

MAGNETISM

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Magnets

A substance which attracts small pieces of iron and points in North-South direction when suspended freely is known as Magnet. A naturally occurring iron ore which is called loadstone or magnetite also behaves as a magnet but it is a very weak magnet. The ones we see are made from them in artificial way and permanent and strong.

Properties of magnet:-

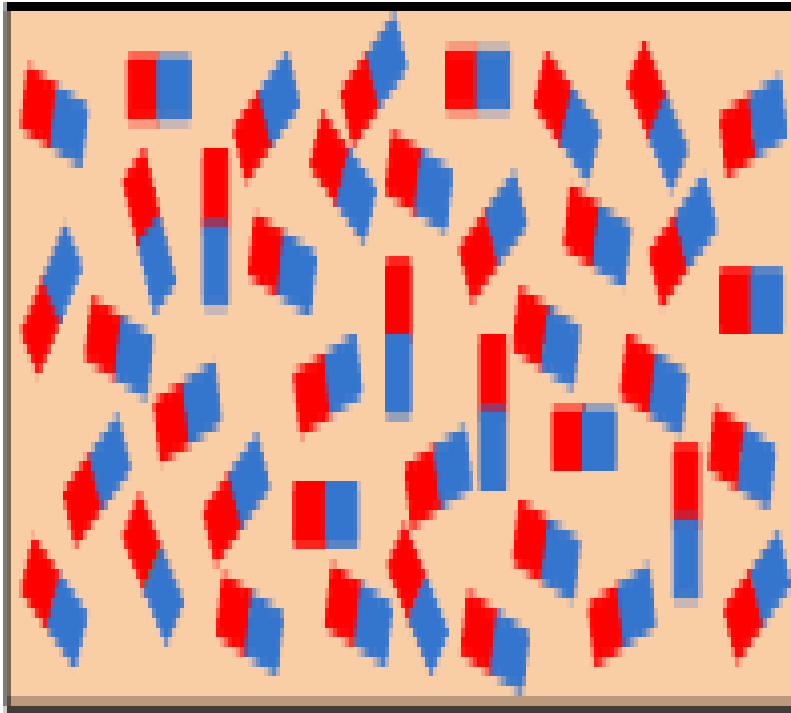
- 1) Has 2 poles- North and South.
- 2) Like poles repel each other and unlike poles attract each other.
- 3) They always exist in pairs of poles.
- 4) Repulsion is the only sure test for a magnet.



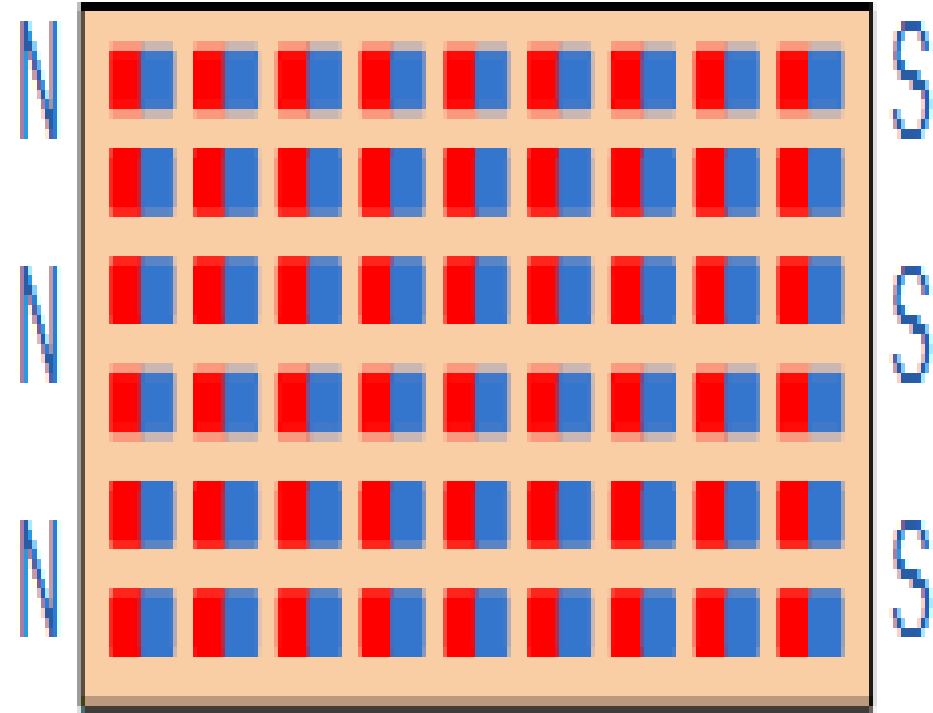
Molecular Theory of Magnetism

- The molecular theory of magnetism was given by Weber. According to this theory:
 - (i) Every molecule of a magnetic substance (whether magnetised or not) is a complete magnet in itself, having a north pole and a south pole of equal strength.
 - (ii) In an unmagnetised substance, the molecular magnets are randomly oriented such that they form closed chains. The north pole of one molecular magnet cancels the effect of south pole of the other so that the **resultant magnetism** of the unmagnetised specimen is zero.
 - (iii) On magnetising the substance, the molecular magnets are realigned so that north poles of all molecular magnets point in one direction and south poles of all molecular magnets point in the opposite direction.

Magnetic Materials



Loose and Random
Magnetic Domains



Effect of Magnetization
Domains Lined-up in Series

Molecular Theory of Magnetism

- (iv) When all the molecular magnets are fully aligned, the substance is said to be saturated with magnetism.
- (v) At all the stages, the strengths of the two poles developed will always be equal.
- (vi) On heating the magnetised specimen, molecular magnets acquire some kinetic energy. Some of the molecules may get back to the closed chain arrangement. That is why magnetism of the specimen would reduce on heating.

electromagnetism

The magnetic effect of electric current is known as electromagnetic effect . It is observed that when a compass is brought near a current carrying conductor the needle of compass gets deflected because of flow of electricity. This shows that electric current produces a magnetic effect. This was discovered by Hans Christian Oersted , who was one of the leading scientists of 19th century . In 1820 , he accidentally discovered that a compass needle got deflected when kept near an current carrying metallic wire placed nearby.

b) Magnetic field lines :-

The imaginary lines of magnetic field around a magnet are called field line or field line of magnet.

The magnetic field lines around a magnet can be observed by sprinkling iron filings around a magnet. When iron filings are allowed to settle around a bar magnet, they get arranged in a pattern which mimics the magnetic field lines.

It can also be observed by moving a magnetic compass around a magnet.

Magnetic field is a vector quantity that has both direction and magnitude.

Field line of a magnet can also be detected using a compass.,

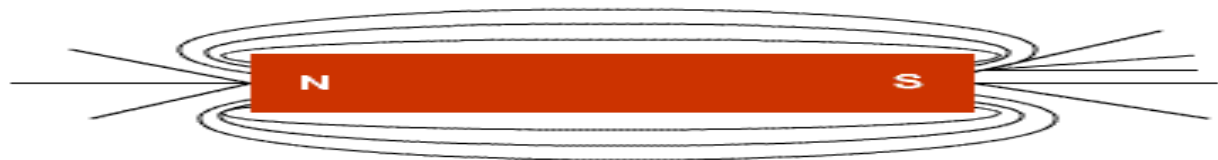
The direction of the magnetic field is taken to be the direction in which a north pole of the compass needle moves inside it. Therefore it is taken by convention that the field lines emerge from north pole and merge at the south pole.

- i) The magnetic field lines emerge at the north pole and merge at the south pole.
- ii) The magnetic field lines are closer at the poles.
- iii) The magnetic field lines do not intersect each other.

MAGNETIC EFFECTS OF ELECTRIC CURRENT

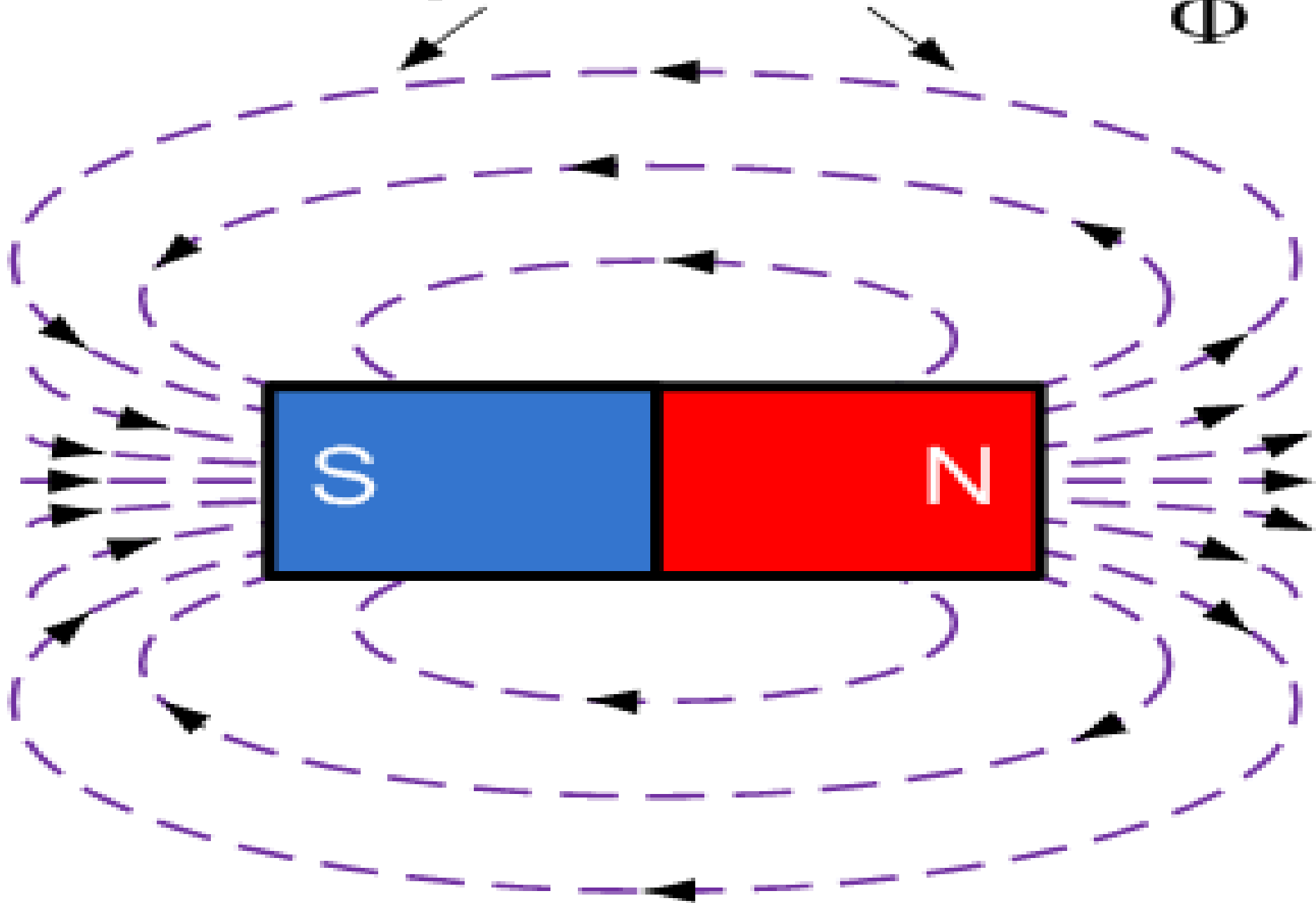
a) Magnetic field :-

- The region around a magnet where the force of attraction or repulsion can be detected is called magnetic field.
- OR
- The influence of force surrounding a magnet is called magnetic field
- So, Magnetic field around a magnet can be detected by using a magnetic compass.



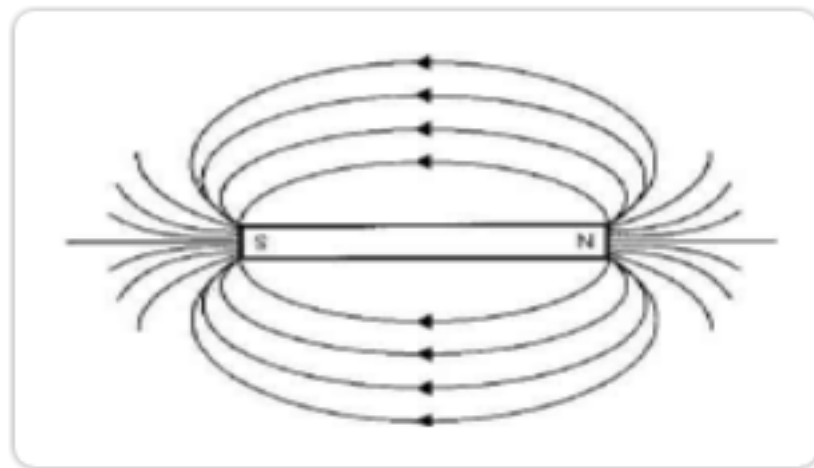
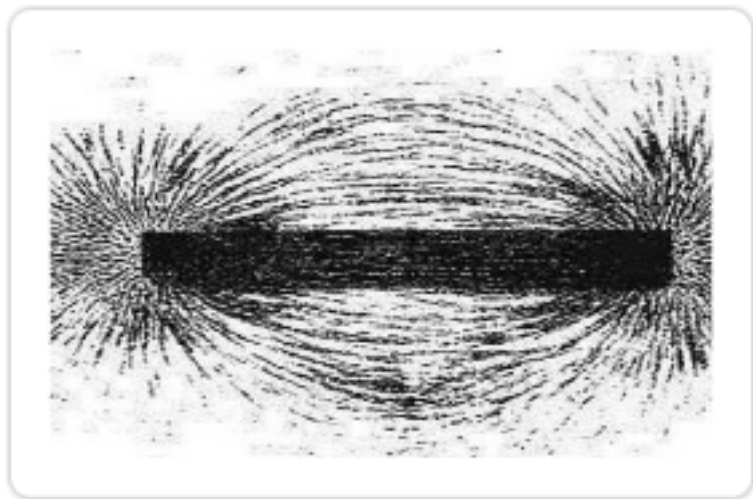
Magnetic Field Lines

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Direction And Strength Of Field Line

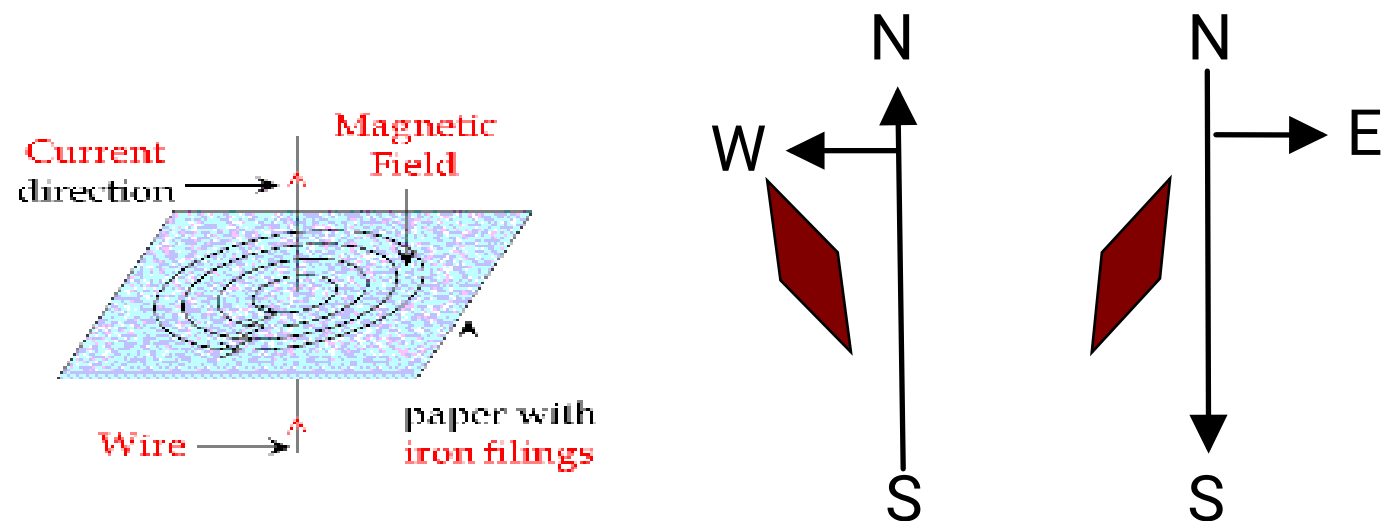
- Direction of Field Line:- Outside the magnet, the direction of magnetic field line is taken from north pole to South Pole. Inside the magnet, the direction of magnetic field line is taken from south pole to north pole.
- Strength of magnetic field: The closeness of field lines shows the relative strength 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

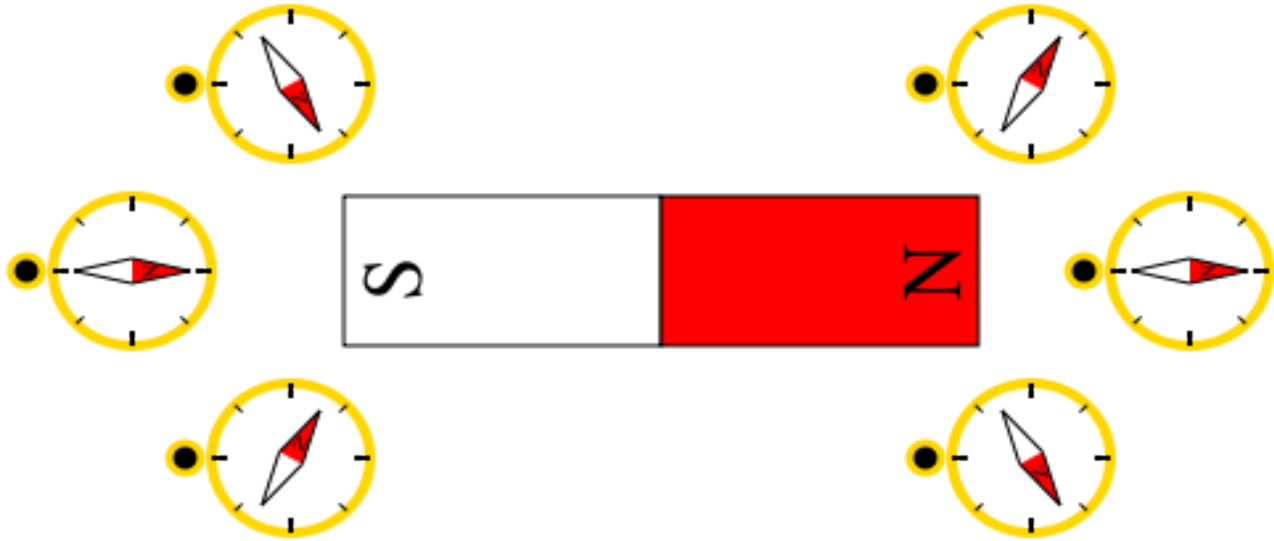


Magnetic Field Due to Current Carrying Conductor

If a magnetic compass is placed near a conductor carrying current (wire), the needle is deflected. This shows that a conductor carrying current has a magnetic field around it.

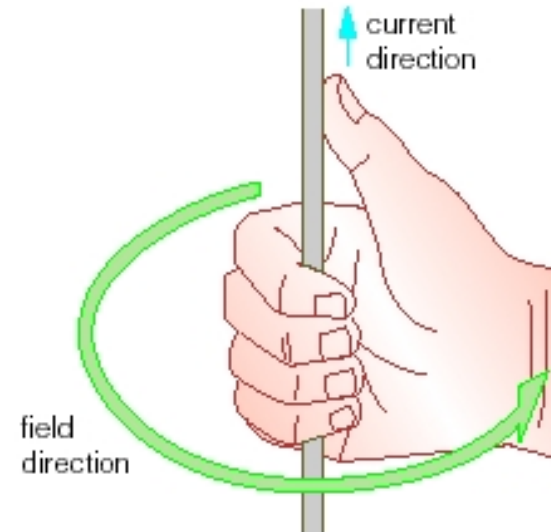
If the direction of the current is from north to south, the deflection of the magnetic needle is towards the east. If the direction of the current is from south to north, the deflection of the needle is towards the west. The magnetic field around a current carrying straight conductor is in concentric circles. It can be observed by passing a current carrying straight conductor through a cardboard and sprinkling iron filings on it.



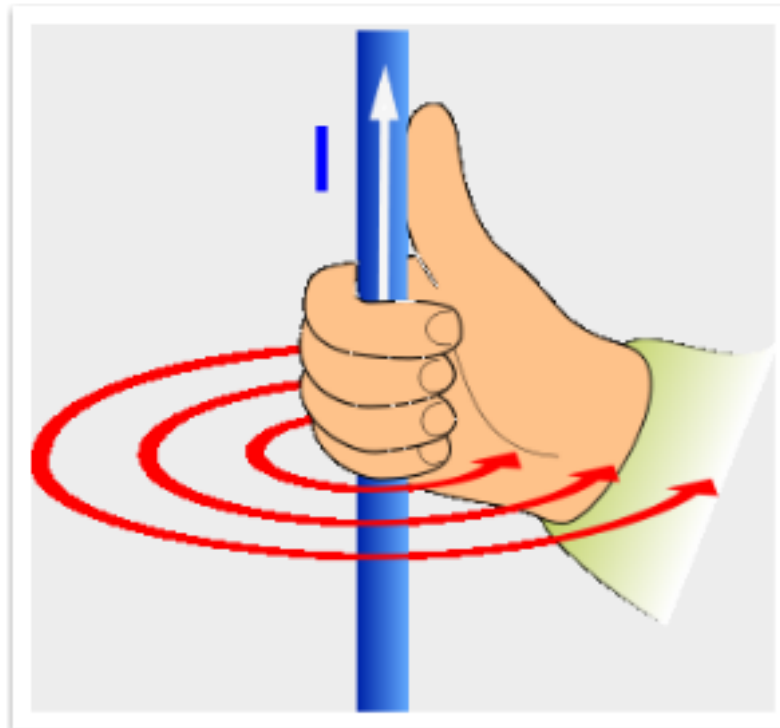


Right Hand Thumb Rule

- The direction of magnetic field; in relation to direction of electric current through a straight conductor can be depicted by using the Right Hand Thumb Rule. It is also known as Maxwell's Corkscrew 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.

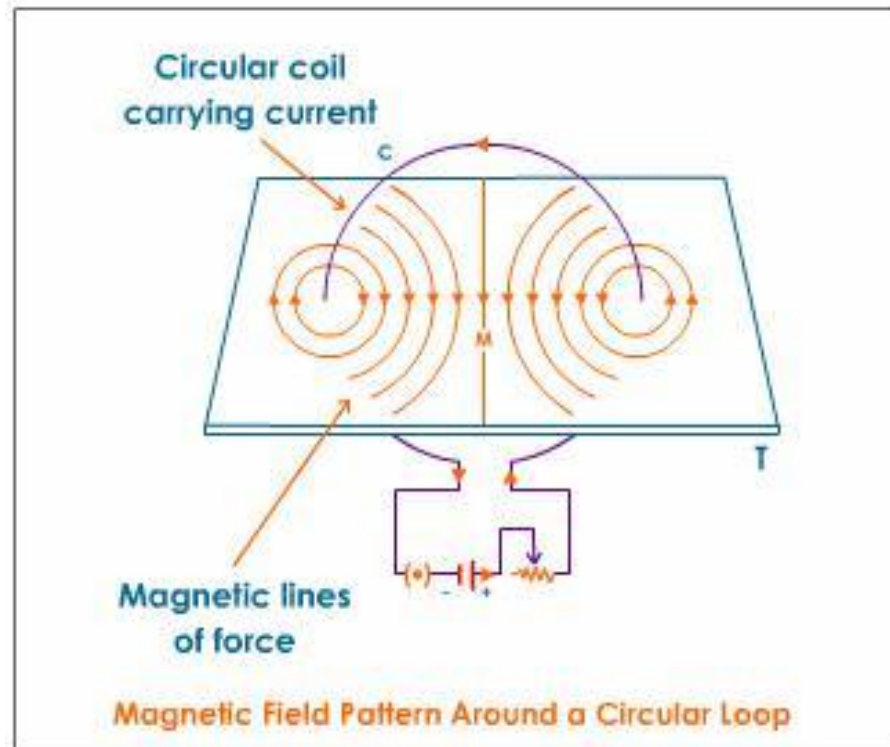


Right Hand Thumb Rule



Magnetic Field Due to Current in Circular Loop

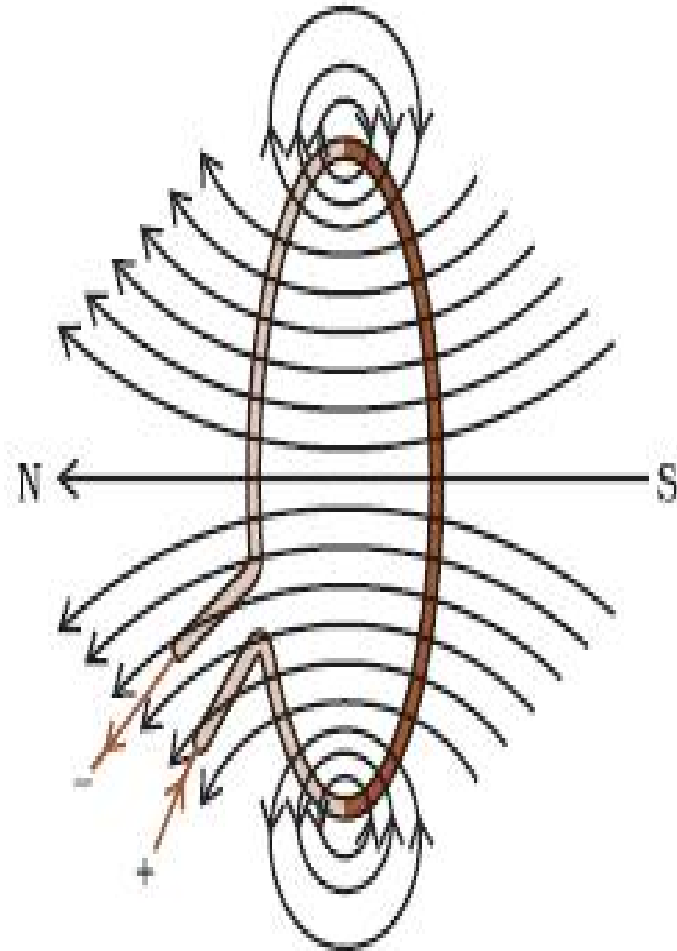
When current is passed through a circular conductor (loop) the magnetic field produced is in the form of concentric circles around the conductor. Towards the centre the arcs of the circles become larger and appears as straight line.



Properties of Magnetic Field

- The magnitude; of magnetic field increases with increase in electric current and decreases with decrease in electric current.
- 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, which shows that magnetic field decreases with distance.
- Magnetic field lines are always parallel to each other.
- No two field lines cross each other

The direction of magnetic field can be identified using Right Hand Thumb's Rule. Let us assume that the current is moving in anti-clockwise direction in the loop. In that case, the magnetic field would be in clockwise direction; at the top of the loop. Moreover, it would be in anticlockwise direction at the bottom of the loop.

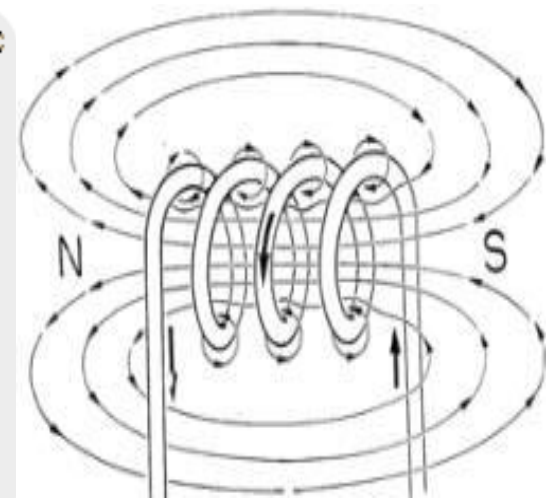
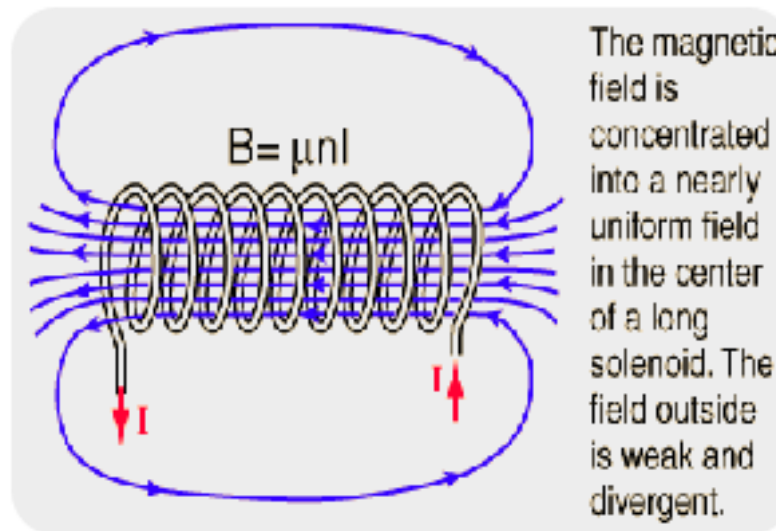
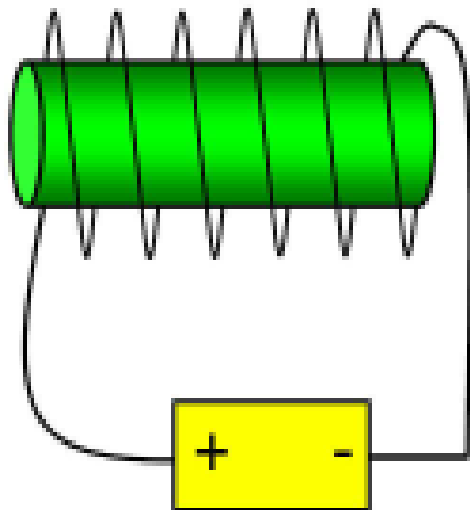


Magnetic Field Due To Current in a Solenoid

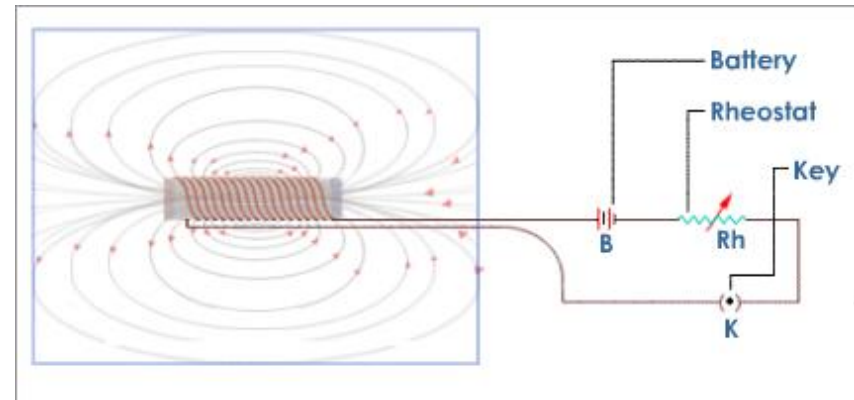
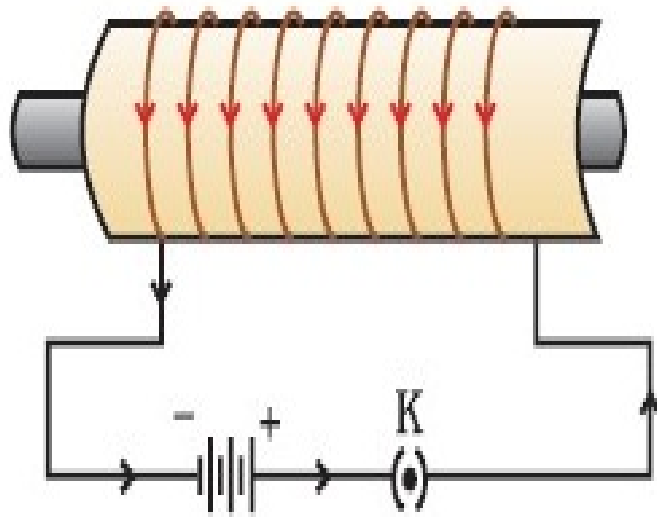
A solenoid is a circular coil of wire in the shape of a cylinder.

When current flows through a solenoid, it behaves like a bar magnet. The ends of the solenoid behaves like the North and South poles of a magnet. The magnetic field produced by a solenoid is similar to the magnetic field produced by a bar magnet.

The strength of the magnetic field depends upon the strength of the current and the number of turns of the coil.



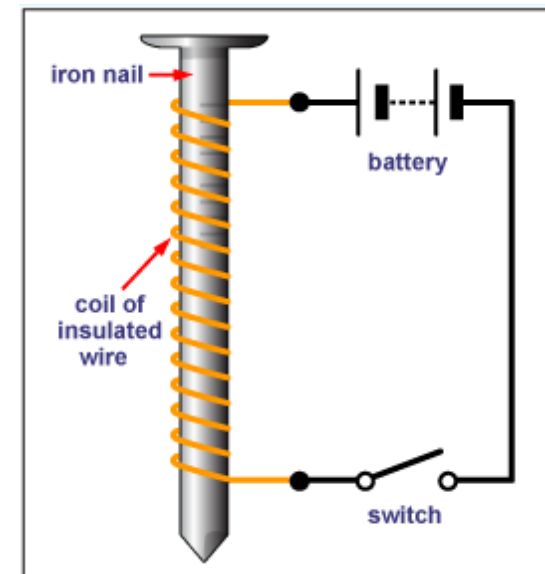
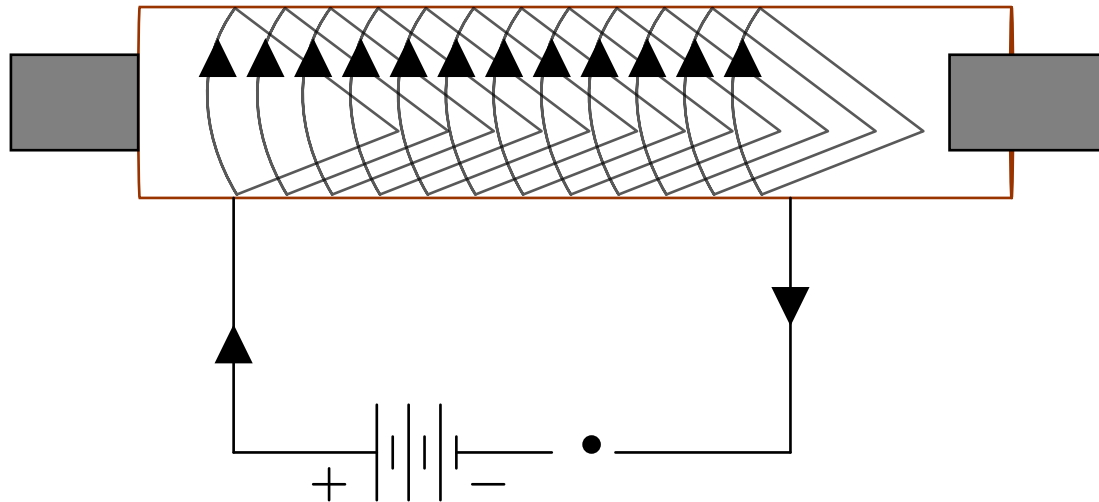
Solenoid



Electromagnet

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

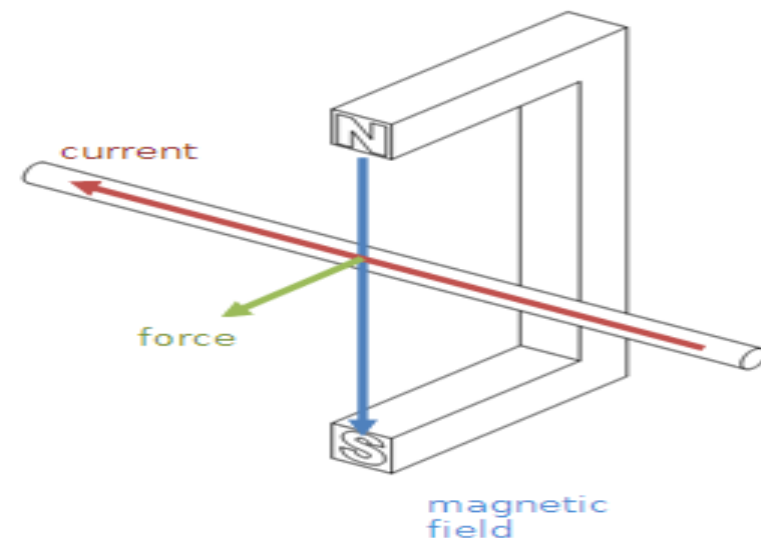
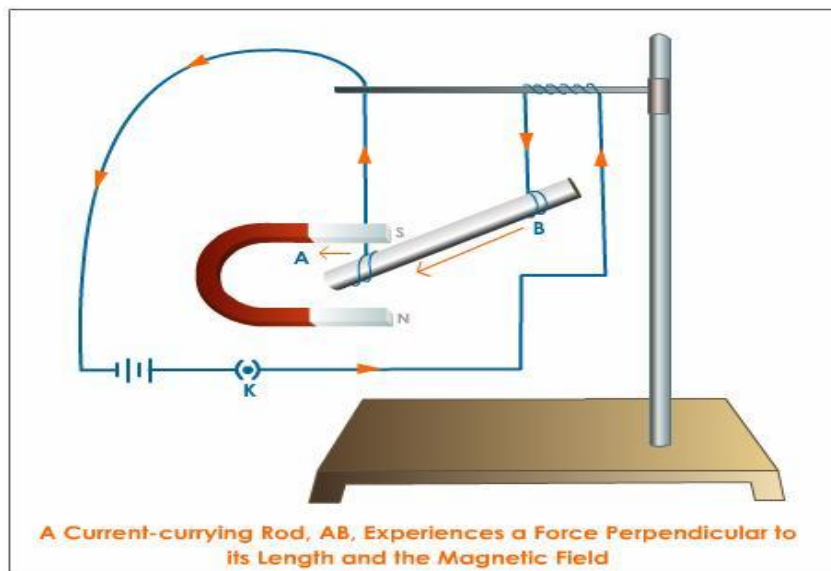
If electric current is passed through a wire wound around a piece of soft iron, it behaves like a magnet. Such a magnet is called an electromagnet.



Force on a Conductor Carrying Current In Magnetic Field

Ampere suggested that if a current carrying conductor produces a magnetic field and exerts a force on a magnet, then a magnet should also exerts a force on a current carrying conductor.

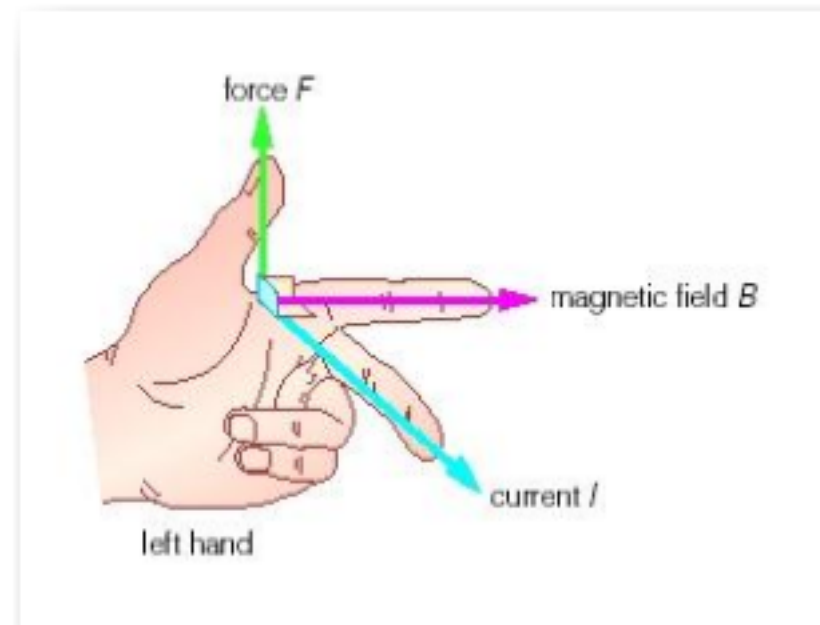
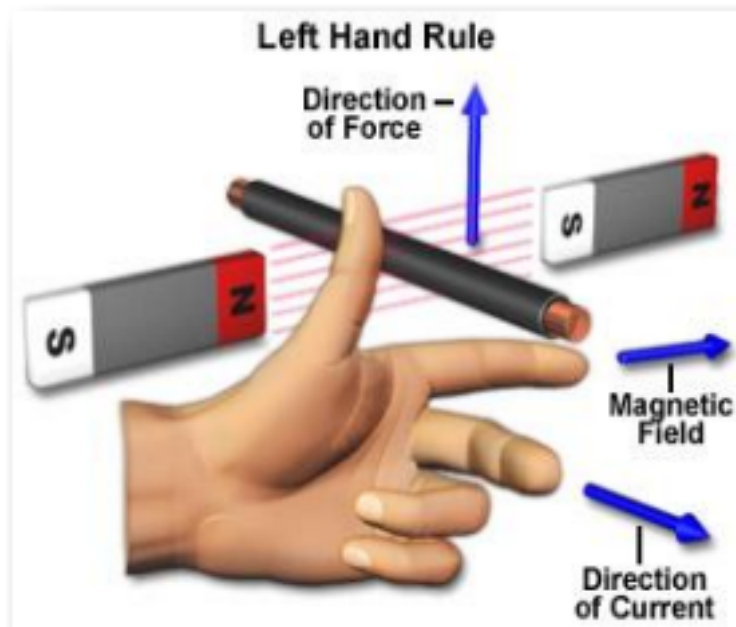
Eg :- If an aluminium rod is suspended horizontally by a wire between the poles of a horse shoe magnet and current is passed through the wire, then the aluminium rod is displaced. If the direction of current is reversed, the direction of displacement is also reversed. The force exerted is maximum if the conductor is perpendicular to the magnetic field.



Fleming's Left Hand Rule

The direction of force (motion) of a current carrying conductor in a magnetic field is given by Fleming's Left Hand Rule.

It states that ' If we hold the thumb, fore finger and middle finger of the left hand perpendicular to each other such that the fore finger points in the direction of magnetic field, the middle finger points in the direction of current, then the thumb shows the direction of force (motion) of the conductor'.

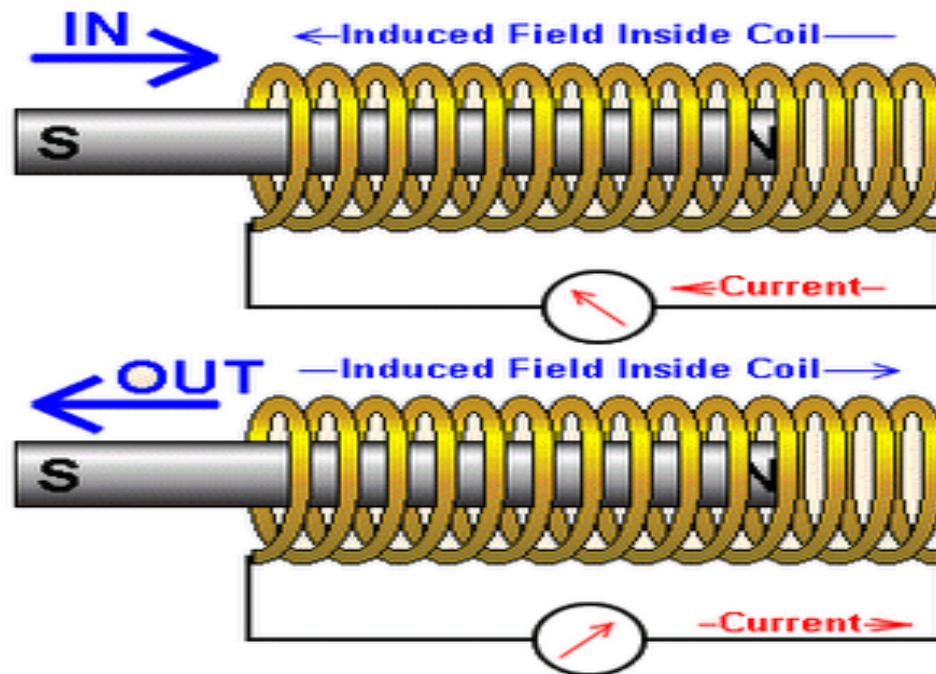


Electromagnetic Induction (Michael Faraday)

The motion of a magnet with respect to a coil or a change in the magnetic field induce a potential difference in the coil and produces induced current. This is called electromagnetic induction.

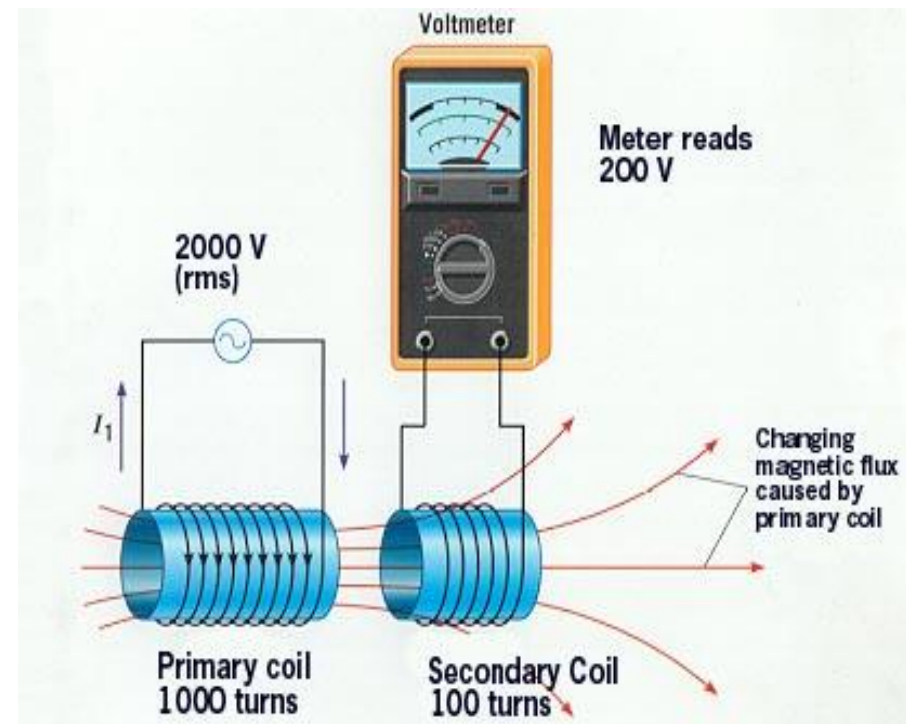
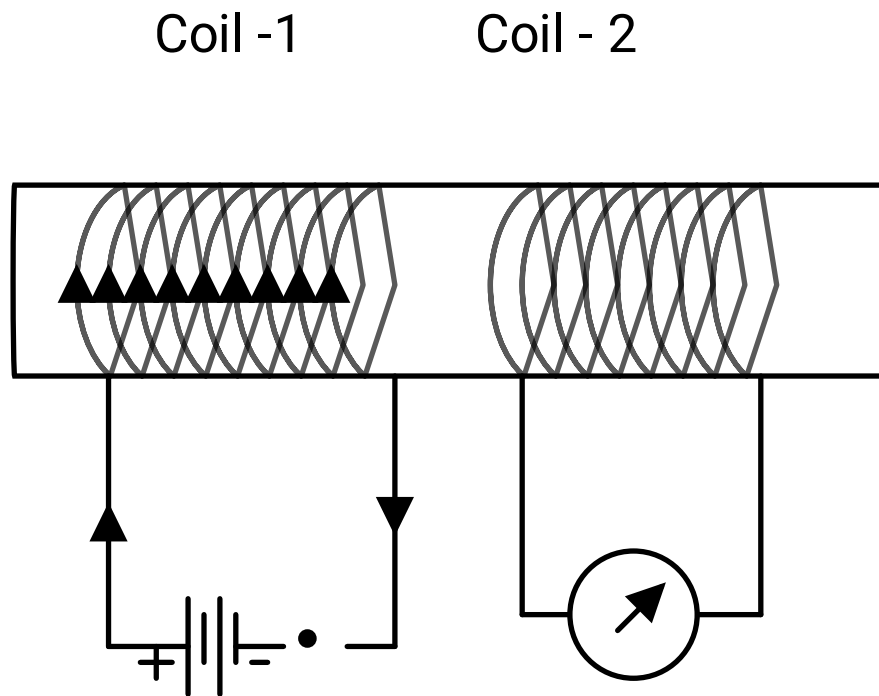
i) Motion of a magnet with respect to a coil produces induced current :-

If a magnet is moved towards or away from a coil of wire connected to a galvanometer, the galvanometer needle shows a deflection. This shows that current is induced in the coil due to the motion of the magnet.

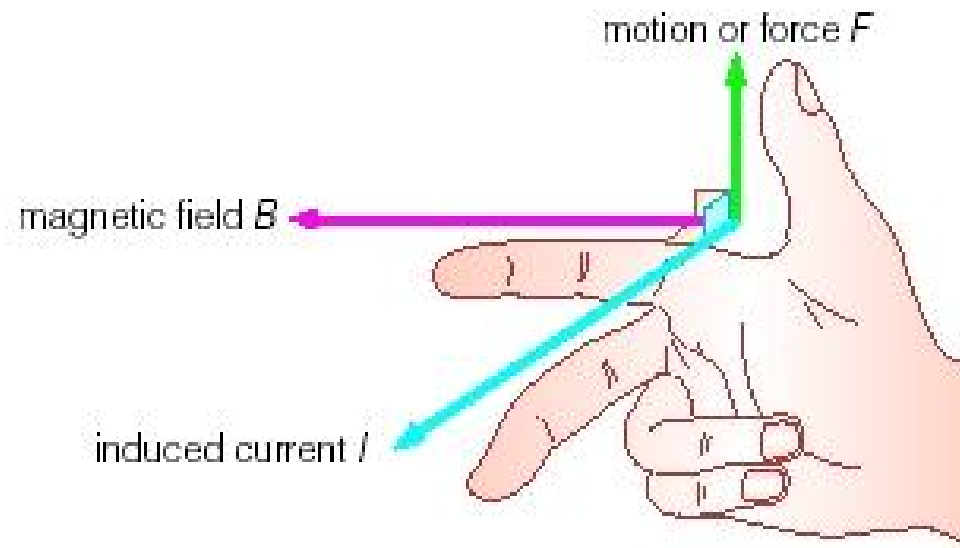


ii) Change in magnetic field produces induced current :-

Take two coils of wires wound around a cylindrical paper roll. Connect one coil to a battery and the other coil to a galvanometer. If current is passed through the first coil, the galvanometer needle shows a deflection in the second coil. If the current is disconnected, the needle moves in the opposite direction. This shows that current is induced due to change in magnetic field.



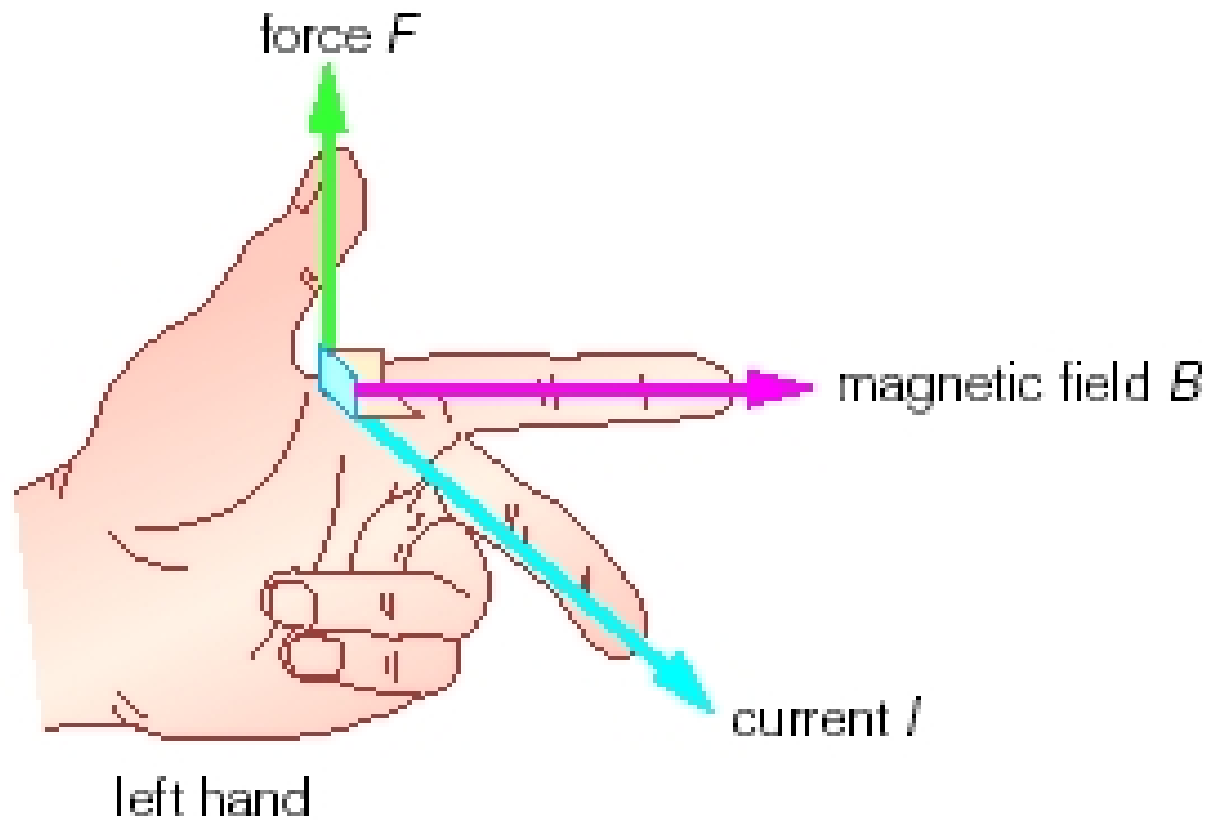
The direction of induced current is given by Fleming's Right Hand Rule. It states that ' If the thumb, fore finger and middle finger of the right hand is held perpendicular to each other such that the thumb points in the direction of motion of the conductor, the fore finger points in the direction of the magnetic field, then the middle finger shows the direction of induced current '.



Fleming's Left Hand Rule:-

- If 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. works on the Fleming's left Hand Rule.

Fleming's Left Hand Rule



Electromagnetic Induction

- Michael Faraday, an English Physicist is supposed to have studied the generation of electric current using magnetic field and a conductor.
- 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 vis-à-vis a magnetic field, a potential difference is induced in it. This is known as electromagnetic induction.

Flemings Right Hand Rule

- Electromagnetic induction can be explained with the help of Fleming's Right Hand Rule. If the right hand is stretched in a way that the index finger, middle finger and thumb are in mutually perpendicular directions, then the thumb shows the direction of movement of the conductor, index finger shows the direction of magnetic field and the middle finger shows the 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.

Fleming's Right Hand Rule

