DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PYB101J-Electromagnetic Theory, Quantum Mechanics, Waves and Optics

Module 2 Lecture-1

Magnetization, permeability and susceptibility – Definitions & relations and Classification of magnetic materials

- **Introduction**

Magnetic materials

- Magnetic materials are the materials, which get magnetized in a magnetic field. These materials are having the ability to create a self magnetic field in the presence of external magnetic field.

Important magnetic materials

- Diamagnetic,
- Paramagnetic,
- Ferromagnetic,
- Antiferromagnetic
- and Ferrimagnetic materials.

Angular momentum of an atom

1. **Orbital angular momentum of the electrons**

   This corresponds to permanent orbital angular magnetic dipole moments.

2. **Electron spin angular momentum**

   This corresponds to electron spin magnetic moments.

3. **Nuclear spin angular momentum**

   This corresponds to nuclear magnetic moments.

Basic Definitions

Magnetic dipole

Any two opposite magnetic poles separated by a distance ‘d’ constitute a magnetic dipole

Magnetic dipole moment

If m is the magnetic pole strength and *l* is the length of the magnet, then its dipole moment is given by $\mu_m = m \times l$

When an electric current of 'i' amperes flows through a circular wire of 1 turn having an area of cross section 'a' m^2, then it is said to have a magnetic moment of,

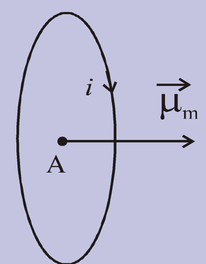

Fig. Magnetic moment

$\mu_m = i \times a$,   Unit: ampere $(\text{metre})^2$

Magnetic Flux

Total number of magnetic lines of force passing perpendicular through a given area. Unit: weber.

Magnetic flux density or Magnetic Induction (B)

Number of magnetic lines of force passing through an unit area of cross section. $B = \Phi/A$ Tesla

It is also defined as the magnetic forec F experienced by an unit north pole placed at the given point in a magnetic field $B = F/m$

Magnetic field strength or Magnetic field intensity (H)

Magnetic field intensity or magnetic field strength at any point in a magnetic field is equal to $\left(\frac{1}{\mu}\right)$ times the force acting on a unit north pole placed at the point.

Magnetization or Intensity of Magnetization (M)

Intensity of magnetization (M) is defined as the magnetic moment per unit volume. It is expressed in ampere/metre.

Magnetic susceptibility

It is the measure of the ease with which the specimen can be magnetized by the magnetizing force. It is defined as the ratio of magnetization produced in a sample to the magnetic field intensity. i.e. magnetization per unit field intensity. $\chi = M/H$

Magnetic permeability

It is the measure of degree at which the lines of force can penetrate through the material. It is defined as the ratio of magnetic flux density in the sample to the applied magnetic field intensity.

$\mu = \mu_0\mu_r = B/H$

Relative permeability

It is the ratio of permeability of the medium to the permeability of free space.

i.e. $\mu_r = \frac{\mu}{\mu_0}$

Relation between μ_r and χ

When a magnetic material is kept in a magnetic field (H), then two types of lines of induction passes through the material.

One is due to the magnetic field (H) and the other one is due to self-magnetization of the material itself.

Total flux density (B) in a solid can be given as,

$$B = \mu_0(H+M) \qquad (1)$$

$$\mu = \frac{B}{H} \; (or) \qquad B = \mu H \qquad (2)$$

Equating (1) and (2), we get,

$$\mu H = \mu_0(H+M) = \mu_0 H + \mu_0 M$$

$$\mu_0 \mu r H = \mu_0 H + \mu_0 M \qquad [\square \; \mu = \mu_0 \mu_r]$$

$$\mu_r = \frac{\mu_0 H}{\mu_0 H} + \frac{\mu_0 M}{\mu_0 H} = 1 + \frac{M}{H} \qquad i.e. \quad \mu_r = 1 + \chi$$

Bohr Magneton (μB)

Bohr magneton is the magnetic moment produced by one unpaired electron in an atom.

1 Bohr magneton = eh/4лm

$1\mu B = 9.27 \times 10^{-24}$ ampere metre ^{2}

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Thank you