Electromagnetism

Describe the results of the Oersted experiment
Oersted found that, for a straight wire carrying a steady (DC) current:
The magnetic field lines encircle the current-carrying wire
The magnetic field lines lie in a plane perpendicular to the wire
If the direction of the current is reversed, the direction of the magnetic force reverses.
The strength of the field is directly proportional to the magnitude of the current.
The strength of the field at any point is inversely proportional to the distance of the point from the wire.
Definition
Effect of Current on a Compass Needle

Compass needle is a magnetic needle , so when placed still will align itself in north-south direction, if we bring a bar magnet near the compass the needle will deflect based on the property that like poles of two magnets repel each other. As soon as the other magnet is removed,the magnetic needle will come back to its original position.
This same thing happens when a current carrying circuit is placed near a compass. As soon as the key is closed current will pass through the coiled wire shown in the figure and it will start behaving as a electromagnet and will deflect the needle and when the key is made open the magnetic needle will again point to north-south direction.
Definition
Magnetic field
The region or space around a magnet, within which its influence can be experienced is called magnetic field of that filed.
Definition
Intensity of Magnetic field
The intensity of magnetic field at a point in a magnetic field is defined as the force experienced by unit north pole when placed at that point.

Magnetic field
The region surrounding the magnet, in which the force of the magnet can be experienced, is called magnetic field.

Arrangement of iron fillings around a bar magnet

When iron filings are placed in magnetic field, they are magnetized and induce poles in them. Hence, they act as small magnets themselves. These filings orient themselves along the magnetic field lines of the bar magnet as shown in the figure.

Magnetic lines of bar magnet

Magnetic lines of force of a magnet shows the direction in which a magnetic material will be aligned when placed at the location. Magnetic field lines for a bar magnet are as shown in the diagram.

Properties of magnetic fields of lines

Magnetic field lines are imaginary lines that represent magnetic fields. It gives direction of magnetic force. An advantage of using magnetic field lines as a representation is that laws of magnetism and (electromagnetism) can be stated using concepts like 'number' of field lines through a surface.

Magnetic field lines are like streamlines in fluid flow, they represent something continuous, and a different resolution would show more or fewer lines. Various phenomena have the effect of displaying magnetic field lines as though the field lines were physical phenomena. For example, iron filings placed in a magnetic field, form lines that correspond to field lines. Field lines can be used as a qualitative tool to visualize magnetic forces.' Unlike' poles of magnets attract because they are linked by many field lines, 'like' poles repel because their field lines do not meet, but run parallel, pushing on each other.

Magnetic flux through an area

Magnetic flux is a measure of the quantity of magnetism, being the total number of magnetic lines of force passing through a specified area in a magnetic field. Magnetic flux through a plane of area A placed in a uniform magnetic field B can be written as

$\phi B = B.A = BA\cos\theta$

Magnetic flux density

Magnetic Flux Density is amount of magnetic flux through unit area taken perpendicular to direction of magnetic flux. Flux Density (B) is related to Magnetic Field (H) by $B=\mu H$. It is measured in Webers per square meter equivalent to Teslas [T].

The total number of magnetic field lines passing through a given area normally is called magnetic flux. In magnetic flux formula μ is the permeability of the medium (material) where we are measuring the fields. The B field is a vector field, which means it has a magnitude and direction at each point in space.

Solenoid

A solenoid is a long wire wound in the form of a helix where the neighboring turns are closely spaced. So each turn is regarded as a circular loop. The net magnetic field is the vector sum of the fields due to all the turns. Enamelled wires are used for winding so that turns are insulated from each other. Generally, the length of the solenoid is large as compared to the transverse dimension. For example, if the solenoid has circular turns, the length is large as compared to its radius. If it has rectangular turns, the length should be as large as compared to its edges.

Magnetic field due to a solenoid

Solenoid is same as a bar electromagnet. Its magnetic field lines are shown in the diagram.

Force on a wire in magnetic field

When the magnetic field (B) and the current carrying wire of length (L) are perpendicular, then force on the wire is given by:

$F=BIL$

Moving charges or current produce magnetic field

When a compass is placed near a current carrying straight wire, then deflection occurs in the needle of the compass.

The alignment of the needle is tangential to an imaginary circle which has the straight wire as its centre and has its plane perpendicular to the wire.

It is noticeable when the current is large and the needle sufficiently close to the wire so that the earths magnetic field may be ignored. Reversing the direction of the current reverses the orientation of the needle.

The deflection increases on increasing the current or bringing the needle closer to the wire.

Thus moving charges or currents produced a magnetic field in the surrounding space.

Induced EMF

The magnetic flux is a measure of the number of magnetic field lines passing through an area. If a loop of wire with an area A is in a magnetic field B, the magnetic flux is given by:

$\phi=BA\cos\theta$, where θ is angle between magnetic field B and vector area A which is perpendicular to plane of loop.

If the flux changes, an emf will be induced. There are 3 ways an emf can be induced in a loop:

Change the magnetic field

Change the area of the loop

Change the angle between the field and the loop

Electromagnetic Induction

The property due to which a changing magnetic field within a closed conducting coil induces electric current in the coil is called electromagnetic induction.