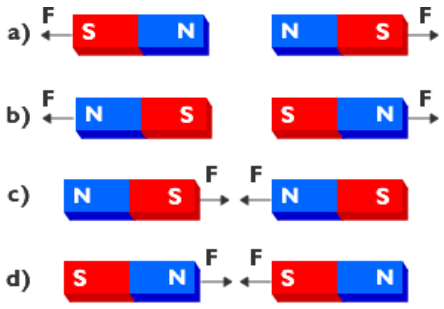
A Magnet is an object which attracts pieces of iron, steel, nickel and cobalt i.e. it applies force on these objects. It has various types. The most common are -

(i) Bar Magnet

(ii) Horse shoe magnet

- The end of a freely suspended magnet always points towards north – south direction.
- The end which points towards north is the north pole of the magnet whereas the end which points towards south direction is the south pole of the magnet.
- If two magnets are placed together with similar poles towards each other, then they repel each other (tends to move away), whereas if two different poles are towards each other, then they attract (tends to move towards each other).

Hence, like poles repel each other and unlike poles attract each other.



Magnetic compass

It is an instrument consisting of base and a needle. The needle has north and south tip whose north tip is painted red (generally). The needle gets deflected when close to magnet and it gives the direction of Magnetic field.

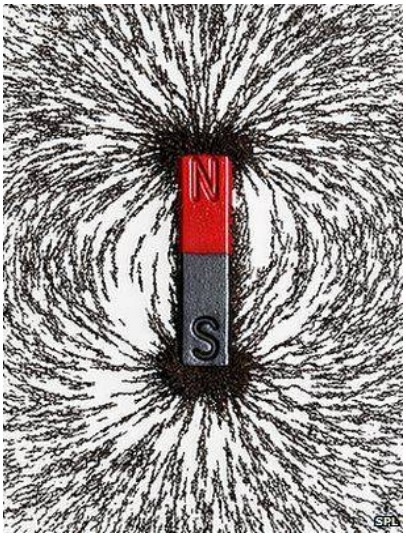
What is magnetic field?

The space surrounding a magnet in which magnetic force can be experienced is called magnetic field. It has both magnitude as well as direction.

Magnetic Field Lines

To describe magnetic field, we need to draw magnetic field lines.
Magnetic field lines are the lines drawn in a magnetic field along which a north magnetic pole would move.

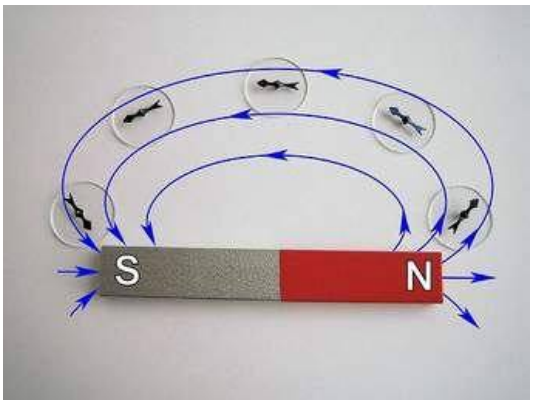
Take a bar Magnet and put it on a cardboard. Sprinkle iron fillings around the bar magnet. Bar magnet applies force on iron fillings scattered on the cardboard. Due to this force they move and re-arrange themselves in a pattern.



In other words we can say that “magnet creates magnetic field in it’s vicinity. This magnetic field applies force on iron fillings and a pattern is made.”

Drawing Magnetic Field Lines using Magnetic Compass Needle and Bar Magnet

Take a Bar magnet. Put the compass needle nearby. The north pole of the magnet will attract the south tip of the compass needle. Move the compass needle slowly and mark the points. Now join all the points from north to South Pole. This will give the direction of Magnetic field.



Thus, *we can also say that,*
The direction of magnetic field at a point is the direction of resultant force acting on a hypothetical north pole placed at that point.

Properties of Magnetic Field Lines

I. Magnetic field lines originate from North Pole and end at South Pole.

II. Magnetic field lines come closer to one another near the poles of magnet but widely separated at other places.

III. Magnetic field lines do not intersect each other.

Note: Magnetic field lines never intersect each other because resultant force at North Pole can only be in one direction. Had the lines intersected, it would be in two directions which not possible.

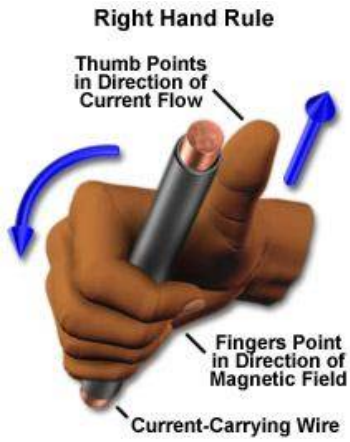
Magnetic field due to Current Carrying Wire

A Danish physicist and chemist **Hans Christian Ørsted ,** once performing an experiment saw that a current flowing in a circuit caused deflection of compass needle which was kept near to it.
He then concluded that current carrying wire produces Magnetic field.

Magnetic field lines due to current carrying wire can also be plotted using iron fillings in the same manner as in case of Bar Magnet. Magnitude of magnetic field is directly proportional to current and inversely proportional to the distance from the wire.

Right hand Thumb Rule

To find the direction of Magnetic field, Right Thumb Rule is used.



Right hand thumb rule states that if we hold the current carrying wire in the right hand and if the thumb points towards the current, the direction in which the fingers encircle gives the direction of Magnetic field.

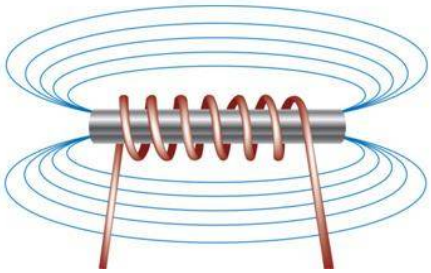
Magnetic Field due to current in solenoid

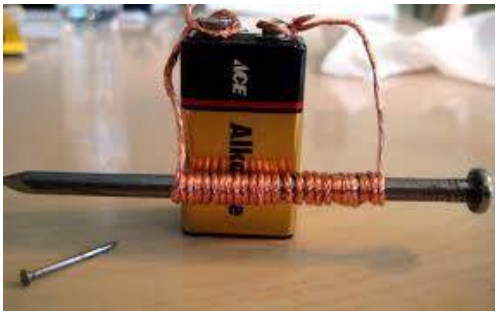
Solenoid is a long coil containing a large number of close turns of insulated copper wire. The Magnetic field lines of a Bar Magnet are similar to that of solenoid.

The magnetic field inside the solenoid is more but less outside it. Magnetic field inside solenoid is uniform i.e. same everywhere.

Electromagnet

It is a magnet formed by putting a soft iron core inside a current carrying solenoid. It is a temporary magnet as the magnetic effect is lost when there is no current flowing into it.

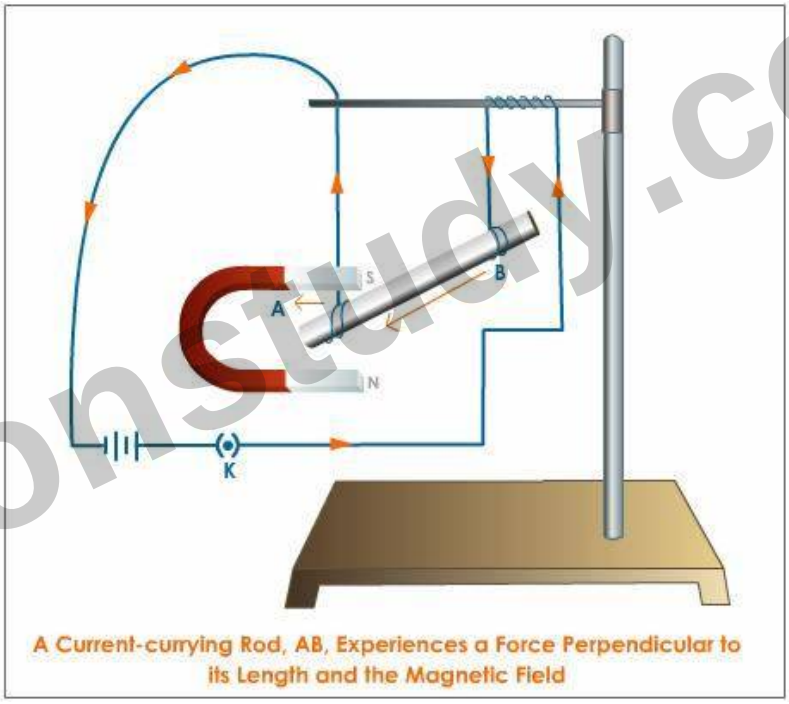




The polarity of electromagnet can also be changed on changing the direction of current.

Magnetic force on a current carrying wire

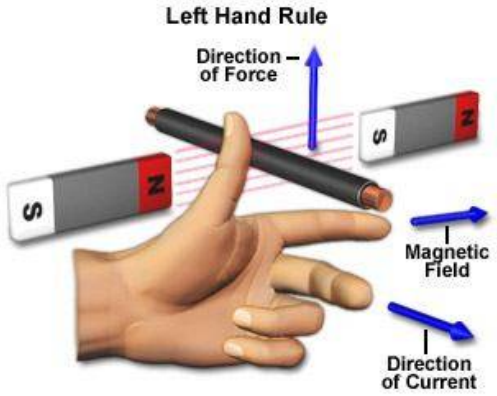
If a current carrying wire is placed in a magnetic field, then force acts on that wire. This phenomenon was discovered by Ampere. As the direction of current (i) is reversed, the magnetic force also acts in different direction.



A Current-currying Rod, AB, Experiences a Force Perpendicular to its Length and the Magnetic Field

- As current increases, force acting on wire also increases.
- As length of the wire increases, value of force increases.
- More magnetic field, more force acting on wire.
- Direction of force depends on direction of current and magnetic field.

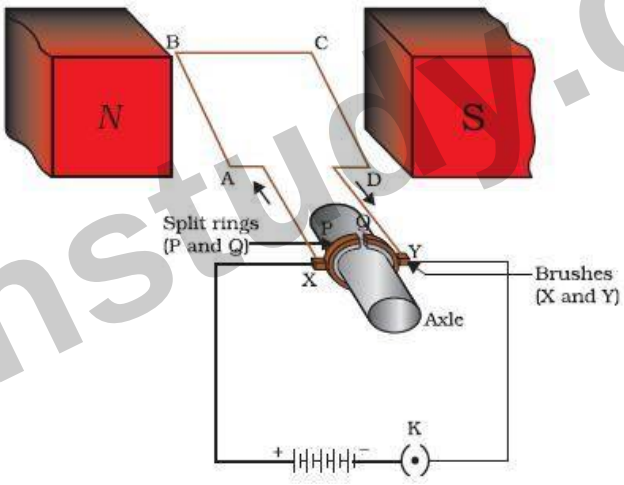
To find out the direction of force, we use Flemmings left hand Rule.



Arrange your fingers of left hand such that the fore finger points towards the direction of magnetic field and centre finger shows the direction of current, then the thumb will show the direction of force or motion.

Electric Motor

Electric Motor is a device that converts electrical energy into mechanical energy.



Principle:

As current flows in the coil placed in the magnetic field then force is produced that rotates the coil.

Construction:

1. Magnet is required to create magnetic field.
2. There is a coil ABCD. It is a loop.
3. Split rings are attached to rectangular loop. They are also called commutator. Commutator is a device which reverses the direction of flow of electric current through a circuit.
4. Brushes touch the split ring.
5. Battery is connected across the brushes.

Working:

1. Due to battery, current flows in the loop placed in magnetic field.
2. Magnetic field applies force on loop so that it rotates. Thus, electrical energy is converted into magnetic energy.
3. But for loop to rotate continuously in one direction, direction of force on wires should keep changing after every half revolution.
4. This is achieved by split rings. They facilitate the change in direction of current.
5. Reversal of direction of current reverses the direction of forces acting on the coil. The change in direction of force pushes the coil; and it moves another half turn.
6. This helps in continuous rotation of the coil.

Commercial Motor

To make motor more powerful, we modify the construction. The motor so obtained is called commercial motor.
It can be done in these ways:

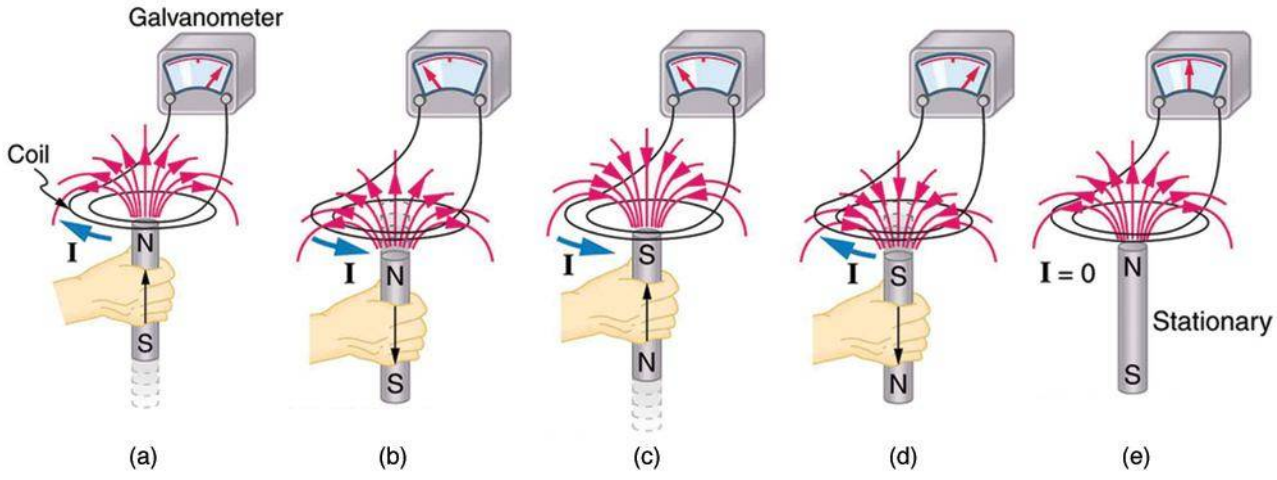
1. Increasing number of loops.
2. Loop can be wound around soft iron core.
3. Electromagnet can be used to create stronger magnetic field.

Electromagnetic Induction (EMI)

Flow of induced current in a coil when a magnetic field changes in the region of coil, this phenomenon is called Electromagnetic Induction.
Whenever there is a change in magnetic field in the region of coil, current flows.

Electromagnetic induction can be demonstrated through various examples.

Example: If there is a relative motion between coil and magnet, then due to change in magnetic field around the coil, current flows. This can be shown below:-

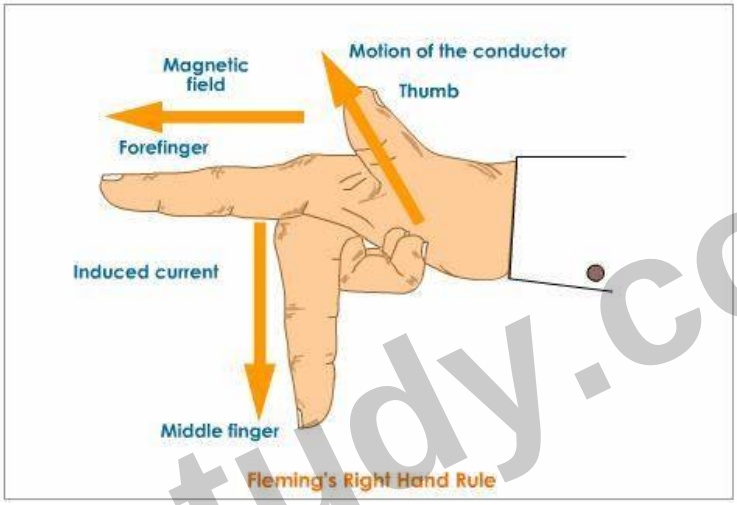


Electromagnetic induction in a straight wire:

When the wire is moved in the magnetic field, then current flows. This current is called induced current.

- If there is more magnetic field or motion of wire is at fast rate, then more current is produced.
- If there is motion along the length of wire or along the line of magnetic field, then there is no current.

Flemmings right hand rule:



Similar to Flemings left hand rule, here we arrange our fore finger, centre finger and thumb of our right hand such that fore finger is in the direction of magnetic field, thumb is in the direction of motion, then centre finger would give the direction of current.

AC and DC

AC refers to Alternating Current. It changes the direction after equal intervals of time.

DC refers to Direct Current. It does not change its direction. It has only one direction.

Electric Generator (Dynamo)

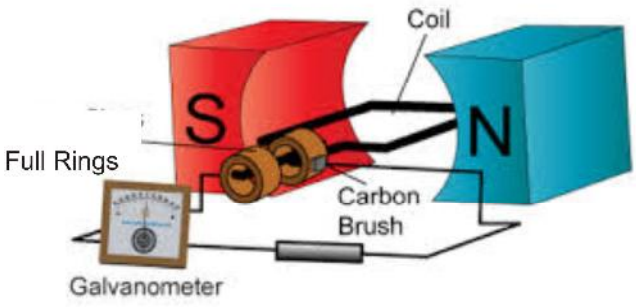
It is a device which converts mechanical energy into electrical energy.

Principle:

When a straight wire is moved in magnetic field, induced current flows in it.

There are 2 types of electric generator – AC and DC.

Alternating Current Generator



Construction:

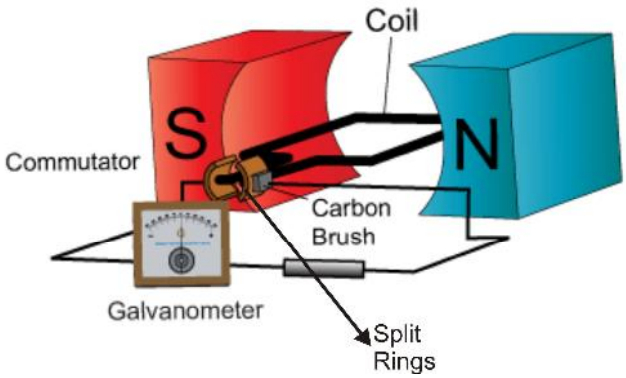
1. Magnetic field is created using a magnet.
2. A rectangular loop ABCD.
3. Two full rings are attached to rectangular loop.
4. Two carbon brushes touch the two rings.
5. Both brushes form loop through galvanometer.

Working:

1. As wires of loop move in magnetic field, induced current flows in them due to EMI.
2. As wires of loop move upwards sometimes and sometimes downwards, the direction of current in the circuit changes. When CD arm moves up during half revolution, current flow in one particular direction. When it moves down in other half revolution, current flows in other direction.

DC Generator

In case of DC generator, split rings are used instead of full rings and they make the current to flow in single direction. Split rings makes the current ‘i’ to flow in single direction through galvanometer.



Note: The only difference between an AC and a DC generator is in the way the two ends of generator coil are linked to the outer circuit.

Domestic electric circuits

To understand the domestic electric circuits or domestic wiring, we should know **what is a fuse?**

Fuse: A device to control the amount of current flowing in the circuit.
If current is more than the rated value, the fuse melts i.e. the circuit gets incomplete and thus over flow of current is avoided into the house.

How electricity reach our home?

1. Electricity is generated at the power house.
2. Electricity is transmitted to our houses through cables over tall towers or underground.
3. There are 3 types of wiring:-

a. Neutral wire (Black in colour) – It has very low potential about 0 V.
b. Ground wire (Green in colour) – It is used as a safety wire.
c. Live wire (RED in colour) – It has very high potential.

The potential difference between live wire and ground wire is about 220 V.

4. Live wire and neutral wire reach to meter box through main fuse. Main fuse limits the supply of current into the house and meter box records the amount of electricity used by house. Meter box is then connected to the distribution Box.
5. From distribution box, two pairs of live and neutral wire run across the house. One wire 15A fuse for heavy devices and one wire 5A fuse is for small devices. This network when setup allows electricity to flow in our house.
6. Fuse in distribution box can melt due to two main reasons.
    a. **Overloading:** When extremely large amount of current is drawn at the same time from the circuit, the situation is called overloading.
    b. **Short-circuiting:** When live and neutral wires come in contact due to any defect such as insulation of wires, heavy current flow, the situation is called short – circuiting.

Insulation of wire can be damaged due to:

a. Breaking of insulation over time
b. Heating

If an insulation break of the live wire and it comes in contact with metallic body of an appliance, it can be very dangerous.

7. Ground wire is connected to a large metallic plate dug deep in earth close to our house.

   If live wire comes in contact with metallic body of an appliance, it can be very dangerous. On touching the body, we can get electric shock. But if ground wire touches the metallic body of appliance, any current through live wire flows through ground wire. It does not flow through our body.

Note: Ground wire goes to all appliances having metallic body.