CH-13 Magnetic Effects of Electric Current Notes

Deleted Portion (Theory):

- Electric Generator
- Direct current
- Alternating current: frequency of AC , Advantage of AC over DC
- Domestic electric circuits.

Magnet: Magnet is an object that attracts objects made of iron, cobalt and nickel. Magnet comes to rest in North – South direction, when suspended freely.

Use of Magnets: Magnets are used in refrigerators, radio and stereo speakers, audio and video cassette players, In children's toys, on hard discs and floppies of computers etc.

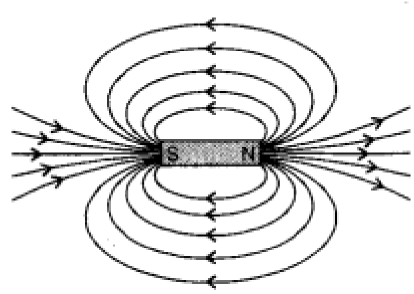
Properties of Magnet:

- A free suspended magnet always points towards the north and south direction.
- The pole of a magnet which points toward north direction is called north pole or north-seeking.
- The pole of a magnet which points toward south direction is called south pole or south seeking.
- Like poles of magnets repel each other while unlike poles of magnets attract each other.

Magnetic field: The area around a magnet where a magnetic force is experienced is called the magnetic field. It is a quantity that has both direction and magnitude. (i.e., Vector quantity)

Magnetic field and field lines: The influence of force surrounding a magnet is called magnetic field. In the magnetic field, the force exerted by a magnet can be detected using a compass or any other magnet.
The magnetic field is represented by magnetic field lines.

- The imaginary lines of magnetic field around a magnet are called field line or field line of magnet.
- When iron fillings are allowed to settle around a bar magnet, they get arranged in a pattern which the magnetic field lines.
- Field line of a magnet can also be detected using



a compass. Magnetic field is a vector quantity,
i.e. it has both direction and magnitude.

Direction of field line: Outside the magnet, the direction of magnetic field line is taken from North Pole to South Pole. Inside the magnet, the direction of magnetic field line is taken from South Pole to North Pole.

Strength of magnetic field: The closeness of field lines shows the relative strength of magnetic field, i.e. closer lines show stronger magnetic field and vice – versa. Crowded field lines near the poles of magnet show more strength.

Properties of magnetic field lines

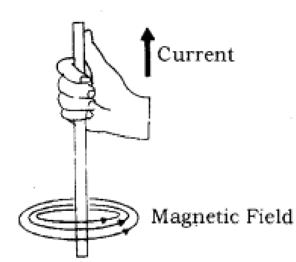
- magnetic field lines are closed curves. (It is taken by convention that magnetic field lines emerge from North Pole and merge at the South Pole. Inside the magnet, their direction is from South Pole to North Pole.)
- The magnitude of magnetic field increases with increase in electric current and decreases with decrease in electric current.
- magnetic field decreases with distance. (The magnitude of magnetic field produced by electric current decreases with increase in distance and vice – versa. The size of concentric circles of magnetic field lines increases with distance from the conductor)
- Magnetic field lines are always parallel to each other. No two field lines cross each other.

Oersted's experiment:

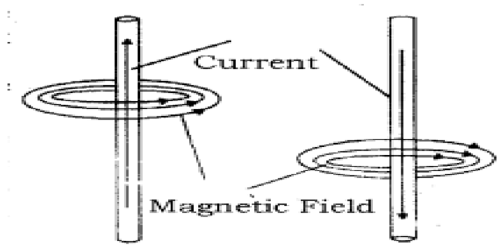
According to this experiment "A current carrying wire creates a magnetic field around it. The direction of magnetic field depends on the direction of current in conductor."

Right-Hand Thumb Rule:

If a current carrying conductor is held by right hand, keeping the thumb straight and if the direction of electric current is in the direction of thumb, then the direction of wrapping of other fingers will show the direction of magnetic field.



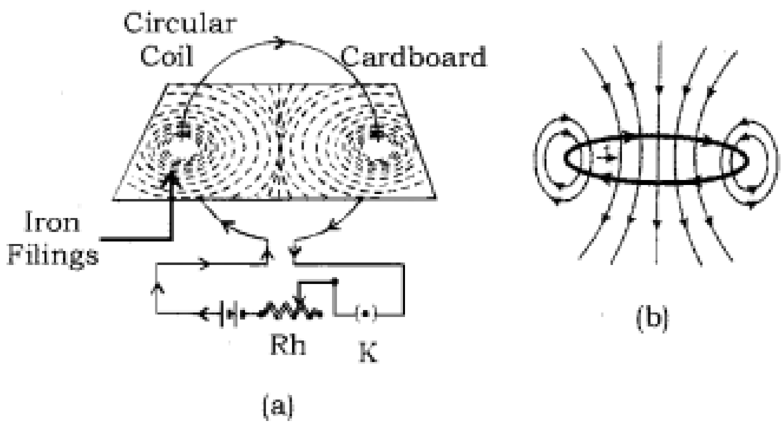
Magnetic field lines due to current a current carrying straight conductor



- A current carrying straight conductor has magnetic field in the form of concentric circles, around it. Magnetic field of current carrying straight conductor can be shown by magnetic field lines.
- The direction of magnetic field through a current carrying conductor depends upon the direction of flow electric current.
- The direction of magnetic field, in relation to direction of electric current through a straight conductor can be obtained by using the Right Hand Thumb Rule.

Magnetic field lines due to a current through a circular loop

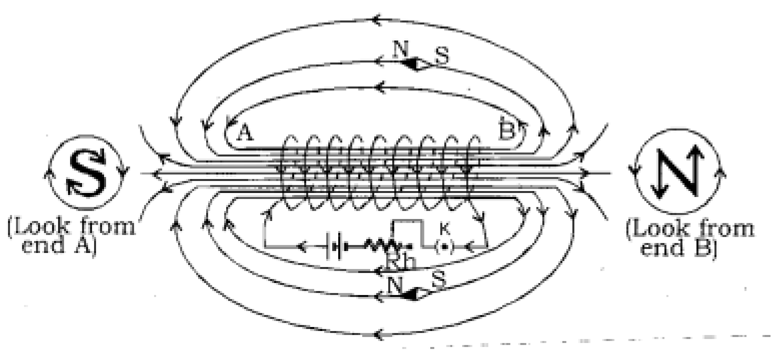
In case of a circular current carrying conductor, the magnetic field is produced in the same manner as it is in case of a straight current carrying conductor.



Since, magnetic field lines tend to remain closer when near to the conductor, so the magnetic field would be stronger near the periphery of the loop. On the other hand, the magnetic field lines would be distant from each other when we move towards the centre of the current carrying loop. Finally, at the centre, the arcs of big circles would appear as a straight line.

Magnetic field due to a current in a Solenoid:

Solenoid is the coil with many circular turns of insulated copper wire wrapped closely in the shape of a cylinder. A current carrying solenoid produces similar pattern of magnetic field as a bar magnet. One end of solenoid behaves as the North Pole and another end behaves as the south pole.

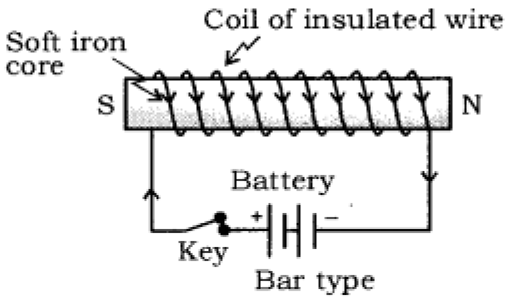


Magnetic field lines are parallel inside the solenoid, similar to a bar magnet, which shows that magnetic field is same at all points inside the solenoid.

The strength of magnetic field is proportional to the number of turns and magnitude of current. By producing a strong magnetic field inside the solenoid, magnetic materials can be magnetized**.** Magnet formed by producing magnetic field inside a solenoid is called **‘electromagnet’.**

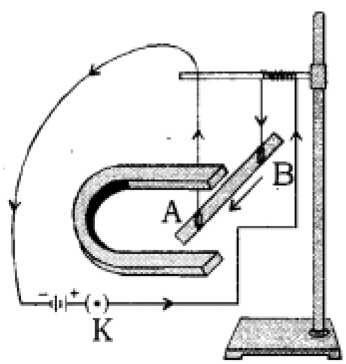
Electromagnet:

An electromagnet consists of a long coil of insulated copper wire wrapped on a soft iron. Magnet formed by producing magnetic field inside a solenoid is called electromagnet.



Force on a current carrying conductor in a magnetic field:

A current carrying conductor exerts a force when a magnet is placed in its vicinity. Similarly, a magnet also exerts equal and opposite force on the current carrying conductor. This was suggested by Marie Ampere, a French Physicist and considered as founder of science of electromagnetism.



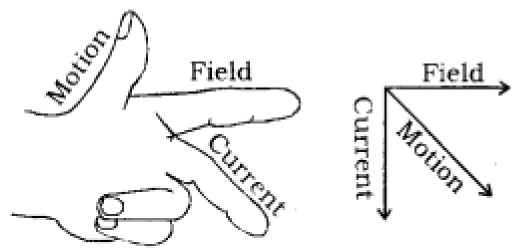
The direction of force over the conductor gets reversed with the change in direction of flow of electric current. **It is observed that the magnitude of force is highest when the direction of current is at right angles to the magnetic field.**

Fleming’s Left-Hand Rule:

If the direction of electric current is perpendicular to the magnetic field, the direction of force is also perpendicular to both of them.

The Fleming’s Left Hand Rule states that if the left hand is stretched in a way that the index finger, the middle finger and the thumb are in mutually perpendicular directions, then the index finger and middle finger of a stretched left hand show the direction of magnetic field and direction of electric current respectively and the thumb shows the direction of motion or force acting on the conductor. The directions of electric current, magnetic field and force are similar to three mutually perpendicular axes, i.e. x, y, and z-axes.

Many devices such as electric motor, electric generator, loudspeaker, etc work on Fleming's Left Hand Rule.



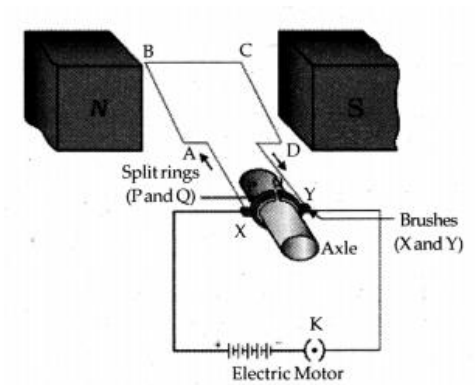
Electric motor:

A device that converts electrical energy to mechanical energy.

It is of two types: AC and DC Motor.
Electrical energy is converted into mechanical energy by using and electric motor. Electric motor works on the basis of rule suggested by Marie Ampere and Fleming's Left Hand Rule.

Principle of Electric Motor:

When a rectangular coil is placed in a magnetic field and a current is passed through it, force acts on the coil, which rotates it continuously. With the rotation of the coil, the shaft attached to it also rotates.



Construction: It consists of the following parts:

Armature: It is a rectangular coil (ABCD) which is suspended between the two poles of a magnetic field.
The electric supply to the coil is connected with a commutator.

Commutator or Split – ring: Commutator is a device which reverses the direction of flow of electric current through a circuit. It is two halves of the same metallic ring.

Magnet: Magnetic field is supplied by a permanent magnet N to S.

Sliding contacts or Brushes Q which are fixed.

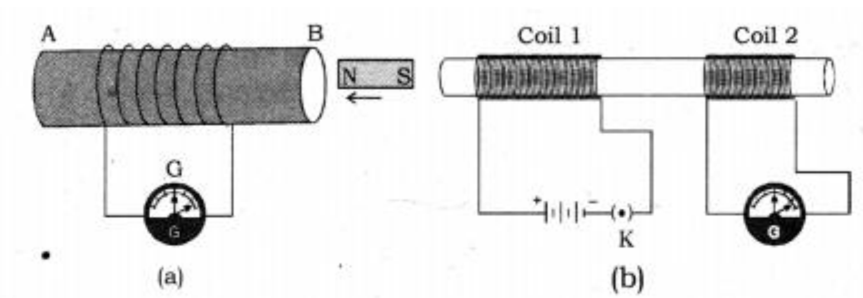
Working: When an electric current is supplied to the coil of the electric motor, it gets deflected because of magnetic field. As it reaches the halfway, the split ring which acts as commutator reverses the direction of flow of electric current. Reversal of direction of the current and reverses the direction of forces acting on the coil. The change in direction of force pushes the coil, and it moves another half turn. Thus, the coil completes one rotation around the axle. Continuation of this process keeps the motor in rotation.

In commercial motor, electromagnet instead of permanent magnet and armature is used. Armature is a soft iron core with large number of conducting wire turns over it. Large number of turns of conducting wire enhances the magnetic field produced by armature.

Electric Motors used in electric fans, pumping water, various toys.

Electromagnetic Induction:

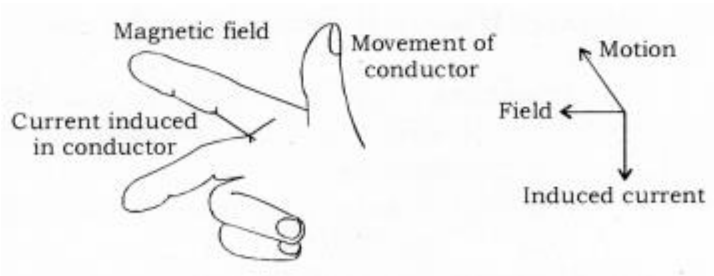
Michael Faraday, an English Physicist is supposed to have studied the generation of electric current using a magnetic field and a conductor.
Electricity production as a result of magnetism (induced current) is called Electromagnetic Induction.



When a conductor is set to move inside a magnetic field or a magnetic field is set to be changing around a conductor, electric current is induced in the conductor. This is just opposite to the exertion of force by a current carrying conductor inside a magnetic field. In other words, when a conductor is brought in relative motion due to change in magnetic field, a potential difference is induced in it. This is known as **electromagnetic induction.**

Fleming's Right-Hand Rule:

Electromagnetic induction can be explained with the help of Fleming's Right Hand Rule. If the right hand is structured in a way that the index finger, middle finger and thumb are in mutually perpendicular directions, then the thumb shows direction of induced current in the conductor. The directions of movement of conductor, magnetic field and induced current can be compared to three mutually perpendicular axes, i.e. x, y and z axes.



The mutually perpendicular directions also point to an important fact that when the magnetic field and movement of conductor are perpendicular, the magnitude of induced current would be maximum.

Electromagnetic induction is used in the conversion of kinetic energy into electrical energy.