CHAPTER-12
MAGNETIC EFFECTS OF ELECTRIC CURRENT

Topic-1	**Magnetic Effects** **Concepts Covered • Magnetic field and Magnetic field lines • Magnetic fields due to current through a straight conductor • Magnetic field due to current through a circular loop • Magnetic field due to current in a Solenoid • Force on a current carrying conductor in a magnetic field • Right hand thumb rule • Fleming's left hand rule**

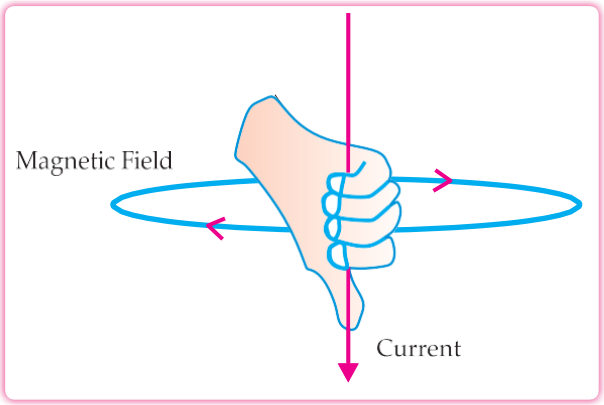
Revision Notes

Magnet:

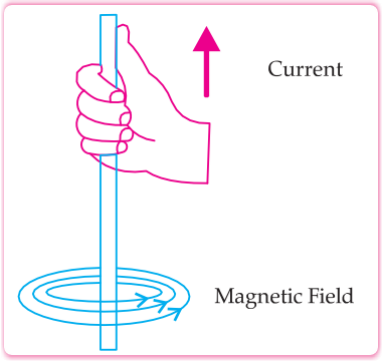
- The black ore of iron (Fe_3O_4) called magnetite, capable of attracting similar pieces of iron is called lodestone. They are naturally existing magnets used by human to find the directions.

- There are two poles of a magnet namely North pole and South pole. Like poles repel each other, while unlike poles attract each other.
- H.C. Oersted, a Danish physicist first noticed thet magnetic effect of electric current. According to him, a needle kept near the wire carrying current will deflect due to the magnetic field produced. Any change in the direction of current will show variation in the deflection.
- Magnet is any substance that attracts iron or iron-like substances.
- **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, with its north pole towards geographical south direction.

- The substances which are attracted by a magnet are called **magnetic substances**. **Examples:** Iron, nickel, cobalt, steel. The substances which are not attracted by a magnet are called **non-magnetic substances. Examples:** wood, glass, copper, aluminium, brass, paper etc.
- **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.
- **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.



Concept: Right Hand Thumb Rule
Mnemonics: When current move upwards, wrap magnetic field
Interpretations:



Concept: Direction of field lines
Mnemonics: O Maria **M**r. **F**ox is moving from **N**orth to **S**outh
Interpretation: Outside, **M**agnet, **M**agnetic, **F**ield, **N**orth, **S**outh

Magnetic Field Due to Current through a Straight Conductor

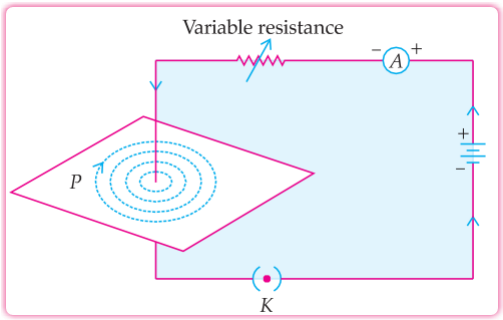
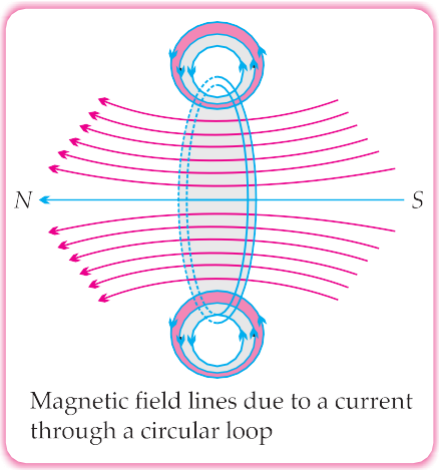


Fig : *A pattern of concentric circles indicating the field lines of a magnetic field around a straight conducting wire. The arrows in the circles show the direction of the field lines.*

- It can be represented by concentric circles at every point on conductor.
- Direction can be given by right hand thumb rule or compass.
- Circles are closer near the conductor.
- Magnetic field ∝ Strength of current
- Magnetic field $\propto \frac{1}{\text{Distance from the conductor}}$



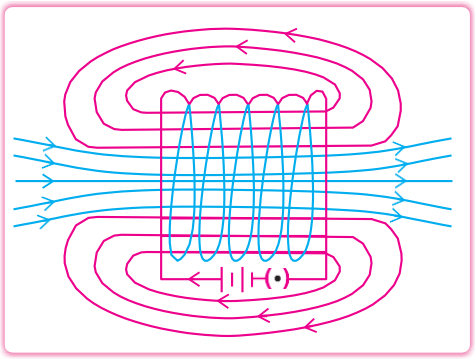
Magnetic field lines due to a current through a circular loop

- **Magnetic Field Due to Current through a Circular Loop**
  - It can be represented by concentric circles at every point.
  - Circles become larger and larger as we move away.
  - Every point on wire carrying current would give rise to magnetic field appearing as straight line at centre of the loop.
  - The direction of magnetic field inside the loop is same.
- **Factors affecting magnetic field of a circular current carrying conductor**

  (i) Magnetic field $\propto$ Current passing through the conductor

  (ii) Magnetic field $\propto \frac{1}{\text{Distance from conductor}}$

  (iii) Magnetic field $\propto$ No. of turns in the coil



- **Factors affecting magnetic field of a circular current carrying conductor**

- Magnetic field is additive in nature i.e., magnetic field of one loop adds up to magnetic field to another loop. This is because the current in each circular turn has same direction.
- The strength of magnetic field produced by a current carrying circular coil can be increased by

  (a) Increasing the number of turns of the coil.

  (b) Increasing the current flowing through the coil.
- **Magnetic field due to 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.

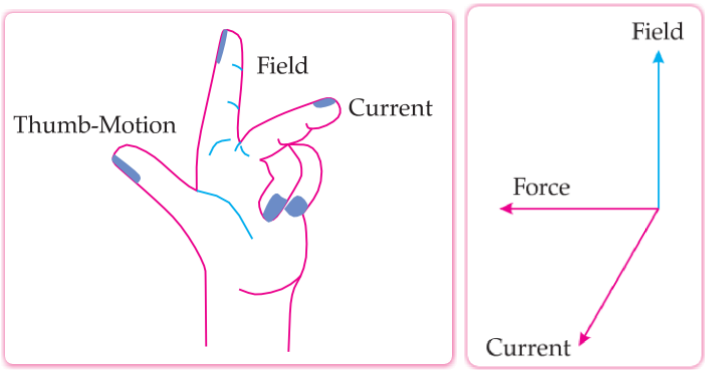
  Direction of magnetic field

  (i) Outside the solenoid : North to South

  (ii) Inside the solenoid : South to North
- **Permanent magnets:** They are made of carbon steel, chromium steel, tungsten steel and some alloys like Alnico and Nipermag. Alnico is an alloy of aluminium, nickel and cobalt. Nipermag is an alloy of iron that contains nickel, aluminium and titanium..
- When a material is placed inside a coil carrying current, it will get magnetised. A bunch of nails or an iron rod placed along the axis of the coil can be magnetised by the current when allowed to pass through the coil. Such magnets are called electromagnets.
- **Force on a current carrying conductor in a magnetic field :** Ampere suggested that when a current I passes through a conductor of length l placed in a perpendicular magnetic field B, then the force experienced is given by $F = IBl \sin\theta$, where θ is the angle between the length of the conductor and magnetic field.
- **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.

Key Facts

- Right hand thumb rule is a convenient way of finding the direction of magnetic field associated with current carrying conductor.
- Many devices such as electric motor, electric generator, loudspeaker etc. work on Fleming's left Hand rule.



Fleming's left hand rule

Topic-2 Domestic Electric Circuits

Concepts Covered • **Direct current and alternating current,** • **Domestic electric circuits.**

Revision Notes

- Direct Current (DC) and Alternating Current (AC)
  (i) Alternate current (AC) : The current which reverses its direction periodically. In India, most of the power stations generate alternate current. The direction of current changes after every 1/100 second in India. i.e., Frequency= 1/ Time period
  = 1/50 Hz
  (ii) Direct Current (DC) : The current which does not reverse its direction and flows in one direction is called direct current. Source of DC are cell, battery, and storage cells. DC can be stored. Loss of energy during transmission over long distance is high.
- **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.

Mnemonics

Concept: Electrical wiring
Mnemonics: **R**are **L**awn **B**eautiful **N**ature **G**reen **E**arth
Interpretation: Red: Live; **Black:** Neutral; **Green:** Earth

- An electric circuit consists of three main wiring components:
  (i) Live wire (positive) with red insulation cover.
  (ii) Neutral wire (negative) with black insulation cover.
  (iii) Earth wire with green insulation cover. It protects us from electric shock in case of leakage of current especially in metallic body appliances. It provides a low resistance path for current in case of leakage of current.
- **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 are :**
  (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.

Key Fact

The potential difference between live and neutral wire in India is 220 V.