Gujarat Technological University

Diploma in Electrical Engineering

Semester-1

D C Circuits - 4310901

www.vishaldevdhar.org

Vishal D Devdhar

Lecturer

Electrical Engineering Department

Government Polytechnic, Rajkot

Unit – 5
Magnetism
&
Electromagnetism

Topics

- Compare magnetic circuit with electric circuit
- Apply laws of electromagnetism to determine direction of flux, magnetic force, induced emf, flux density and field strength
- State Faraday's laws of electromagnetic induction, Flemings right- and left-hand rule and Lenz's law
- Compute equivalent inductance in various series-parallel combinations
- State applications of the given type of inductor
- Calculate the energy stored in the given inductor

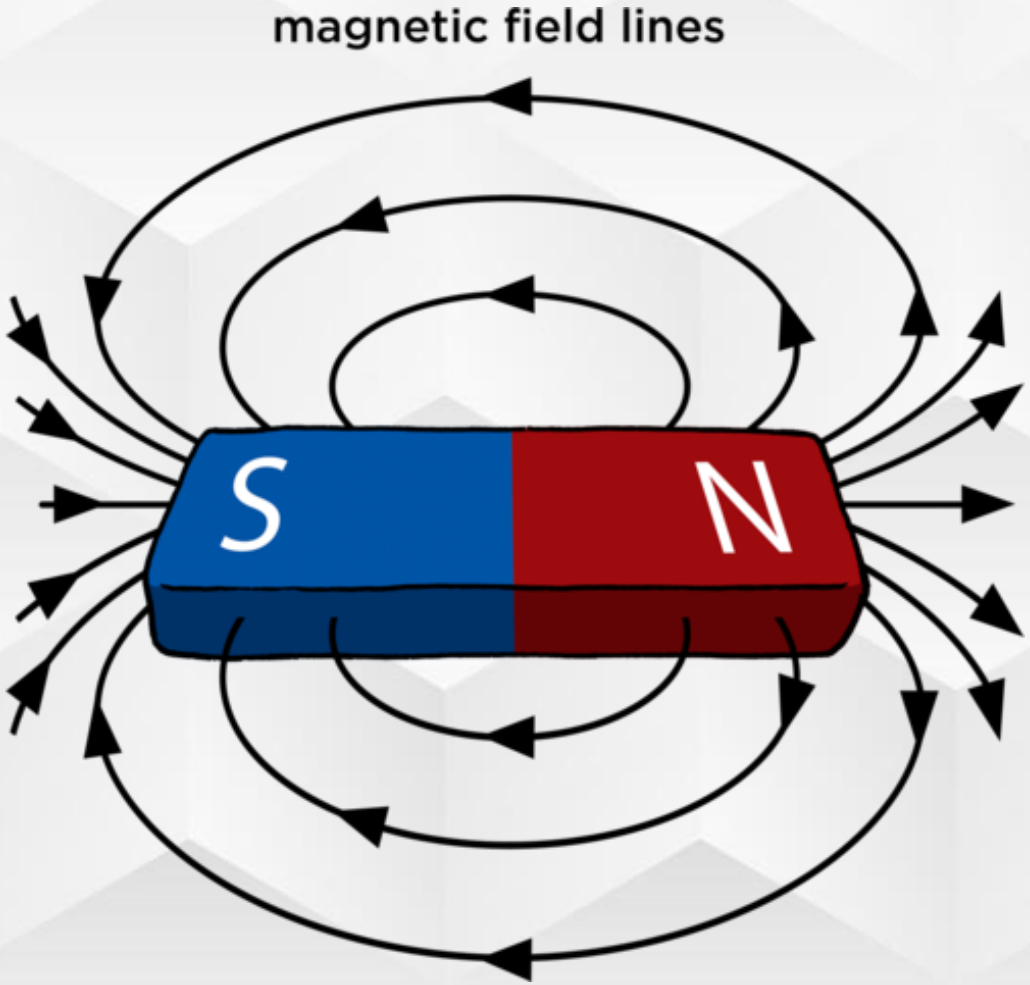
Magnet & Magnetic Materials

Magnet :

A substance that attracts pieces of iron and steel is called magnet

Magnetism :

Property of a magnet is called magnetism



Magnet & Magnetic Materials

Magnetic Material :

Those substance which are attracted by magnet are called magnetic materials

- **Iron, steel, nickel, cobalt**

Iron

Steel

Nickel

Cobalt

Non-Magnetic Material :

Substance which do not exhibit magnetic properties are known as non-magnetic materials

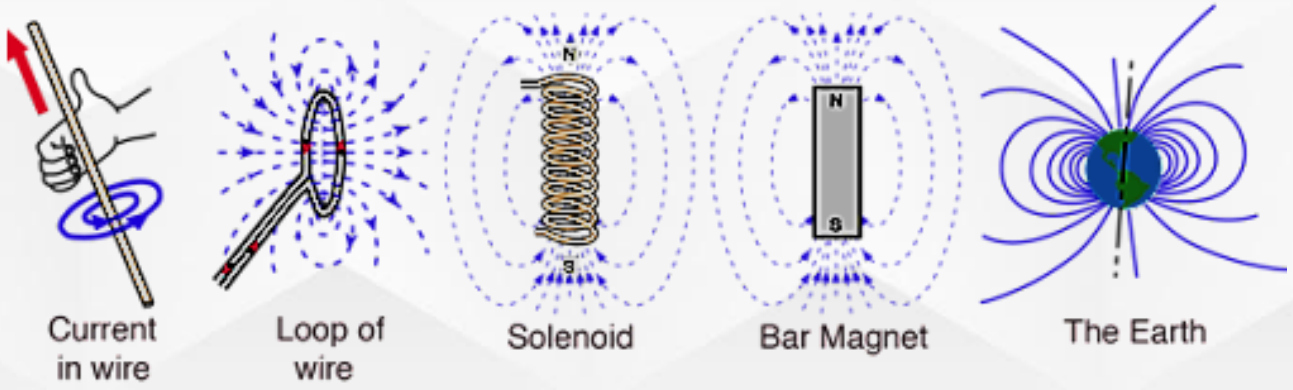
- **Wood, Copper, Rubber**

Wood

Copper

Rubber

Type of Magnets



Permanent Magnet :

Materials when magnetize retain their magnetic property indefinitely are called Permanent magnets.

- **Hardened steel, cobalt steel, tungsten steel**
- **No exciting coil needed**
- **Not controllable**

Temporary (Electro) Magnet :

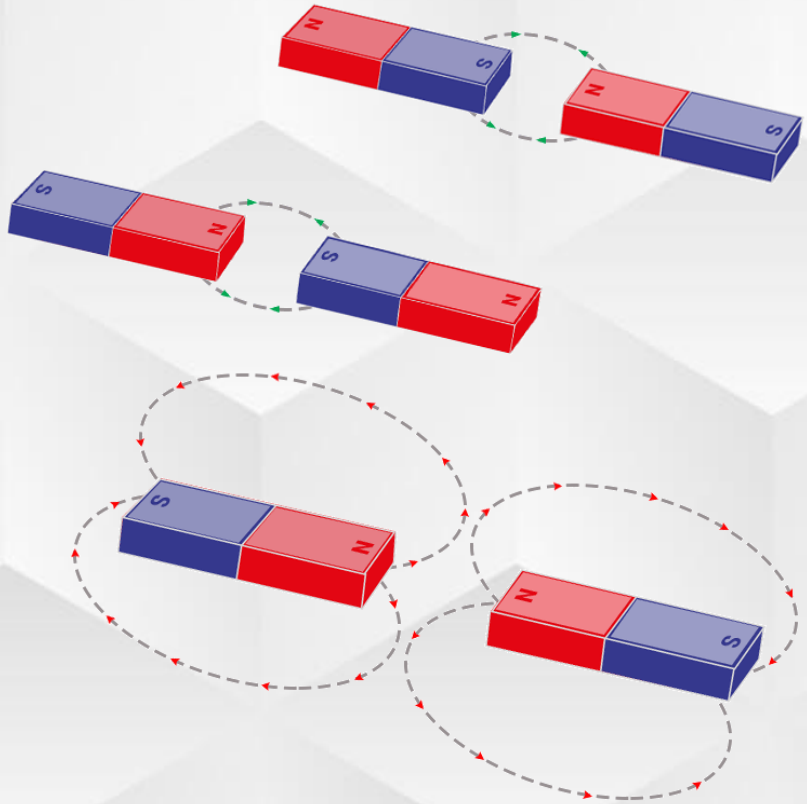
Materials which do not retain their magnetizing property when magnetization is removed are called temporary magnets.

- **Iron, soft steel, nickel**
- **Controllable**

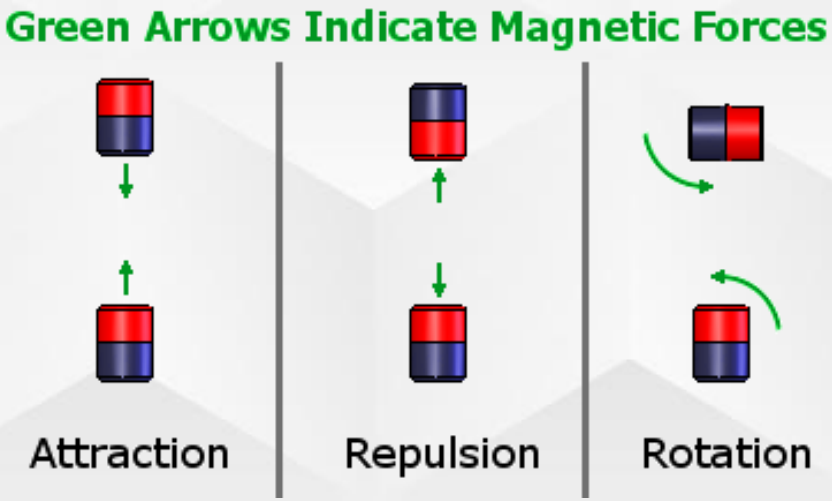
Poles of a Magnet

The end of a bar magnet are known as poles of a magnet:

- **The poles of a magnet are not separated**
- **The poles of a magnet are of equal strength *m***
- **Like pole repel other & unlike pole attract each other**



Laws of Magnetic Force

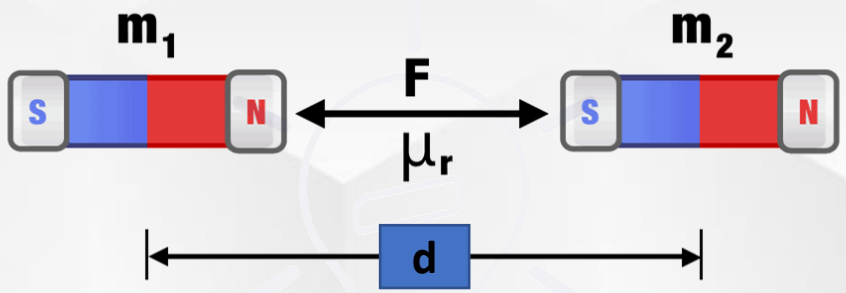


Charles Coulomb's Laws of Magnetic Force:

- ***First Law***

Like pole repel other & unlike pole attract each other.

Laws of Magnetic Force



Charles Coulomb's Laws of Magnetic Force:

- ***Second Law***

The force between two magnetic poles is directly proportional to the product of their pole strength and inversely proportional to the square of distance between their centers.

$$F \propto \frac{m_1 m_2}{d^2}, \qquad F = K\frac{m_1 m_2}{d^2}$$

$$K = \frac{1}{4\pi\mu_0\mu_r}$$

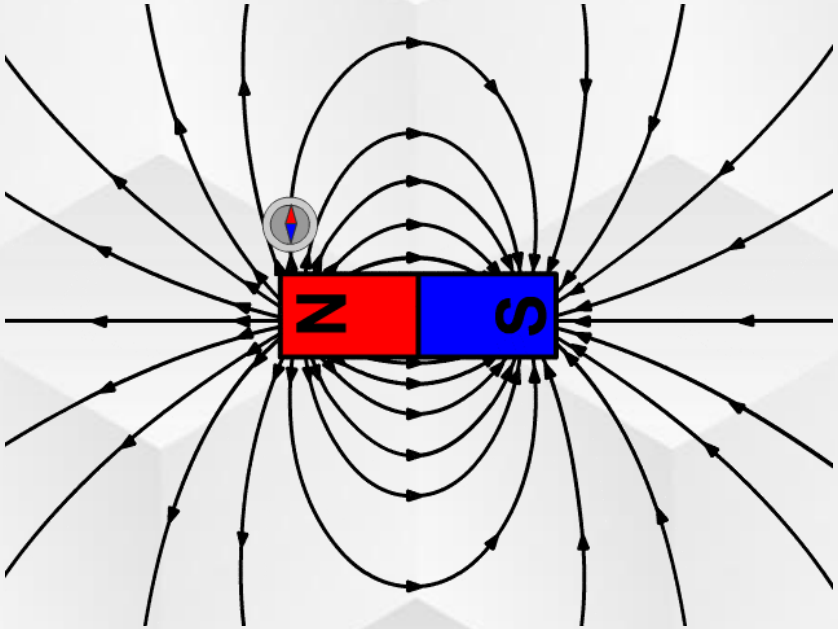
$$\mu_0 = 4\pi \times 10^{-7}\ H/m$$

$$\mu_0 = Absolute\ permeability\ of\ Air\ or\ Vaccum$$

$$\mu_r = Relative\ permeability\ of\ surrounding\ medium$$

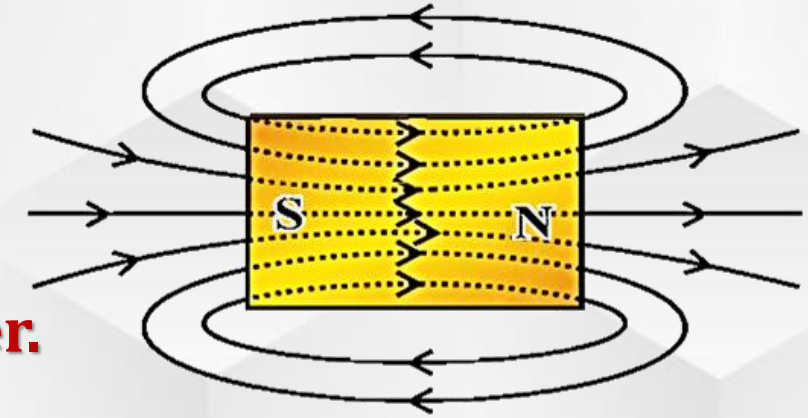
Magnetic Field

- The space in which a magnetic pole experience a force is called a magnetic field.
- The magnetic field around a magnet is represented by imaginary lines called magnetic lines of force.
- The magnetic field is a vector quantity, it has magnitude & direction.



Properties of Magnetic Field Lines

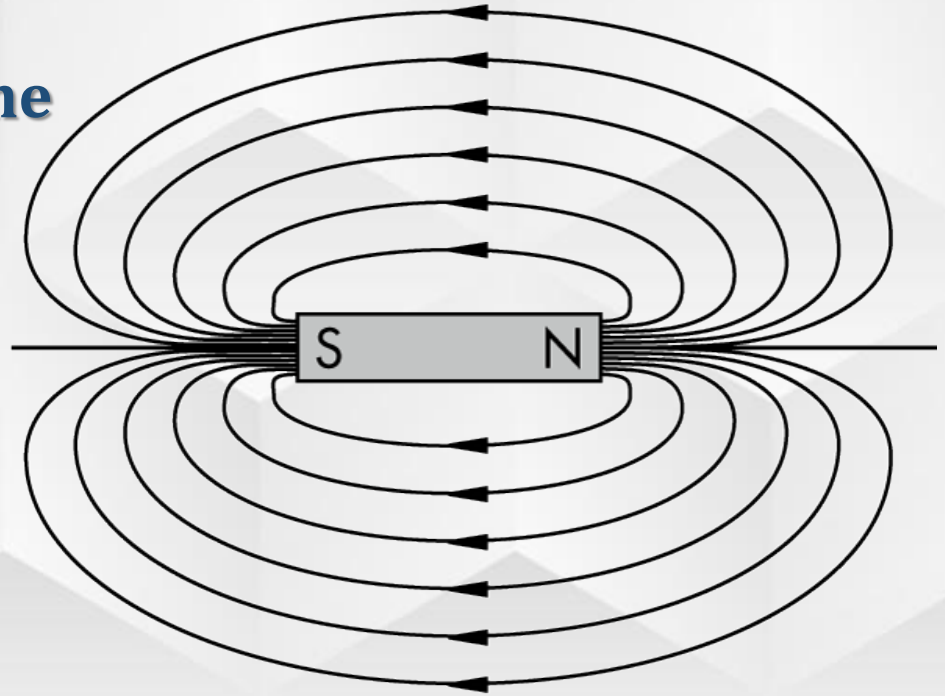
- Magnetic field lines of a bar magnet starts from North(N) pole and reach to South(S) pole, inside the magnet each line of force passes from S-pole to N-pole.
- Magnetic field lines forms a close loop.
- Magnetic field lines do not intersect each other.



- The portion of the curve within the magnetic material is called line of induction.

Magnetic Flux (∅)

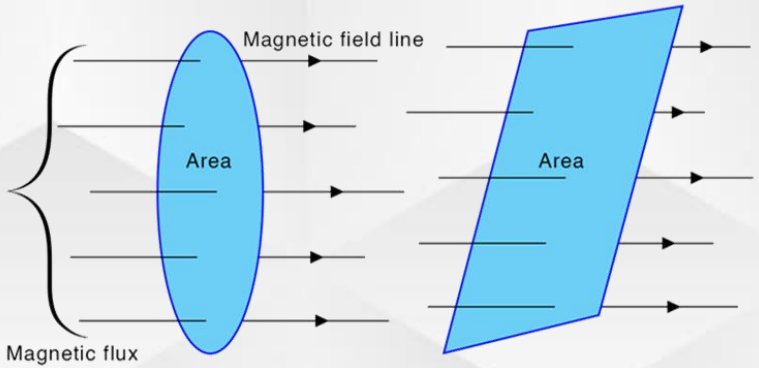
- **The amount of magnetic field produced by a magnetic source is called Magnetic Flux.**
- **To identify magnetic field quantitatively the term magnetic flux is used.**
- **Symbol = ∅**
- **Unit = Weber**
- **$1\ \text{Wb} = 10^8\ lines$**



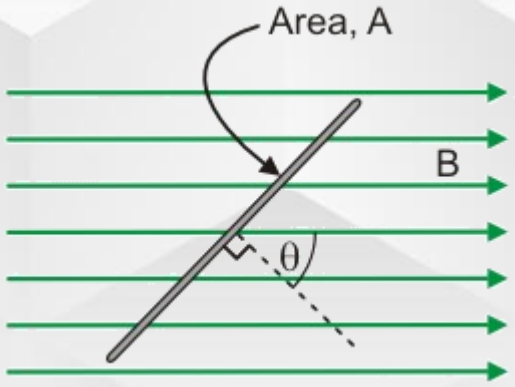
Magnetic Flux Density (B)

- **Magnetic flux passing per unit area through any material through a plane right angles to the direction of flux.**

- **Symbol = B**
- $B = \frac{\emptyset}{A}$
- **Unit =Wb/m^2**
- $\emptyset$ **= flux in Wb**
- **A=area in m^2 normal to flux**



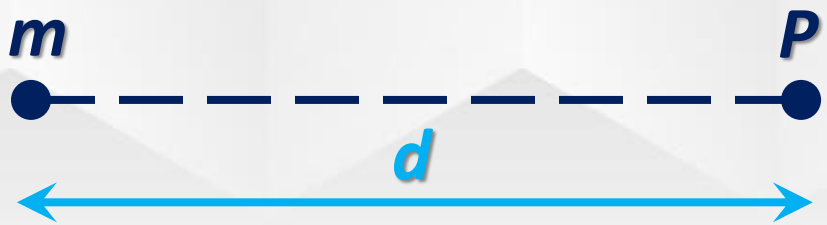
$\emptyset = B\,A$ Wb



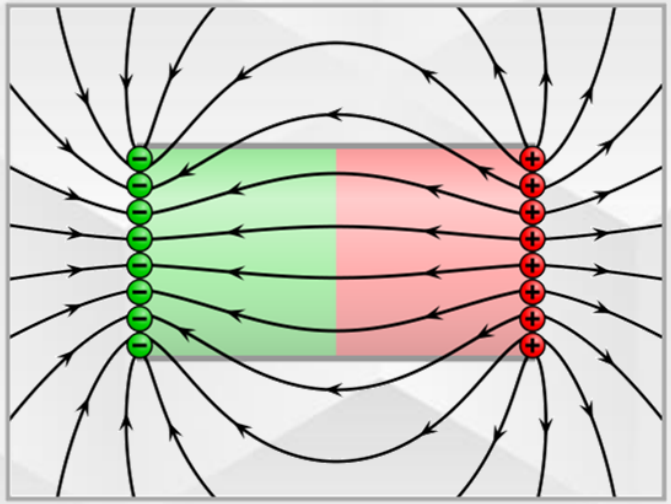
$\emptyset = B\,A \sin\theta$ Wb

Magnetic Field Intensity/Strength (H)

- **Magnetic field intensity at a point in a magnetic field is the force acting on a unit *n*-pole placed at the point.**
- **The magnetic field Intensity is a vector quantity, it has magnitude & direction.**



- **Symbol = H**
- **Unit = Newtons/Weber**



$\vec{H}$

- $H = \frac{m \times 1}{4 \pi \mu_0 d^2} = \frac{m}{4 \pi \mu_0 d^2}$ N/Wb
- **Force acting on pole, $F = m H$ Newtons**

Permeability (μ)

- **Permeability of a material is the conductivity for magnetic flux of that material**
- **Absolute permeability μ_0 of air/vacuum is $4\pi\times10^{-7}\ H/m$**
- **The absolute permeability of magnetic material is grater than μ_0**
- **The ratio μ/μ_0 is called relative permeability**

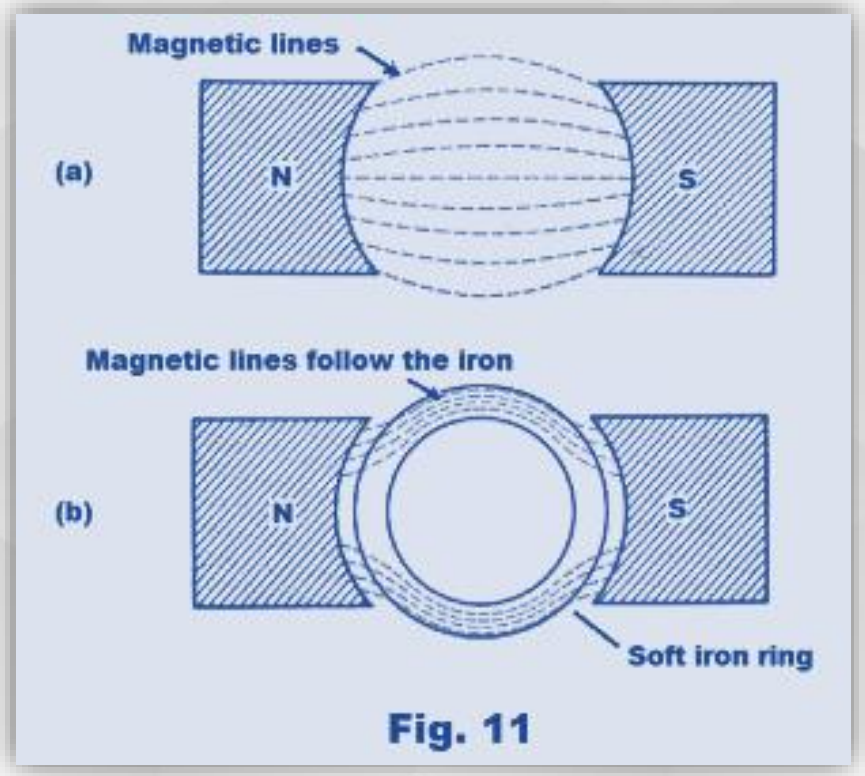


Fig. 11

Relation between B & H

- **The flux density B produced in a material is directly proportional to the applied magnetizing force H**
- ***Relative Permeability*** **(*μ_r*) of a material is the ratio of flux density produced in that material to the flux density produced in air by the same magnetizing force.**

$$B \propto H$$

$$B = \mu H$$

$$B = \mu_0 \mu_r H$$

$$B = \mu_0 H$$

$$\frac{B_{mat}}{B_0} = \frac{\mu_0 \mu_r H}{\mu_0 H} = \mu_r$$

Relative Permeability (μ_r)

- **Permeability of a material is the conductivity for magnetic flux of that material**
- **Absolute permeability μ_0 of air/vacuum is $4\pi\times10^{-7}\ H/m$**
- **The absolute permeability of magnetic material is grater than μ_0**
- **The ratio μ/μ_0 is called relative permeability**

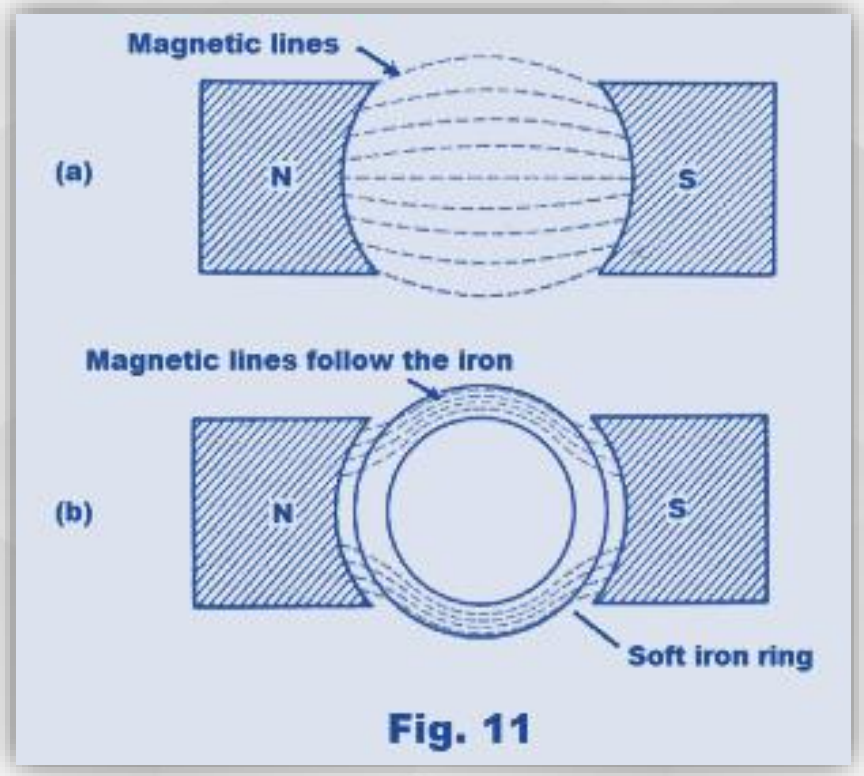
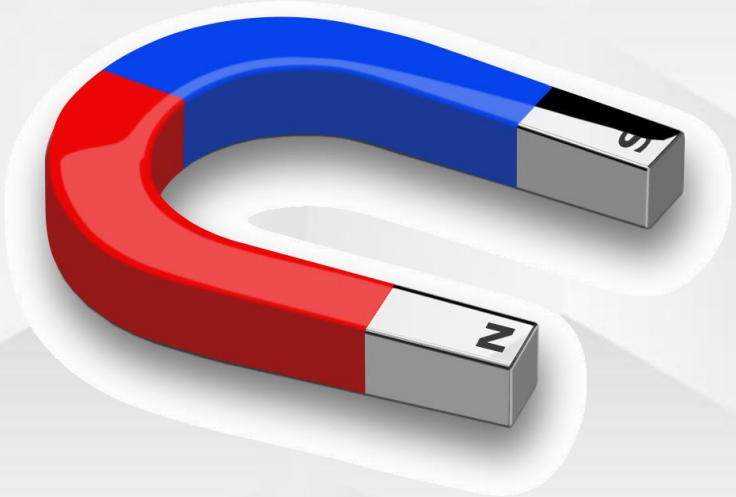


Fig. 11

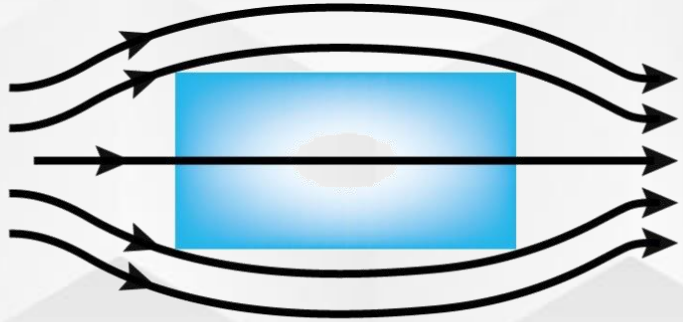
Magnet & Magnetic Material

- **Substance that attracts the piece of iron and steel is called a magnet and the property of the material is known as magnetism.**
- **The substances which are attracted by magnets are called magnetic materials.**



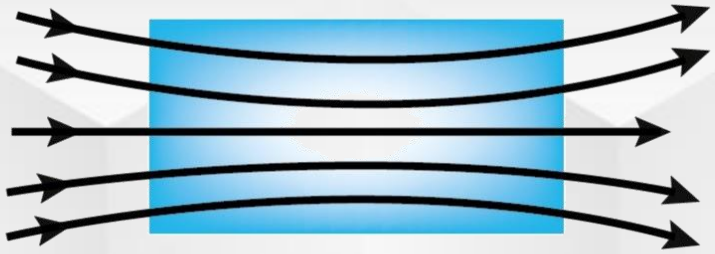
Types of Magnetic Materials

- **Diamagnetic - Copper, Zinc, Bismuth**
  - Substances that are weakly magnetised in the direction opposite to that of applied field are called diamagnetic materials.
  - Weakly repelled by strong magnet.



Magnetic Field lines through Diamagnetic material

- **Paramagnetic – Aluminum, Antimony, Oxygen**
  - Substances weakly magnetised in the direction of the applied field are known as magnetic materials.
  - Weakly attracted by a strong magnet.



Magnetic Field lines through paramagnetic material

Types of Magnetic Materials

- **Ferromagnetic – Iron, Cobalt, Nickel**
  - **Substances that are strongly magnetised in the direction of the applied magnetic field are known as ferromagnetic materials.**
  - **Strongly attracted by a magnet.**

References

Basic Electrical Engineering

by

V. K. Mehta

Thank You

www.vishaldevdhar.org

Vishal D Devdhar

Lecturer

Electrical Engineering Department

Government Polytechnic, Rajkot