12 Magnetic Effects of Electric Current

Introduction

Magnet is any substance that attracts iron or iron-like substances. An electric current-carrying wire behaves like a magnet.

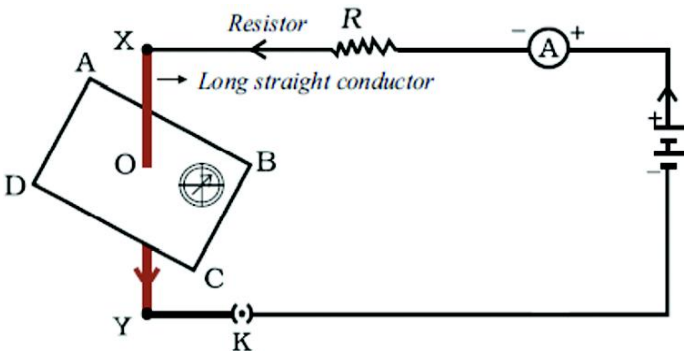
Current and Magnetism: When an electric current flows through a conductor, it generates a magnetic field around it. This is the fundamental concept of electromagnetism. The direction of the magnetic field can be determined using the *right-hand thumb rule

12.1 Oersted Experiment:

Aim: To show that compass needle is deflected on passing an electric current through a metallic conductor.

Required Materials: Thick copper wire, Magnetic compass, Card board, Resistor, Ammeter, Key.

Procedure:



1. Take a straight thick copper wire and place it between the points X and Y in electric circuit as shown in the figure.
2. The wire XY is kept perpendicular to the plane of paper.
3. Horizontally place a small compass near to this copper wire.
4. See the position of its needle.
5. Pass the current through the circuit by inserting the key into the plug.

Observations:

1. We observe that the needle is deflected.
2. The electric current through the copper wire has produced a magnetic field around it.

12.2 Magnetic substances: The substances which are attracted by a magnet are called magnetic substances. Examples: Iron, nickel, cobalt, steel etc.

Non-Magnetic substances: The substances which are not attracted by a magnet are called non-magnetic substances. Examples: wood, glass, copper, aluminium, brass, paper etc.

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Properties of magnet:

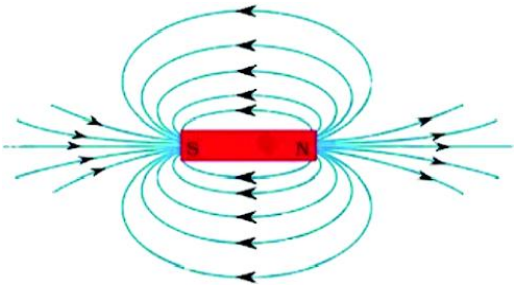
(i) Every magnet has two poles i.e., North and South.

(ii) Like poles repel each other.

(iii) Unlike poles attract each other.

(iv) A freely suspended bar magnet aligns itself in nearly north-south direction.

Magnetic Field: The area around a magnet in which its magnetic force can be experienced.



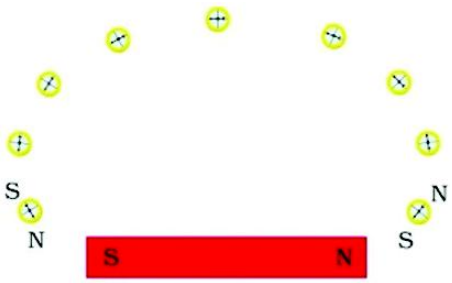
(i) Its SI unit is Tesla (T).

(ii) Magnetic field has both magnitude and direction. It is a vector quantity.

(ii) Magnetic field can be described with help of a magnetic compass. The needle of a magnetic compass is a freely suspended bar magnet.

Magnetic field lines: The imaginary lines of magnetic field around a magnet are called magnetic field lines.

Characteristics of Field Lines:



(i) Field lines arise from North pole and end into South pole of the magnet.

(ii) Field lines are closed curves.

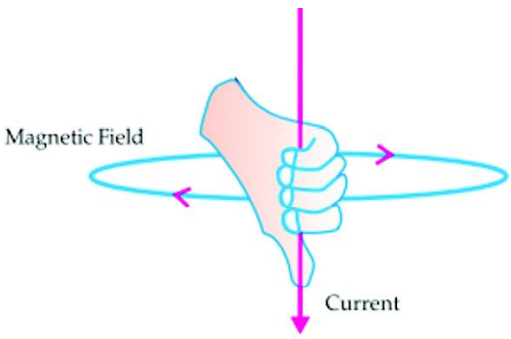
(iii) Field lines are closer in stronger magnetic field.

(iv) Field lines never intersect each other as for two lines to intersect, there must be two directions of magnetic field at a point, which is not possible.

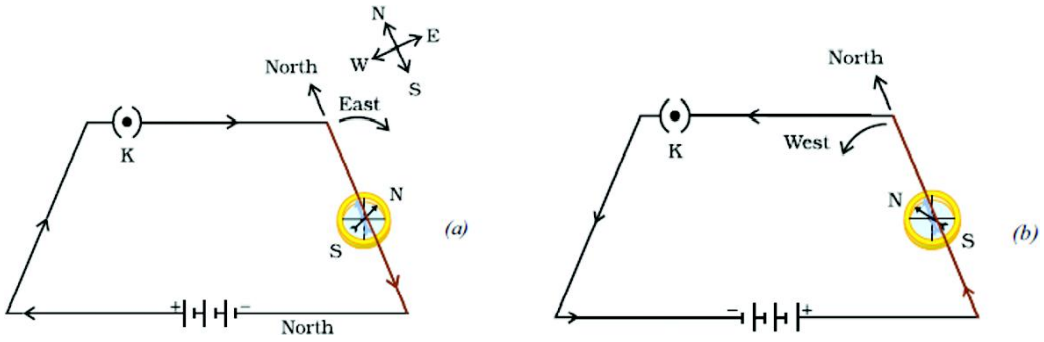
(v) Direction of field lines inside a magnet is from South to North.

(vi) The relative strength of magnetic field is shown by degree of closeness of field lines. Closer the lines, more will be the strength and farther the lines, less will be the magnetic field strength.

12.3 Right Hand Thumb Rule: Imagine you are holding a current carrying straight conductor in your right hand such that the thumb is pointing towards the direction of current. Then the fingers wrapped around the conductor give the direction of magnetic field.



12.4 Magnetic field due to a current-carrying conductor:



i) Observe the direction of deflection of the north pole of the needle. If the current flows from north to south, as shown in Fig. (a), the north pole of the compass needle would move towards the east.

ii) Replace the cell connections in the circuit as shown in Fig. (b). This would result in the change of the direction of current through the copper wire, that is, from south to north.

iii) Observe the direction of deflection of the south pole of the needle. If the current flows from south to north, as shown in Fig. (b), the south pole of the compass needle would move towards the west.

12.5 Magnetic field due to a current through a straight conductor:

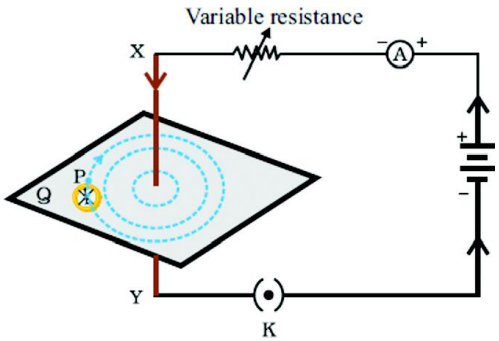
i) It can be represented by concentric circles at every point on conductor.

ii) Direction can be given by right hand thumb rule or compass.

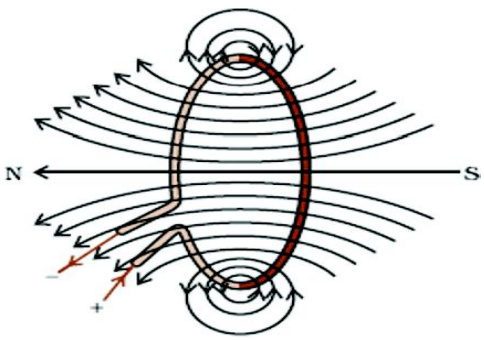
iii) Circles are closer near the conductor.

iv) Magnetic field $\propto$ Strength of current

v) Magnetic field $\propto$ 1 / Distance from the conductor.



12.6 Magnetic field due to a current through a circular loop:



i) It can be represented by concentric circles at every point.

ii) Circles become larger and larger as we move away.

iii) Every point on wire carrying current would give rise to magnetic field appearing as straight line at centre of the loop.

iv) The direction of magnetic field inside the loop is same.

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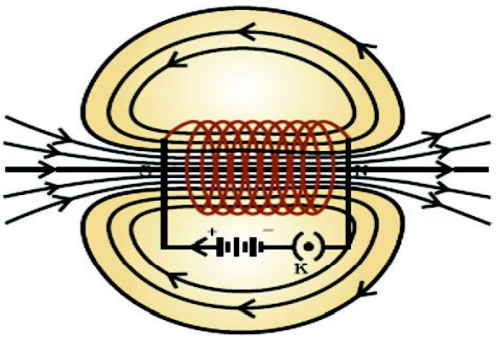
12.7 Magnetic field due to a current in a solenoid:



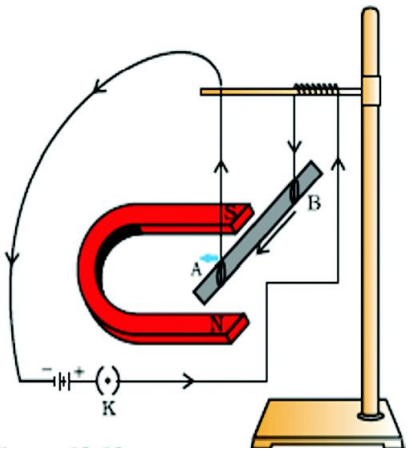
Solenoid is a coil of many circular turns of insulated copper wire wrapped closely in the shape of a cylinder. The end of the solenoid having clockwise current will act as south while on the other hand having anti-clockwise current will act as north pole.

Thus, a solenoid acts as a normal magnet. Direction of magnetic field

(i) Outside the solenoid : North to South

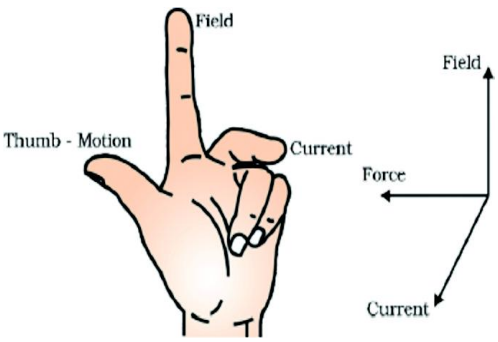
(ii) (ii) Inside the solenoid : South to North

12.8 Force on a current-current conductor in a magnetic field:



1. Place a strong horse-shoe magnet in such a way that the rod lies between the two poles with the magnetic field directed upwards. For this put the north pole of the magnet vertically below and south pole vertically above the aluminium rod.
2. Connect the aluminium rod in series with a battery, a key and a rheostat.
3. Now pass a current through the aluminium rod from end B to end A.
4. We observed that the rod is displaced towards the left and rod gets displaced.
5. Reverse the direction of current flowing through the rod and observe the direction of its displacement. It is now towards the right.

12.9 Fleming's left-hand rule:



Stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular. If forefinger points in the direction of magnetic field, middle finger in the direction of current then thumb will point in the direction of motion or force.

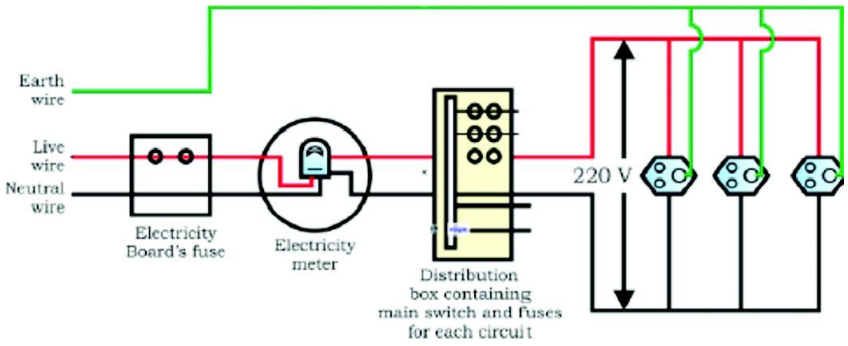
12.10 Domestic electric circuits: We receive electric supply through main supported through the poles. In our houses, we receive AC electric power of 220 V with a frequency of 50 Hz.

There are three kinds of wires used:

(i) Live wire (positive) with red insulation cover.

(ii) Neutral wire (negative) with black insulation cover.

(iii)Earth wire with green insulation cover.



Faults and Safety Measures in Domestic Electric circuit:

i) Short Circuiting : It is caused by touching of live wire and neutral wire either directly or via conducting wire.

ii) Overloading of an electric circuit : The overheating of electrical wire in any circuit due to flow of a large current through it is called overloading of the electrical circuit.

Safety measures:

i) Electric fuse : It is a protective device which is used for protecting the circuit from short-circuiting and overloading. It is a piece of thin wire of material having a low melting and high resistance. Fuse is always connected in series to live wire and works on the principal of heating effect.

ii) Earth wire : The metallic body of electric appliances is connected to the Earth by means of earth wire so that any leakage of electric current is transferred to the ground. This prevents any electric shock to the user