1. MAGNETISM

SYNOPSIS

I. MAGNETIC MOMENT :

Magnet: A piece of matter, which when suspended freely rests itself in a particular direction (north-south) and which possesses a net magnetic moment and which attracts pieces of fernomagnetic materials like Iron, Cobalt, Nickel etc towards it, is called a magnet

i) **Natural Magnets :**

a) The magnet which is found in nature is called a natural magnet e.g. magnetite. (Fe_3O_4).

ii) **Artificial magnets:**

The magnets which are artificially prepared are known as artificial magnets. These are generally made of iron, steel and nickel.

✧ **Magnetic poles:**

i) If a piece of magnet is dipped in iron filings, they cling to it, especially at certain points. These points are called the poles of the magnet

ii) If a bar-shaped permanent magnet (or) bar magnet is free to rotate, one end points north. This end is called north-seeking end north pole (or) N-pole. The other end is a south pole (or) S-pole.

iii) Unlike poles attract each other and like poles repel each other

iv) Earth is also a big magnet. Its geographical north pole is close to magnetic south pole. Its geographical south pole is close to its magnetic north pole.

v) The two poles of the magnet generally are of equal strength and near the ends of the magnet.

vi) The straight line joining the two poles of a bar magnet is called axial line.

vii) The line passing through the midpoint normal to the axial line is called equatorial line.

viii) The vertical plane passing through the magnetic axis of a freely suspended bar magnet is called magnetic meridian

ix) The distance between the two poles of a magnet is called magnetic length of a magnet. It is generally represented as '$2l$'

x) Magnetic length = 5/6 x geometric length.

✧ **Magnetic moment (M) :**

i) It is measured as the product of magnetic length and pole strength $\boxed{M = 2\ell \times m}$.

ii) It is a vector with its direction from south pole to north pole along its axial line ($S \rightarrow N$)

✧ **Magnet divided into parts :**

i) When a bar magnet is cut into 'n' equal parts parallel to its axis

a) Pole strength of each part = $m^1 = m/n$

b) Length of each part = $(2l)^1 = 2l$

c) Magnetic moment of each part $\boxed{M^1 = M/n}$

ii) When a bar magnet is cut into 'n' equal parts normal to its axis

a) Pole strength of each part $m^1 = m$

b) Length of each part $(2l)^1 = 2l/n$

c) Magnetic moment of each part $\boxed{M^1 = M/n}$

iii) When a bar magnet is cut into 'xy' equal parts x parts parallel to its axis and y parts normal to the axis.

a) Pole strength of each part $m^1 = \frac{m}{x}$

b) Length of each part $(2\ell)^1 = 2\ell/y$

c) Magnetic moment of each part $\boxed{M^1 = M/xy}$

✧ Resultant magnetic moment :

i) When two magnets of magnetic moments M_1 and M_2 are kept at an angle 'θ' with like poles touching each other, then the resultant magnetic moment $\boxed{M^1 = \sqrt{M_1^2 + M_2^2 + 2M_1M_2\,\mathrm{Cos}\theta}}$

ii) When two magnets of magnetic moments M_1 and M_2 are kept at an angle 'θ' with unlike poles touching each other, then the resultant magnetic moment $\boxed{M^1 = \sqrt{M_1^2 + M_2^2 - 2M_1M_2\,\mathrm{Cos}\theta}}$

iii) When two magnets of magnetic moments M_1 and M_2 are placed one above the other with like poles touching each other (or) placed side by side with unlike poles touching each other then $M^1 = M_1 + M_2\ (\theta = 0^0)$

iv) When two magnets of magnetic moments M_1 and M_2 are placed one above the other with unlike poles touching each other (or) placed side by side with like poles touching each other then $M^1 = M_1 \sim M_2\ (\theta = 180^0)$

v) When 'n' identical bar magnets form a closed polygon with unlike poles nearer, the resultant magnetic moment is zero.

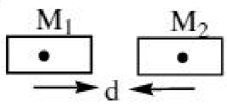
✧ Bending of magnets :

i) When a thin bar magnet of magnetic moment 'M' and length '2ℓ' is bent at its mid point with an angle 'θ' between the two parts (a) its effective length becomes $2\ell\sin\frac{\theta}{2}$ (b)its new magnetic moment $\boxed{M^1 = M\sin(\theta/2)}$

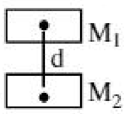
ii) When a Magnetised wire of length '2ℓ' and magnetic moment 'M' is bent in to an arc of a circle, that makes an angle 'θ' at the centre of the circle.

Its magnetic moment decreases and becomes $\boxed{M^1 = \left[\frac{2M\mathrm{Sin}(\theta/2)}{\theta}\right]}$ where θ is in radian

Note: i) Force between two co-axial magnetic dipoles $\boxed{F = \frac{\mu_0}{4\pi}\frac{6M_1M_2}{d^4}}$



ii) The force between two parallel magnets $\boxed{F = \frac{\mu_0}{4\pi}\frac{3M_1M_2}{d^4}}$



* **Coulomb's inverse square law :**

i) The force between two isolated magnetic poles air or vacuum are $\boxed{F = \frac{\mu_0}{4\pi}\frac{m_1 m_2}{d^2}}$

The force between two isolated magnetic poles any medium is $\boxed{F = \frac{\mu}{4\pi}\frac{m_1 m_2}{d^2}}$

ii) Where μ is the absolute permeability of the medium between the poles. $\mu = \mu_0\mu_r$,

iii) Relative permeability of the medium $(\mu_r) = \frac{\text{Permeability of the medium}}{\text{Permeability of air or vacuum}} = \frac{\mu}{\mu_0}$

✧ Resultant force in different cases :

i) Force on a magnetic pole due to other poles surrounding it can be found by the principle of super position. i.e. by the vector sum of the individual forces on it due to surrounding poles.

ii) Two magnetic poles of same strength (m) are placed at two vertices of an equilateral triangle of side 'a' the force on a similar magnetic pole on third corner is given by $\boxed{F^{1} = \sqrt{3}\frac{\mu_0}{4\pi}\frac{m^2}{a^2}}$

iii) Two unlike magnetic poles of same strength (m) are placed at two vertices of an equilateral triangle of side 'a'. If a north pole of same strength is placed at the thirdvertex, it experiences a force of magnitude which is given by $\boxed{F^{1} = \frac{\mu_0}{4\pi}\frac{m^2}{a^2}}$

iv) Four like poles each of pole strength 'm' are kept at the four cornes of a square of side 'a'. The net magnetic force on the pole at any one corner is given by
$$\boxed{F^{1} = \frac{\mu_0}{4\pi}\frac{m^2}{a^2}\left[\sqrt{2}+\frac{1}{2}\right]}$$

II) MAGNETIC FIELD INDUCTION :

The space (or) region in which a magnetic pole will experience force.

i) Like in electric field, the intensity of Magentic induction at a point in a magnetic field is defined as force experienced by a unit north pole placed at that point in magnitude as well as direction $\boxed{\vec{B} = \frac{\vec{F}}{m}}$

ii) The magnetic field due to an isolated north pole is $B = \frac{\mu_0}{4\pi}\frac{m}{d^2}$. The direction is away from the north pole and the direction due to south pole is towards it.

iii) Magnetic induction field strength at a point due to a number of poles can be found by the principle of superposition i.e. at a point field is vector sum of magnetic induction field strengths due to individual poles.

iv) Three identical magnetic poles each of strength 'm' placed at the three vertices of an equilateral triangle. The resultant magnetic induction at the centre is equal to zero

v) The magnetic induction at the centre of the line joining the two poles of a horse shoe magnet of pole strength 'm' and separated by a distance 'd' is

$\boxed{B = 8\frac{\mu_0}{4\pi}\frac{m}{d^2}}$ direction from N to S pole

vi) When a pole of pole strength m is placed in a magnetic field of induction $\vec{B}$,the force $\vec{F}$ experienced by it 1is given by $\boxed{\vec{F} = m\vec{B}}$

✧ Magnetic lines of force :

i) A magnetic line of force is the path followed by a free unit north pole in a magnetic field.

ii) Magnetic field can be represented by magnetic lines of force. They are imaginary.

iii) They diverge from north pole and converge at south pole.

iv) Two magnetic lines of force never intersect; If they intersect it means that field has two directions at the point of intersection which is impossible.

v) Inside the magnet they are from south pole to north pole. Outside the magnet they are from north pole to south pole. They are closed curves.

vi) They contract longitudinally and expand laterally.

vii) The tangent at any point to the line of force gives the direction of magnetic induction field strength at that point.

viii) If lines of force are crowded it implies a stronger field and weak if they are far apart

ix) Magnetic lines of force pass through the magnetic substance of the magnet. Electric lines do not pass through a conductor.

x) Magnetic lines of force are closed curves where as electric lines of force are open curves

✧ **Uniform magnetic field :**

i) The magnetic field, in which the magnetic induction field strength is same both in magnitude and direction at all points, is known as uniform magnetic field.

✧ **Non uniform magnetic field :**

i) The magnetic field, in which the magnetic induction or field strength differs either in magnitude, in direction or both is known as non uniform magnetic field.

* **Magnetic Flux :** Magnetic flux (ϕ) linked through a cross section is defined as dot product of $\vec{B}$ and $\vec{A}$ $\boxed{\phi = \vec{B}.\vec{A} = BA\cos\theta}$

✧ **Magnetic induction due to a bar magnet:**

* **Field on axial line :**

i) B at a point 'p' on the axial line of a bar magnet at a distance 'd' from the centre of the magnet is

$$\boxed{B_a = \frac{\mu_0}{4\pi}\frac{2Md}{(d^2 - l^2)^2}}$$

ii) In case of short bar magnet ($\because l << d$) $\boxed{B_a = \frac{\mu_0}{4\pi}\frac{2M}{d^3}}$

* **Field on equatorial line :**

i) B at a point 'p' on the equatorial line of a bar magnet at a distance 'd' from centre of the magnet is

$$\boxed{B_e = \frac{\mu_0}{4\pi}\frac{M}{\left(d^2 + l^2\right)^{\frac{3}{2}}}}$$

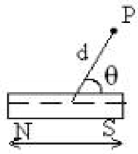
ii) In case of short magnet $\boxed{B_e = \frac{\mu_0}{4\pi}\frac{M}{d^3}}$ ($\because l<<d$)

iii) The ratio of fields on the axial and equatorial lines of a short bar magnet is $\frac{B_{axial}}{B_{equitorial}} = 2$

NOTE: Magnetic induction at a point 'p' and whose position vector from the mid point of the magnet makes an angle θ with magnetic axis is given by $\boxed{B = \frac{\mu_0}{4\pi}\frac{M}{d^3}\sqrt{1+3\cos^2\theta}}$

Case -I: If $\theta = 0^0$ $B = \frac{\mu_0}{4\pi}\frac{2M}{d^3}$ (Axial line)

Case -II: If $\theta = 90^0$ $B = \frac{\mu_0}{4\pi}\frac{M}{d^3}$ (equatorial line)



* **Neutral points or Null points :**

i) A point where magnetic induction field strength is zero is called null point.

ii) If two poles of pole strengths m_1 and m_2 ($m_1<m_2$) are seperated by distance d, then the distance of the neutral point from the first pole m_1 is

$$\boxed{x = \frac{d}{\sqrt{\frac{m_2}{m_1}} \pm 1}} \quad \begin{pmatrix} \text{+ for like poles} \\ \text{- for unlike poles} \end{pmatrix}$$

iii) If two short bar magnets of magnetic moments $M_1$and M_2 ($M_1 < M_2$) are placed along the same line with like poles facing eachother and 'd' is the distance between their centres, the distance of null point from M_1 is

$$\boxed{x = \frac{d}{\left(\frac{M_2}{M_1}\right)^{1/3} \pm 1}}$$

iv) When a short bar magnet is placed in the earth's magnetic field with its north pole towards geographic north, then two null points are formed on the equatorial line, one on either side at equal distances from mid point of the magnet.

At the null point $\vec{B} = -\vec{B}_H$ $\boxed{B_H = \frac{\mu_0}{4\pi}\frac{M}{d^3}}$

v) When a short bar magnet is placed in earth's field with south pole pointing geographic north, then two null points are formed on axial line one on either side at equal distances from mid point of the magnet..

At the null point $\vec{B} = -\vec{B}_H$ $\boxed{B_H = \frac{\mu_0}{4\pi}\frac{2M}{d^3}}$

vi) a) If a very long magnet is placed vertically with one pole on the table then a single neutral point will be formed

b) If 'm' is the polestrength and 'd' is the distance from the pole of the magnet where the neutral point is formed then $\boxed{B_H = \frac{\mu_0}{4\pi}\frac{m}{d^2}}$

c) If the north pole is on the table, then the neutral point lies towards geographic south.

d) If the south pole is on the table, then the neutral point lies towards geographic north.

III) COUPLE & TORQUE, POTENTIAL ENERGY, WORKDONE :

i) When a magnet with magnetic moment M is suspended in a uniform field of induction B at an angle θ with the field direction then the couple (C) acting on the magnet is given by $\boxed{C = MB\sin\theta}$

Vectorially $\boxed{\vec{C} = \vec{M} \times \vec{B}}$

Case – I : When $\theta = 90^0$, C is maximum $\left|\vec{C}_{max}\right|$ =MB.

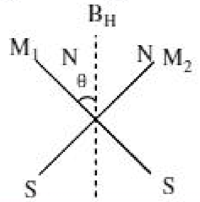
Case -II: When θ = 0° (or) 180^0 $\left|\vec{C}_{min}\right| = \vec{O}$

ii) In an uniform magnetic field a bar magnet experiences only a couple but no net force. Therefore it undergoes only rotatory motion.

iii) In a non-uniform magnetic field a bar magnet experiences a couple and also a net force. So it undergoes both rotational and translational motion.

iv) Two magnets of magnetic moments M_1 and M_2 are joined in the form of a cross and this arrangement is pivoted so that it is free to rotate in a horizontal plane under the influence of earth's magnetic field. If θ is the angle made by the magnetic meridian with M_1 then

$$\boxed{\tan\theta = \frac{M_2}{M_1}}$$



✧ **Potential energy of bar magnet :** The P.E. of a bar magnet of magnetic moment $\vec{M}$ placed in a uniform magnetic field $\vec{B}$ is given by

$U = -\vec{M}.\vec{B}$ $\quad U = -MB\cos\theta$

Where θ is the angle between $\vec{M}(\vec{SN})$ and $\vec{B}$.

i) If $\vec{M}$ is parallel to $\vec{B}$ then P. E. is minimum, then U = –MB. Then magnet is said to be in **stable equilibrium.**

ii) If $\vec{M}$ is anti–parallel to $\vec{B}$ then P. E. is maximum, then U = +MB. Then magnet is said to be in **unstable equilibrium.**

✧ **Work done by external agent in deflecting a magnet and magnetic potential:**

i) The work done in deflecting a magnet from angular positions θ_1 to an angular position θ_2 with the field is given by W = ΔU. (or) $\boxed{W = MB(\cos\theta_1 - \cos\theta_2)}$

ii) The work done in deflecting a bar magnet through an angle θ from its stable equilibrium position in a uniform magnetic field is given by $\boxed{W = MB(1-\cos\theta)}$

iii) The magnetic potential at a point due to a bar magnet is $V = \frac{\mu_0}{4\pi}\frac{M\cos\theta}{r^2}$.

iv) On the axial line of dipole, $\theta = 0^0$ and $V = \frac{\mu_0}{4\pi}\frac{M}{r^2}$.

v) On the equitorial line of dipole, $\theta = 90^0$ and V = 0.

IV) TIME PERIOD OF OSCILLATION :

i) When a bar magnet is suspended freely in a uniform magnetic field and is displaced from its equilibrium, it starts vibrating and executes angular SHM about the equilibrium position.

ii) The time period of vibrating magnet is

$\boxed{T = 2\pi\sqrt{\frac{I}{MB_H}}}$ and The frequency of vibrating magnet $\boxed{n = \frac{1}{2\pi}\sqrt{\frac{MB_H}{I}}}$

Where $I = m\left(\frac{\ell^2 + b^2}{12}\right)$ is the moment of inertia of the bar magnet

iii) A magnet is oscillating in a magnetic field and its time period is T. If another identical magnet is placed over that magnet with like poles together, then time period remains unchanged.

iv) A magnet is oscillating in a magnetic field B and its time period is T. If another identical magnet is placed over that magnet with unlike poles together, then time period becomes infinite since resultant magnetic moment is equal to zero

v) A thin bar magnet is oscillating in a magnetic field, its time period is T.

a) If magnet is cut into 'n' equal parts, parallel to length then time period of each part remains same $T^1 = T$

b) If magnet is cut into 'n' equal parts perpendicula to length then time period of each part is $\boxed{T^1 = \frac{T}{n}}$

vi) Two magnets of magnetic moments M_1 and M_2 ($M_1 > M_2$) are placed one over the other. If T_1 is time period when like poles touch each other and T_2 is the time period when unlike poles touch each other, then $\boxed{\frac{M_1}{M_2} = \frac{T_2^2 + T_1^2}{T_2^2 - T_1^2}}$. In terms of frequencies of oscillating magnet $\boxed{\frac{M_1}{M_2} = \frac{n_1^2 + n_2^2}{n_1^2 - n_2^2}}$

V) TERRESTRIAL MAGNETISM :

i) The branch of physics which deals with earth's magnetism is called as terrestrial magnetism or geomagnetism.

ii) The axis of rotation of the earth is called geographic axis. The points where the axis of rotation cuts the surface of the earth are called geographic poles.

iii) The magnetic field of the earth is now thought to arise due to electrical currents produced by convective motion of matalic fluids (iron and nickel) in the outer core of the earth. This is known as dynamo effect.

iv) The magnetic field lines of the earth resembles that of a magnetic dipole located at the centre of the earth. The axis of dipole is does not coincide with the axis of rotation.

v) The magnetic axis cuts the earth's surface at two points. One point is near the geographic north pole and is known as **geomagnetic south pole.** The other point is near the geographic south pole and is known as **geomagnetic north pole**.

vi) The axis passing through geomagnetic south and geomagnetic north is known as geomagnetic axis.

vii) The vertical plane at a given place containing longitude circle and geographic axis of earth is called geographic meridian.

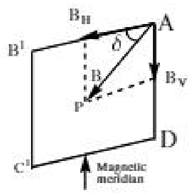
viii) The vertical plane at a given place containing mangetic axis of earth intersect the surface of the earth in a longitude like circle. This verticle plane is called magnetic meridian.

ix) The magnetism of earth is completely specified (in magnitude and direction) by the following three parameters :

1. Magnetic declination (θ),
2. Magnetic inclination or magnetic dip (δ), and
3. Horizontal component of earth's magnetic field (B_H).

* **Magnetic declination (θ) :** At a given place, the angle between geographical meridian and magnetic meridian is called as magnetic declination (θ).

* **Magnetic dip (δ) :** The angle of dip (δ) at a place is defined as the angle made by the direction of earth's magnetic field with the horizontal direction in magnetic meridian.



i) At a place on poles, earth's magnetic field is perpendicular to the surface of earth, i.e., $\delta = 90^0$

$\therefore B_v = B\sin 90^0 = B$ and $B_H = B \cos 90^0 = 0$

ii) At a place on equator, earth's magnetic field is parallel to the surface of earth, i.e., $\delta = 0^0$

$\therefore B_H = B\cos 0^0 = B$ and $B_V = B_H \sin 0^0 = 0$

* **Horizontal component of earth's magnetic field (B_H) :**

i) At a given place, the horizontal component of earth's magnetic field is defined as the component of earth's magnetic field along the horizontal direction in the magnetic meridian.

ii) Let B_H and B_V represent the horizontal and vertical components of earth's magnetic field B respectively. Then $B_H = B\cos\delta$ and $B_V = B\sin\delta$

$$B_H^2 + B_V^2 = B^2\cos^2\delta + B^2\sin^2\delta = B^2 \;;\; \therefore B = \sqrt{\left(B_H^2 + B_V^2\right)} \;;\; \frac{B\sin\delta}{B\cos\delta} = \frac{B_V}{B_H} \text{ or } \tan\delta = \frac{B_V}{B_H}$$

iii) B_H is always directed from geographic south to north.

iv) If earth is considered as a short magnet with its centre coinciding with the centre of earth, then the angle of dip δ at a place where the magnetic latitude λ is given by $\tan\delta = 2\tan\lambda$ or $\delta = \tan^{-1}(2\tan\lambda)$

* **Dip Circle**

i) The dip at a place can be determined by an apparatus known as dip circle.

ii) It consists of a vertical circular scale S and a magnetic needle (a small pointed permanent magnet) pivoted at the centre of the scale.

iii) The needle can rotate freely in the vertical plane of the scale. The pointed ends move over the graduations on the scale which are marked 0 – 0 in the horizontal and $90^0 - 90^0$ in the vertical direction.

* **Measurement of dip :** The earth's magnetic field $\vec{B}$ is in this same plane when the plane of the vertical scale S is the same as the magnetic meridian.

* **Apparent Dip :** If the dip circle is at an angle θ to the meridian, the effective horizontal component in this place is $B'_H = B_H\cos\theta$.

$$\tan\delta_1 = \frac{B_v}{B'_H} = \frac{B_V}{B_H\cos\theta} \text{ or } \tan\delta_1 = \frac{\tan\delta}{\cos\theta} \quad \left(\because \tan\delta = \frac{B_V}{B_H}\right)$$

If δ_2 be the apparent dip in perpendicular plane, $\tan\delta_2 = \frac{B_V}{B''_H} = \frac{B_V}{B_H\sin\theta}$ or $\tan\delta_2 = \frac{\tan\delta}{\sin\theta}$

From the above two equations $\cot^2\delta_1 + \cot^2\delta_2 = \cot^2\delta$

i) **Isogonic lines :** Lines drawn through different places having the same declination are called isogonic lines. The line which passes through places having zero declination is called **agonic line** .

ii) **Isoclinic lines :** These are lines passing through places of equal dip. The line joining places of zero dip is called **aclinic line** (or magnetic equator).

iii) **Isodynamic lines :** These are the lines passing through places of equal values of B_H (horizontal component of earth's magnetic field)

VI) PROPERTIES OF MAGNETIC MATERIALS

i) 'H' is an auxillary field which is measured as the ratio of magnetic induction to the permeability of the medium at the given point.

ii) $\boxed{B = \mu_0 H}$ in vacuum $B = \mu H = \mu_0\mu_r H$ in any medium

✧ **Intensity of magnetisation (I) :**

i) It is the magnetic moment per unit volume or polestrength per unit area $\boxed{I = \frac{M}{V} = \frac{2\ell.m}{2\ell.a} = \frac{m}{a}}$

✧ **Magnetic susceptibility (χ) :**

i) The ratio of magnitude of intensity of magnetisation (I) in a material to that of magnetising field(H) is called magnetic susceptibility of that material(χ). $\boxed{\chi = I/H}$

✧ **Relation between μ and χ :**

i) When a magnetic material is placed in a magnetising field for its magnetisation the field inside the magnetic material is the resultant of the magnetising field $\vec{B_0}$ and the induced field $\vec{B_i}$ i.e $\vec{B} = \vec{B_0} + \vec{B_i}$

$$B = \mu o H + \mu o I = \mu o(H + I) \Rightarrow \boxed{\mu_r = 1 + \chi}$$

✧ **Electron Theory of magnetism :**

i) Molecular theory of magnetism was first given by Weber and was later developed by Ewing.

ii) Electron theory of magnetism was proposed by Langevin.

iii) The main reason for the magnetic property of a magnet is spin motion of electron. Most of the magnetic moment is produced due to electron spin. The contribution of the orbital revolution is very small.

✧ **Explanation of diamagnetism :**

i) Since diamagnetic substance have paired electrons, magnetic moments cancel each other and there is no net magnetic moment.

ii) When a diamagnetic substance is placed in an external magnetic field each electron experiences radial force F = Bev either inwards or outwards. Due to this the angular velocity, current, and magnetic moment of one electron increases and of the other decreases. This results in a non-zero magnetic moment in the substances in a direction opposite to the field.

iii) Since the orbital motion of electrons in atoms is an universal phenomenon, diamagnetism is present in all materials. Hence diamagnetism is a universal property.

✧ **Explanation of Paramagnetism :**

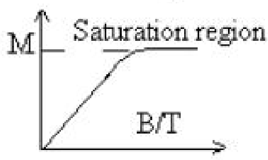
i) Paramagnetic materials have a permanent magnetic moment in them. The moments arise from both orbital motion of electrons and the spinning of electrons in certain axis.

ii) In absence of external magnetic field atomic magnets are randomly oriented due to the thermal agitation and the net magnetic moment of the substance is zero.

iii) When it is placed in an external magnetic field the atomic magnets align in the direction of the field and thermal agitation oppose them to do so.

iv) At low fields the total magnetic moment would be directly proportional to the magnetic field B and inversely proportional to temperature T.

v) At high field and low temperature the total moment reaches the saturation when all the atomic magnets align in the direction of the field. $M = C\frac{B}{T}$ C is a constant



✧ Explanation of ferro magnetism (Domain Theory) :

i) Every ferromagnetic material is made of a number of very small region which are known as domains

ii) Domain theory proposed by Weiss explains ferro magnetism.

iii) **Exchange interaction :-** It is the interaction through which the magnetic moments of individual atoms are coupled to neighbouring moments very strongly.

iv) Domain : A small volume of the order 10^{-6} to 10^{-2} cm^3 containing 10^{17} to 10^{21} atoms whose magnetic moments are aligned in the same direction.

v) Due to exchange interaction domains are formed in ferro magnetic substance. Each domain possesses a resultant magnetic moment.

vi) In the absence of external magnetic field the magnetic moments of domains are randomly oriented giving zero resultant magnetic moment.

vii) When the ferro magnetic substance is placed in an external magnetic field the domains having the magnetic moment in the direction of external magnetic field increase their volume at the cost of those which are in opposite direction till saturation state of magnetization.

✧ Curie's Law:

i) According to this law, the magnetic susceptibility of paramagnetic substances is inversely proportional to absolute temperature, i,e., $\chi \propto \frac{1}{T} \Rightarrow \chi = \frac{C}{T}$ where C = curie constant, 'T' absolute temperature.

ii) On increasing temperature, magnetic susceptibility of paramagnetic substances decreases or vice-versa.

iii) The magnetic susceptibility of ferro magnetic substances does not change according to curie law.

✧ Curie Temperature or Cuire Point (Tc)

i) The magnetic susceptibility of these substances decreases on increasing the temperature and above a particluar tempeture, a ferromagnetic substance behaves like a paramagnetic substance. This particular temperature is called the **Curie** temperature.

Ex: For Ni, $T_{C_{Ni}} = 358^0C$ for Fe, $T_{C_{Fe}} = 770^0C$ for CO, $T_{C_{CO}} = 1120^0C$

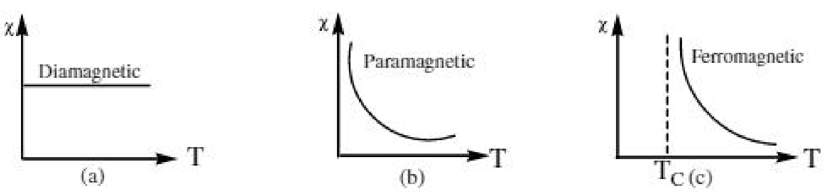
ii) At this temperature the ferromagnetism of the substances suddenly vanishes.

✧ Curie - weiss law:

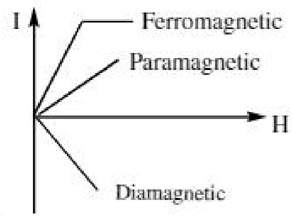
i) At temperatures above Curie temperature the magnetic susceptibility of ferromagnetic materials is inversely proportional to $(T - T_C)$ i.e. $\chi \propto \frac{1}{T - T_C} \Rightarrow \chi = \frac{C}{(T - T_C)}$

Here T_C - Curie temperature χ -T curve is shown (for Curie - Weiss Law)

ii) Susceptibility – absolute temperature curve



iii) Intensity of magnetisation (I)-Magnetising field (H) curve shown above

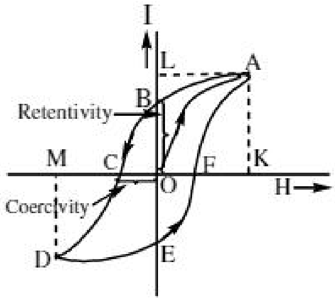


(D)

✧ Hysteresis :

i) The lagging of intensity of magnetisationbehind the magnetising field intensity is called hysteresis

ii) The variation of magnetisation intensity with magnetising force for a ferro magnetic material is shown in hysteresis loop.



ii) The retentivity or remanence is defined as the intensity of magnetisation remaining in the substance when the magnetising field has been reduced to zero.

iii) The coercivity is a measure of the magnetising field intensity required to destory the residual magnetism in the specimen.

iv) When a ferro-magnetic substance is taken through a cycle of magnetisation and demagnetisation some energy is lost, which is called Hysteresis loss.

v) The loss of energy per unit volume of specimen per cycle of magnetisation in C.G.S. system, is equal to area of *I-H* loop of specimen. In S.I. system, this is equal to area of *B-H* loop.

vi) The shape and size of *I-H or B-H* loops depend on the nature of material of specimen.

vii) The Hysteresis loop help to study study the properties like retentivity, coercivity, permeability, susceptibility and energy loss etc.

viii) The Hysteresis loop enable us to select a suitable material for different purposes i.e., for electromagnets, transformer cores, permanent magnets etc.

✧ Permanent magnets

i) The substances which retain their ferromagnetic property for a long period of time are called permanent magnets.

ii) A permanent magnet should have both large retentivity and large coercivity along with high permeability.

iii) The best suited materials are cobalt, steel, alnico, ticonol etc. Steel is perferred for making permanent magnets because its coercivity is large.

iv) The very suitable alloy of highest coercivity is vicalloy (vanadium + iron + cobalt).

v) Permanent magnets are used in galvanometers, voltmeters, ammeters, microphones, loud speakers, telephones, etc.

✧ Temporary magnets

i) These have low retentivity ,low coercivity and small hysteresis loss and are suitable for temporary magnetism.

ii) The soft magnets are used for making electromagnets, cores of transformers, motors and generators.

iii) Soft iron, mu - metal and stalloy are examples of ferromagnetic materials of this type.

iv) Eletromagnets are used in electric bells, loudspeakers and telephone diaphragms.

v) Giant electromagnets are used in cranes to life machinery, and bulk quantities of iron and steel.

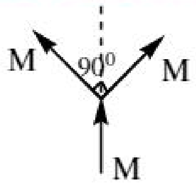
LECTURE SHEET

EXERCISE-I

(Bar magnet, Magnetic Moment)

Straight Objective Type Questions

1. Find the resultant magnetic moment for the following arrangement



1) $\sqrt{2}M$
2) $(\sqrt{2}+1)M$
3) $(\sqrt{2}-1)M$
4) M

2. A bar magnet of magnetic moment 'M_1' is axially cut into two equal parts. If these two parts are arranged perpendicular to each other, the resultant magnetic moment is M_2. Then the value of M_1/M_2 is

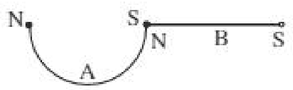
1) $\frac{1}{2\sqrt{2}}$ 2) 1 3) $\frac{1}{\sqrt{2}}$ 4) $\sqrt{2}$

3. In an iron bar $(5 \times 1 \times 1)cm^3$ magnetic moment of an atom is 1.8×10^{-23} Am^2. What is magnetic moment of the bar in the state of saturation. (Density = 7.8×103 kg/m^3, atomic mass = 56 gm)

1) 6.54 Am^2 2) 7.54 Am^2 3) 4.54 Am^2 4) 3.54 Am^2

Numerical Value Type Questions

4. A magnet of length L and moment M is cut into two halves (A and B) perpendicular to its axis. One piece A is bent into a semicircle of radius R and is joined to the other piece at the poles as shown in the figure below.



Assuming that the magnet is in the form of a thin wire initially, the moment of the resulting magnet is given by $\frac{M(x+\pi)}{x\pi}$ then 'x' is

EXERCISE-II

(Magnetic induction, Coulomb law and Null points)

Straight Objective Type Questions

1. The length of a magnet of moment $5Am^2$ is 14cm. The magnetic induction at a point, equidistant from both the poles is 3.2×10^{-5} wb/m^2. The distance of the point from each pole is

1) 5cm 2) 10cm 3) 25cm 4) 15cm

2. A magnet of length 10cm and magnetic moment $1Am^2$ is placed along the side AB of an equilateral triangle ABC. If the length of the side AB is 10cm, the magnetic induction at the point C is

1) 10^{-9}T 2) 10^{-7}T 3) 10^{-5}T 4) 10^{-4}T

3. Two short bar magnet of magnetic moment M each are arranged at the opposite corners of a square of side 'd' such that their centres coincide with the corners and their axes are parallel. If the like poles are in same direction the magnetic induction at any of the other corner of the square is

1) $\frac{\mu_0}{4\pi}\frac{M}{d^3}$ 2) $\frac{\mu_0}{4\pi}\frac{2M}{d^3}$ 3) zero 4) $\frac{\mu_0}{4\pi}\frac{3M}{d^3}$

4. The magnetic induction at a point on the axial line of a short magnet is 10 Tesla east. The magnetic induction at the same point when the magnet is rotated in the anticlock wise direction by 90^0 and 180^0 are

1) 10T south and 5T west
2) 5T south and 10T west
3) 20T south and 10T west
4) 10T south and 20T west

5. A short bar magnet of magnetic moment 5.25×10^{-2} JT^{-1} is placed with its axis perpendicular to the earth's field direction. At what distance from the centre of the magnet, the resultant field is inclined at 45^0 with earth's field on (a) its normal bisector and (b) its axis. Magnitude of the earth's field at the place is given to be 0.45G. Ignore the length of the magnet in comparison to the distances involved.

1) 2.8 cm, 5 cm
2) 2 cm, 5 cm
3) 8 cm, 1.2 cm
4) 5 cm, 6.3 cm

6. Two short bar magnets P and Q are arranged such that their centres are on the X-axis and are separated by a large distance. The magnetic axes of P and Q are along X, Y-axis respectively. R lies midway between their centres. If B is the magnitude of induction due to Q at R, then magnitude of total induction at R due to both the magnets is

1) 3B
2) $\sqrt{5}$B
3) $\frac{\sqrt{5}}{2}B$
4) B

7. A short bar magnet is kept along the magnetic meridian with its north pole pointing north. A neutral point is located at distance 'd' from the centre. The ratio of magnetic inductions at a distance d/2 and 2d from the centre of the magnet on the equitorial line is

1) 1 : 4
2) 4 :1
3) 8 : 1
4) 1 : 8

8. A bar magnet of length 8 cm and having a pole strength of 1.0 Am is placed vertically on a horizontal table such that with its south pole on table. A neutral point is found on table at a distance of 6 cm north of the magnet. Calculate B_H value.

1) 11 μT
2) 22 μT
3) 33 μT
4) 33 μT

9. The earth magnetic field at a geomagnetic poles has a magnitude 6.2×10^{-5} T. Find magnetic field at this point on the surface where the radius makes an angle of 135^0 with this axis of the earths assumed to be dipole

1) 4.9×10^{-5}
2) 3.9×10^{-5}
3) 2.9×10^{-5}
4) none

10. The intensities of magnetic field at two points on the axes of a bar magnet at distances 0.1 m, 0.2 m are 12.5:1 from the mid point. Calculate the distance between the poles of a magnet.

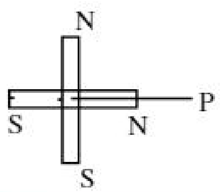
1) 0.2 m
2) 0.3 m
3) 0.1 m
4) 0.5 m

11. Two short magnets a, b of moments 0.108 Am^2 and 0.192 Am^2 are placed along mutually perpendicular directions meeting at a point p, find the direction of magnetic field at point p. If it lies at a distance 30 cm and 60 cm respectively from the centres of two magnets.

1) 24^0
2) 34^0
3) 44^0
4) 14^0

Numerical Value Type Questions

12. Two short magnets each of moment M are placed one over the other at right angles. The resultant magnetic induction at a point 'P', that lies at a distance 'd' from the common centre is $\sqrt{p}\frac{\mu_0}{4\pi}\frac{3M}{d^3}$ then 'p' is



13. A bar magnet of 10 cm long is kept with its N - pole pointing north. A neutral point is formed at a distance of 15 cm from each pole. Given the horizontal component of earth's field is 0.4 Gauss, the pole strength of the magnet is _____ amps-m

EXERCISE-III

(Couple, p.E and work done)

Straight Objective Type Questions

1. A magnet is suspended in the magnetic meridian with an untwisted wire. The upper end of the wire is rotated through 180^0 to deflect the magnet by 30^0 from magnetic meridian. Now this magnet is replaced by another magnet. Now the upper end of the wire is rotated through 270^0 to deflect the magnet 30^0 from the magnetic meridian. The ratio of the magnetic moments of the two magnets is

   1) 3 : 4 2) 1 : 2 3) 4 : 7 4) 5 : 8

2. A magnetic dipole is under the influence of two magnetic fields. The angle between the field directions is 60^0 and one of the fields has a magnitude of 1.2×10^{-2}T. If the dipole comes to stable equilibrium at angle of 15^0 with this field, then the magnitude of the other field ($\sin15^0 = 0.2588$)

   1) 1.39×10^{-3}T 2) 2.39×10^{-3}T 3) 3.39×10^{-3}T 4) 4.39×10^{-3}T

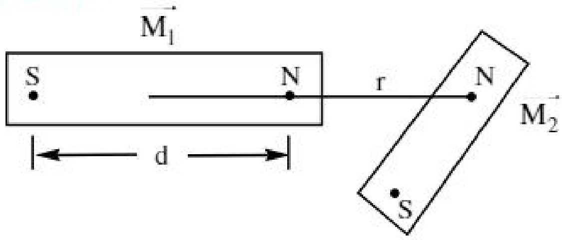
3. If 'W' Joule is the work done in rotating the magnet from the field direction to a position that makes an angle 60^0 with the direction of the field, the torque required to hold the magnet in that direction is

   1) W N-m 2) $\frac{W}{2}N-m$ 3) $\frac{W}{\sqrt{3}}N-m$ 4) $\sqrt{3}WN-m$

4. Two small bar magnets having dipole moments M_1, M_2 placed at distance r. Find the magnetic interaction energy of this system of dipoles for d < < < r.

   1) $-\frac{\mu_0 M_1 M_2 \cos\theta}{2\pi r^3}$ 2) $\frac{\mu_0 M_1 M_2 \sin\theta}{2\pi r^3}$

   3) $\frac{\mu_0 M_1 M_2 \tan\theta}{2\pi r^3}$ 4) $\frac{\mu_1 M_1 M_2 \cot\theta}{2\pi r^3}$



5. A magnetic dipole with a dipole moment of magnitude 0.020 Am^2 is released from rest in a uniform magnetic field of induction 52 mT. When the dipole rotates due to magnetic couple on it through the orientation where its dipole moment is aligned with the magnetic field its KE is 0.80 mJ. The angle between the dipole moment and magnetic field

   1) 46.67^0 2) 56.67^0 3) 76.67^0 4) 76.67^0

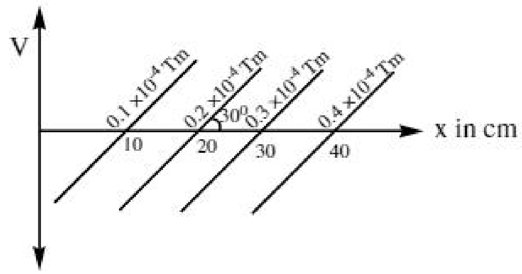
6. A magnetic needle having magnetic moment $10Am^2$ and length 10 cm is clamped at its centre in such a way that it can be rotated in the vertical east and west plance. A horizontal force towards east is applied at the north pole to keep the needle fixed at an angle of 30^0 with vertical. Find the magnitude of applied force. ($B_V = 40\,\mu$ T)

   1) 1.3×10^{-2} N 2) 4.3×10^{-2} N 3) 2.3×10^{-2} N 4) 0.3×10^{-2} N

7. Magnetic scalar potential due to a magnetic dipole at a point on its axis situated it a distance of 20 cm from the centre of is found to be 1.2×10^{-5} Tm. Find the magnetic dipole moment of the dipole is

   1) 1.8 Am^2 2) 2.8 Am^2 3) 5.8 Am^2 4) 4.8 Am^2

8. Figure shows some equipotential surfaces of the magnetic scalar potential. Find the magnetic field at B at a point in the region.

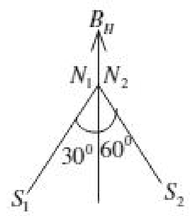


1) 10^{-4} T   2) 3×10^{-4} T   3) 2×10^{-4} T   4) 5×10^{-4} T

Numerical Value Type Questions

9. A short bar magnet of magnetic moment M = 0.32 JT^{-1} is placed in a uniform magnetic field of 0.15 T. If the bar is free to rotate in the plane of the field, which orientation would correspond to its (a) stable, and (b) unstable equilibrium? What is the potential energy of the magnet in each case -4.8×10^{-x} J, $+4.8\times10^{-y}$ J then x, y are

10. Two small magnets X and Y of dipole moments M_1 and M_2 are fixed perpendicular to each other with their north poles in contact. This arrangement is placed on a floating body so as to move freeely in earth's magnetic field as shown in figure then the ratio of magnetic moment is $\sqrt{2^n - 1}$ then n is



11. A bar magnet of magnetic moment $2Am^2$ is free to rotate about a vertical axis passing through its centre. The magnet is released from rest from east - west position. Then the K.E of the magnet as it takes north-south position is (2n + 40) μJ then n is (B_H = 25 μT)

12. A short bar magnet placed with its axis at 30^0 with a uniform external magnetic field of 0.16T experiences a torque of magnitude 0.032Nm. If the bar magnet were free to rotate, its P.E when it is in stable and unstable equilibrium are (Only magnitude)

EXERCISE-IV

(Time period of oscillation)

Straight Objective Type Questions

1. A small magnet of moment 4.8×10^{-2}J/T is suspended freely in the plane of a uniform magnetic field of magnitude 3×10^{-2}T. If the magnet is slightly displaced from its stable equilibrium and released then the angular frequency of its oscillations in rad/sec. (Moment of inertia of the magnet about the axis of rotation is 2.25×10^{-5} kgm^2)

1) 8   2) 4   3) 3   4) 2

2. A combination of two identical bar magnets are placed one over the other such that they are perpendicular and bisect each other. The time period of oscillation in a horizontal magnetic field is $2^{5/4}$ seconds. One of the magnets is removed and if the other magnet oscillates in the same field, then the time period in seconds is

1) $2^{1/4}$ 2) $2^{1/2}$ 3) 2 4) $2^{5/4}$

3. A magnetic needle has a frequency of 20 oscillations per minute in the earth's horizontal field. when the field of a magnet supports the earths horizontal field, the frequency increases to 30 oscillations per minute. The ratio of the field of the magnet to that of the earth is

1) 4:7 2) 7:4 3) 5:4 4) 4:5

4. Two long bar magnet of magnetic moment $6Am^2$ and $8Am^2$ can be fastened together with their axes horizontal and their centres in a vertical line about which the system is free to oscillate. Compare the time periods in the earth's field when the axes of the magnets are (i) in the same direction (ii) in opposite direction (iii) at right angle

1) 1:7:5 2) $1:\sqrt{7}:\sqrt{5}$ 3) $1:\sqrt{7}:\sqrt{7/5}$ 4) $1:\sqrt{7/5}:\sqrt{14/5}$

5. A compass needle makes 10 oscillations per minute in the earths horizontal field.A bar magnet deflects the needle by 60^0 from the magnetic meridian. The frequency of oscillation in the deflected position in oscillations per minute is (field due to magnet is perpendicular to B_H)

1) $5\sqrt{2}$ 2) $20\sqrt{2}$ 3) $10\sqrt{2}$ 4) 10

6. T_0 is time period of oscillation of the needle in uniform horizontal magnetic field (B_H) of the earth. If another magnetic field is applied perpendicular to B_H such that the needle deflects by θ for its equilibrium. Now period of oscillation of the needle is T. The relation between T and T_0 is :

1) $T^2 = T_0^2 \cos\theta$ 2) $T = T_0 \cos\theta$ 3) $T = \frac{T_0}{\cos\theta}$ 4) $T^2 = \frac{T_0^2}{\cos\theta}$

7. With a standard rectangular bar magnet the time period of a vibration magnetometer is 4 seconds. The bar magnet is cut parallel to its length into four equal pieces. The time period of vibration magnetometer when one piece is used (in seconds) (bar magent breadth is small) is

1) 16 2) 8 3) 4 4) 2

8. A compass needle oscillates 20 times per minute at a place where the dip is 45^0 and 30^0 times per minute where the dip is 30^0. Compare the total magnetic field due to earth at the two places.

1) 2.83 2) 1.83 3) 0.83 4) 3.83

Numerical Value Type Questions

9. The magnetic needle of a vibration magnetometer makes 12 oscillations per minute in the horizontal component of earth's magnetic field.When an external short bar magnet is placed at some distance along the axis of the needle in the same line it makes 15 oscillations per minute. If the poles of the bar magnet are inter changed, the number of oscillations it takes per minute is $\sqrt{q\times 9}$ then q is

10. In an uniform field the magnetic needle completes 10 oscillations in 92seconds. When a small magnet is placed in the magnetic meridian 10cm due north of needle with north pole towards south completes 15 oscillations in 69seconds. The magnetic moment of magnet (B_H = 0.3 G) is

11. A short magnet oscillates in vibration magnetometer with a frequency 10Hz where horizontal component of earth's magnetic field is $12\mu T$. A downward current of 15A is established in the vertical wire placed 20cm west of the magnet. New frequency is $\sqrt{4n+5}$ then n is

EXERCISE-V

(Terrestrial Magnetism)

Straight Objective Type Questions

1. The plane of the dip circle is set in the geo-graphical meridian and the apparent dip is θ_1. It is then set in a vertical plane perpendicular to the geographical meridian, the apparent dip becomes θ_2. The angle of declanation α at that place is given by

   1) $\tan\alpha = \sqrt{\tan\theta_1 \tan\theta_2}$ 2) $\alpha = \sqrt{\tan^2\theta_1 \tan^2\theta_2}$ 3) $\tan\alpha = \dfrac{\tan\theta_1}{\tan\theta_2}$ 4) $\tan\alpha = \dfrac{\tan\theta_2}{\tan\theta_1}$

2. A dip circle lying initially in the magnetic meridian is rotated through angle θ in the horizontal plane. The ratio of tangent of apparent angle of dip to true angle of dip is

   1) $\cos\theta : 1$ 2) $\sin\theta : 1$ 3) $1 : \cos\theta$ 4) $1 : \sin\theta$

3. In the magnetic meridian of a certain place, the horizontal component of the earth's magnetic field is 0.26 G and the dip angle is 60^0. What is the magnetic field of the earth at this location ?

   1) 0.24 G 2) 0.58G 3) 0.52G 4) 0.33 G

4. A dip needle vibrates in the vertical plane perpendicular to the magnetic meridian. The time period of vibration is found to be 2 seconds. The same needle is then allowed to vibrate in the horizontal plane and the time period is again found to be 2 seconds. Then the angle of dip is

   1) 0^0 2) 30^0 3) 45^0 4) 90^0

5. A ship is to reach a place 10^0 south of west. In which direction should be steered if the declination at the place is 18^0 west of north.

   1) 82^0 2) 92^0 3) 72^0 4) none

6. True value of dip at a place is 45^0. The plane of the dip circle is rotated through 60^0 from the magnetic meridian. The apparent value of dip

   1) 53.4^0 2) 63.4^0 3) 43.4^0 4) 73.4^0

Numerical Value Type Questions

7. A magnet makes 12 oscillation per minute at a place where horizontal component of earth's field is 6.4×10^{-3}T . It is found to require 8 seconds per oscillation at another place X. The vertical component of earths field at X where resultant field makes angle 60^0 with horizontal is $\sqrt[25]{x}\times10^{-4}$T then x is

8. Obtain the earth's magnetisation, assuming that the earth's field can be approximated by a giant bar magnet of magnetic moment 8.0×10^{22} Am^2. Radius of earth = 6400km.

9. The horizontal component of earth's magnetic field at place is 0.36×10^{-4} weber/m^2. If the angle of dip at that place is 60^0 then the value of vertical component of earth's magnetic field will be $1.2\sqrt{x}\sqrt{3}\times10^{-5}$T then x is (in wb/$m^2$)

EXERCISE-VI

(Properties of magnetic materials, Hysterin loop, χ, Curie Law)

Straight Objective Type Questions

1. A rod of ferromegnetic material with dimensions 10cm × 0.5cm × 2cm is placed in a magnetising field of intensity 2×10^5A/m. The magnetic moment produced due it is 6 amp–m^2. The value of magnetic induction will be ----- 10^{-2}T.

   1) 100.48 2) 200.28 3) 50.24 4) 300.48

2. A magnetic material of volume $30cm^3$ is placed in a magnetic field of intensity 5 oersted. The magnetic moment produced due it is 6 amp–m^2. The value of magnetic induction will be.
   1) 0.2517 Tesla 2) 0.025 Tesla 3) 0.0025 Tesla 4) 25 Tesla

3. The total magnetic flux in a material, which produces a pole of strength m_P when a magnetic material of cross-sectional area A is placed in a magnetic field of strength H, will be
   1) $\mu_0(AH+m_p)$ 2) $\mu_0 AH$ 3) $\mu_0 m_p$ 4) $\mu_0(m_p AH+A)$

4. A magnetizing field of 1600 Am^{-1} produces a magnetic flux of 2.4×10^{-5} weber in a bar of iron of cross - section $0.2\times10^{-4}m^2$. Calculate permeability and susceptibility of the bar.
   1) 7.5×10^{-5} $TA^{-1}m$, 496.1 2) 75×10^{-5} $TA^{-1}m$, 596.1
   3) 1.5×10^{-4} $TA^{-1}m$, 596.1 4) 1.5×10^{-4} $TA^{-1}m$, 396.1

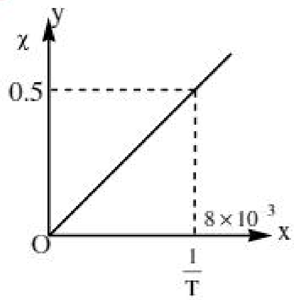
5. The core of a toroid having 3000 turns has inner and outer radii of 11cm and 12cm respectively. The magnetic flux density in the core for a current of 0.70A is 2.5T. What is the relative permeability of the core?
   1) 484 2) 584 3) 384 4) 684

6. A magnetising field of 1500 A/m produces a magnetic flux of 2.4×10^{-5} wb in a bar of iron cross section 0.5 cm^2. Calculate the permeability.
   1) 3.2×10^{-4} Tm/A 2) 2.2×10^{-4} Tm/A 3) 4.2×10^{-4} Tm/A 4) 6.2×10^{-4} Tm/A

7. The coercivity of certain permanent magnet is 4×10^4 A/m. This magnet is placed in side a solenoid 15 cm long and having 600 turns and a current is passed in the solenoid to demagnetise it completely find the current.
   1) 20A 2) 30A 3) 10A 4) 40A

8. The susceptability of magnesium at 300 K is 1.2×10^{-5}. At what temperature will be the susceptability increases to 1.8×10^{-5}.
   1) 300K 2) 200K 3) 400K 4) 500K

9. Find curie constant from it χ vs $\frac{1}{T}$ graph shown in the figure.



   1) 62.5 K 2) 72.5 K 3) 82.5 K 4) 42.5K

Numerical Value Type Questions

10. An iron rod is subjected to cycles of magnetisation at the rate of 50Hz. Given the density of the rod is $8\times10^3 kg/m^3$ and specific heat is 0.11×10^{-3} cal/kg^0C. The rise in temperature per minute, if the area enclosed by the B – H loop corresponds to energy of 10^{-2} J is (Assume there is no radiation losses) $(\sqrt{8^y}+0.1)^0C$ then y is

11. A magnetic dipole is placed under the effect of two magnetic fields inclined at 75^0 to each other. One of the fields has a magnetic induction of 1.5×10^{-2} T. The magnet comes to rest at an angle of 30^0 with the direction of this field. The magnetude of the other field is $\frac{3}{\sqrt{n}}\times10^{-2}T$ then n is

KEY SHEET (LECTURE SHEET)

EXERCISE-I	1) **2**	2) **4**	3) **2**	4) **2**				
EXERCISE-II	1) **3**	2) **4**	3) **1**	4) **2**	5) **4**	6) **2**	7) **3**	8) **2**
	9) **1**	10) **3**	11) **4**	12) **3**	13) **13.5**			
EXERCISE-III	1) **4**	2) **4**	3) **4**	4) **1**	5) **3**	6) **3**	7) **4**	8) **3**
	9) **x=2, y = 2**		10) **2**	11) **5**	12) **+0.064, 0.064**			
EXERCISE-IV	1) **1**	2) **3**	3) **3**	4) **3**	5) **3**	6) **1**	7) **3**	8) **2**
	9) **7**	10) **0.75**		11) **5**				
EXERCISE-V	1) **3**	2) **3**	3) **3**	4) **3**	5) **1**	6) **2**	7) **3**	
	8) **72.8 Am^{-1}**		9) **9**					
EXERCISE-VI	1) **1**	2) **1**	3) **1**	4) **2**	5) **4**	6) **1**	7) **3**	8) **2**
	9) **1**	10) **2**	11) **8**					

PRACTICE SHEET

EXERCISE-I

(Bar magnet)

Straight Objective Type Questions

1. A thin bar magnet of length 'l' and magnetic moment 'M' is bent at the mid point so that the two parts are at right angles. The new magnetic length and magnetic moment are respectively

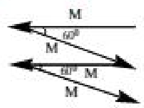
   1) $\sqrt{2}\ell, \sqrt{2}M$ 2) $\frac{\ell}{\sqrt{2}}, \frac{M}{\sqrt{2}}$ 3) $\sqrt{2}\ell, \frac{M}{\sqrt{2}}$ 4) $\frac{\ell}{\sqrt{2}}, \sqrt{2}M$

2. If three identical bar magnets each of magnetic moment 'M' are arranged in the form of an equilateral triangle such that unlike poles are in contact. The resultant magnetic moment is

   1) $\sqrt{3}M$ 2) $\frac{M}{3}$ 3) 3M 4) Zero

3. The resultant magnetic moment for the following arrangement is (the vectors are non coplanar)

   1) M 2) 2M
   3) 3M 4) 4M



4. A bar magnet of magnetic moment M is bent in the 'U' shape such that all the parts are of equal lengths. Then the new magnetic moment is

   1) $\frac{M}{3}$ 2) $\frac{M}{\sqrt{2}}$ 3) $\sqrt{3}M$ 4) $3\sqrt{3}M$

5. A magnet of moment 'M' is cut into two equal parts, the two parts are placed perpendicular to each other. The resultant magnetic moment is

   1) $\sqrt{2}M$ 2) $\frac{M}{\sqrt{2}}$ 3) $\sqrt{3}M$ 4) $3\sqrt{3}M$

6. A bar magnet of moment M is cut into two identical pieces along the length. One piece is bent in the form of a semi circle. If two pieces are perpendicular to each other, then resultant magnetic moment is

1) $\left(\frac{M}{\pi}\right)^2+\left(\frac{M}{2}\right)^2$ 2) $\sqrt{\left(\frac{M}{\pi}\right)^2+\left(\frac{M}{2}\right)^2}$ 3) $\sqrt{\left(\frac{M}{\pi}\right)^2-\left(\frac{M}{2}\right)^2}$ 4) $\frac{M}{\pi}+\frac{M}{2}$

7. The force between two magnetic poles is F in air. If the pole strength of first pole is doubled, that of second pole is tripled and the distance between the poles is halved the force between the poles becomes and increases by

1) 24F and 2300% 2) 24F and 2400% 3) $\frac{3}{2}F$ and 150% 4) 2F and 100%

8. Force between two identical bar magnets whose centres are r metre apart is 4.8 N when their axes are in the same line. If separation is increased to 2r, the force between them is recued to

1) 2.4 N 2) 0.6 N 3) 1.2 N 4) 0.3 N

Numerical Value Type Questions

9. A magnetised wire of moment 'M' is bent into an arc of a circle subtending an angle 60^0 at the centre. The new magnetic moment will be $\frac{xM}{\pi}$ then 'x' is

10. A magnet of moment $80Am^2$ is placed in a uniform magneticfield of induction $1.8\times10^{-5}T$. If each pole of the magnet experiences a force of $25\times10^{-3}N$, the length of the magnet is ___ cm.

11. The force between two poles is reduced to P newton, when their original separation is increased to x times, it is increased to Q newton, when their separation is made 1/xth of their original value. Then the relation between P and Q is $Q = x^y P$ then y is

EXERCISE-II

(Magnetic induction and Null points:)

Straight Objective Type Questions

1. Two points A and B are located at distances 20cm and 30 cm from the centre of a short bar magnet on its axial line. The ratio of magnetic induction at A and B is

1) 2 : 3 2) 3 : 2 3) 9 : 4 4) 27 : 8

2. The force experienced by a magnetic pole of strength m kept at a distance of d from the centre of a short magnet of magnetic moment M on its equatorial line is

1) $m\frac{\mu_0}{4\pi}\frac{M}{d^3}$ 2) $m\frac{\mu_0}{4\pi}\frac{2M}{d^3}$ 3) $\frac{1}{m}\frac{\mu_0}{4\pi}\frac{2M}{d^3}$ 4) $\frac{1}{m}\frac{\mu_0}{4\pi}\frac{2}{Md^3}$

3. Two short bar magnets have their magnetic moments $1.2Am^2$ and $1.0Am^2$. They are placed on a horizontal table parallel to each other at a distance of 20 cm between their centers, such that their north poles pointing towards geographical south. They have common magnetic equatorial line. Horizontal component of earth's magnetic field is $3.6\times10^{-5}T$. The resultant horizontal magnetic induction at mid point of the line joining their centers is $\left(\frac{\mu_0}{4\pi}=10^{-7}H/m\right)$

1) $3.6\times10^{-5}T$ 2) $1.84\times10^{-4}T$ 3) $2.56\times10^{-4}T$ 4) $5.8\times10^{-5}T$

4. A short magnet of moment 6.4 A-m^2 lies in the magnetic meridian with north pole facing south (B_H = 1.6 gauss). The distance between the two neutral points is

1) 20 cm along the axial line 2) 20 cm along the equatorial line
3) 40 cm along the axial line 4) 40 cm along the equatorial line

5. A very long magnet of pole strength 16 A-m is placed vertically with its one pole on the table. At what distance from the pole, there will be a neutral point on the table. ($B_H = 4\times10^{-5} Wbm^{-2}$)

1) 0.4 m 2) 0.2 m 3) 0.4 m 4) 0.8 m

6. The magnetic moment of a circular loop is 2.1×10^{-25} Am^2. Find magnetic field on the axis of loop at distance of 1A° from the loop

1) 4.2×10^{-2} T 2) 2.2×10^{-2} T 3) 3.2×10^{-2} T 4) 5.2×10^{-2} T

Numerical Value Type Questions

7. Two isolated north poles of pole strengths 16 A-m and 4 A-m are at 30 cm apart in air. The distance of neutral point from the weaker pole is $2^n + 2$ then n is

8. A short bar magnet with its north pole facing north forms a neutral point at P in a horizontal plane. If the magnet is rotated by 90^0 in the horizontal plane, the net magnetic induction at P is (Horizontal component of earth's magnetic field = B_H) $\sqrt{n}\,B_H$ then n is

EXERCISE-III

(Couple, P.E and work done)

Straight Objective Type Questions

1. Calculate the moment of couple required to keep a bar magnet of magnetic moment 2×10^2 Am^2 in a uniform field of induction 0.36 T at an angle of 30^0 with the direction of uniform field.

1) 36 Nm 2) 3.6 Nm 3) 72 Nm 4) 7.2 Nm

2. A magnet of magnetic moment $50\,\hat{i}$ Am^2 is placed along the x-axis in a magnetic field $\vec{B} = (0.5\hat{i} + 3.0\hat{j})$ T. The torque acting on the magnet is

1) $175\,\hat{K}$ N-m 2) $150\,\hat{K}$ N-m 3) $75\,\hat{K}$ N-m 4) $25\sqrt{37}\,\hat{K}$ N-m

3. A magnetic needle of pole strength $20\sqrt{3}$ Am is pivoted at its centre. Its N-pole is pulled eastward by a string. The horizontal force required to produce a deflection of 30° from magnetic meridian (take $B_H = 10^{-4}$ T) is

1) $4\times10^{-3} N$ 2) $2\times10^{-3} N$ 3) $\frac{2}{\sqrt{3}}\times10^{-3}$N 4) $4\sqrt{3}\times10^{-3}$N

4. A bar magnet of magnetic moment1.5J/T is along the direction of the uniform magnetic field of 0.22T. The work done in turning the magnet opposite to the field direction and the torque requried to keep in that position are

1) 0.33J and 0.33 N-m 2) 0.66J and 0.66 N-m 3) 0.33J and 0 N-m 4) 0.66J and 0 N-m

5. A bar magnet of magnetic moment 5 Am^2 is suspended in a uniform magnetic field of strength 2T making an angle 60^0 with the direction of the field. The potential energy of the magnet in that position is

1) 5 J 2) –5 J 3) 10 J 4) –10 J

6. A uniform magnetic field of 0.2×10^{-2}T exist in the space find the change in the magnetic scalar potential as one moves through the 50cm along the field

1) decreases by 0.10×10^{-3} Tm 2) increases by 0.10×10^{-3} Tm
3) decreases by 0.20×10^{-3} Tm 4) increases by 0.20×10^{-3} Tm

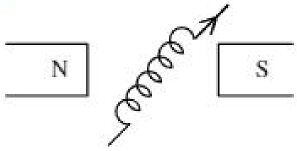
7. In an iron bar (5cm×1cm×1cm) magnetic moment of am atom is 1.8×10^{-23} Am^2. What is the torque acting on the magnet when it si normal to magnetic field 15000G (density of iron 7.8g/cc, atomic mass 56)

1) 11.3 Nm 2) 10.3 Nm 3) 9.3 Nm 4) 12.3 Nm

8. A bar magnet with poles 25cm apart and of pole strength 14.4 Am rests with its centre on a friction less pivot. It is held in equilibrium at 60° to a uniform magnetic field of induction 0.25T by applying a froce F at right angle to the axis from its pivot. Calculate F

1) 7.5 N 2) 5.5 N 3) 4.5 N 4) 6.5 N

9. A closely wound solenoid of 1000 turns and area of cross section 2×10^{-4} m^2 carries a current of 2A it is placed with its horizontal axis at 30^0 with direction of uniform horizontal magnetic field of 0.16T. What is torque acting on it.



1) 0.042 Nm 2) 0.032 Nm 3) 0.053 Nm 4) 0.063 Nm

Numerical Value Type Questions

10. A bar magnet of moment 2A-m^2 is free to rotate about a Vertical axis passing through its centre. The magnet is released form rest from east west direction. The K.E of the magnet as it takes north-south direction is $(B_H = 25 \times 10^{-6}T)$ $(7^x + 1)\times10^{-6}$ then x is

11. A short bar magnet placed with its axis at 30^0 with an external field of 800 G experiences a torque of 0.016 Nm. (a) What is the magnetic moment of the magnet ? (b) The bar magnet is replaced by a solenoid of cross - sectional area 2×10^{-4} m^2 and 1000 turns, but of the same magnetic moment. Determine the current flowing through the solenoid are 0.1×2^nAm^2, nA then n is

EXERCISE-IV

(Time period of oscillation)

Straight Objective Type Questions

1. A long bar magnet of time period T is cut into four equal parts by cutting it perpendicular to both length and breadth. The time period of each part is

1) T/4 2) T/16 3) T/32 4) T/2

2. Two magnets are placed one above the other with like poles together the time period of this combination is 10seconds. Now they are placed one above the other with unlike poles together the time period of this combination in the same field is 20sec. The ratio of magnetic moments is

1) 3:1 2) 5:1 3) 5:3 4) 3:5

3. A bar magnet suspended in a field of induction 1.5×10^{-6}T has a time period $\frac{\pi}{5}$sec. The moment of inertia about the axis of suspension is 1.5×10^{-4} kgm^2. The magnetic moment of the magnet is

1) 10000Am^2 2) $\frac{1}{16}$Am^2 3) 10Am^2 4) 1 Am^2

4. With a standard rectangular bar magnet of length (l) breadth ($b << l$) and magnetic moment M, the time period of magnet in a vibration magnetometer is 4 s. If the magnet is cut normal to its length into 4 equal pieces, the time period (in seconds) with one of the pieces is

1) 16 2) 2 3) 1 4) $\frac{1}{4}$

5. A bar magnet is oscillating in a magnetic field and its frequency is 10Hz. If another identical piece of brass be placed over that magnet, the frequency of that combination in that field is

1) 20 Hz 2) 10 Hz 3) $\frac{10}{\sqrt{2}}$ Hz 4) $10\sqrt{2}$ Hz

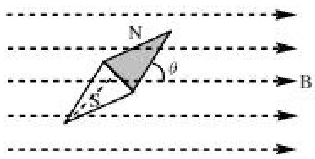
6. A bar magnet freely suspended in a vibration magnetometer has time period T at a place A and T/2 at a place B. If horizantal Component of earth's magnetic field at A is 36×10^{-6} T, then its value at 'B' is
   1) 100×10^{-6}T 2) 72×10^{-6}T 3) 144×10^{-6}T 4) None

7. A bar magnet suspended freely in uniform magnetic field is vibrating with a time period of 3 seconds.If the field strength is increased to four times of the earlier field strength,the time period will be (in seconds)
   1) 12 2) 6 3) 1.5 4) 0.75

8. The magnet supended in uniform magnetic field is heated so as to reduce its magnetic moment by 19%. By doing this, the time period of the magnet will
   1) increases by 11% 2) decreases by 19% 3) increases by 19% 4) decreases by 4%

Numerical Value Type Questions

9. In Fig. the magnetic needle has magnetic moment 6.7×10^{-2} Am^2 and moment of inertia I = 7.5×10^{-6} kg m^2. It performs 10 complete oscillations in 6.70 s. What is the magnitude of the magnetic field ?



10. A magnet has time period 'T' in a certain magnetic field. If an identical magnet be kept over it with their moments perpendicular to each other now the time period is $\frac{1}{2^n}$ then n is

EXERCISE-V

(Earth's magnetism)

Straight Objective Type Questions

1. A Dip circle lying initially in the magnetic meridian, the angle of dip is 45^0. Now dip circle is rotated through 30^0 in the horizontal plane. The apparent angle of dip is
   1) $\text{Tan}^{-1}\frac{2}{\sqrt{3}}$ 2) $\text{Tan}^{-1}\frac{\sqrt{3}}{2}$ 3) $\text{Tan}^{-1}2$ 4) $\text{Tan}^{-1}\frac{1}{2}$

2. If at any place, the angle of dip is θ and magnetic latitude is λ, then
   1) $2\tan\theta=\tan\lambda$ 2) $\tan\theta=2\tan\lambda$ 3) $\sqrt{3}\tan\theta=\tan\lambda$ 4) $\tan\theta=\sqrt{3}\tan\lambda$

3. A ship is sailing due to west according to mariner's compass. If the diclination of the place is 15° east of north what is the true direction of ship
   1) 75^0 2) 15^0 3) 90^0 4) 85^0

4. The values of apparent angles of dip at two places at right angles to each other are 30° and 45°. calculate the true value of angle of dip at the place
   1) 16.6^0 2) 36.6^0 3) 46.6^0 4) 26.6^0

Numerical Value Type Questions

5. If the angles of dip at two places are 30^0 and 45^0 respectively, then the ratio of horizontal components of Earth's magnetic field at the two places will be $\sqrt{\frac{2n+1}{2n}}$ then n is

6. The true value of dip at a place is 45^0. If the vertical plane carrying the needle is turned through 60^0 from the magnetic meridian, the apparent dip is $\tan^{-1}(p)$ then p is

EXERCISE-VI

(Properties of magnetic materials)

Straight Objective Type Questions

1. A magnetising force of $360Am^{-1}$ produces a magnetic flux density of 0.6T in a ferromagnetic material. The susceptibility of the material is

1) 1625 2) 1329 3) 2105 4) 1914

2. The magnetic susceptibility of a material of a rod is 499. Permeability of vaccum is $4\pi\times10^{-7}$ H/m. The absolute permeability of the material of the rod in henry/meter is

1) $\pi\times10^{-4}$ 2) $2\pi\times10^{-4}$ 3) $3\pi\times10^{-4}$ 4) $4\pi\times10^{-4}$

3. The mass of an iron rod is 80 gm and its magnetic moment is 10 Am^2. If the density of iron is 8 gm/c.c. Then the value of intensity of magnetisation will be

1) 10^6 A/m 2) 10^4 A/m 3) 10^2 A/m 4) 10 A/m

4. A bar magnet has a coercivity 4×10^3 Am^{-1}. It is desired to demagnetise it by inserting it inside a solenoid 12cm long and having 60 turns. The current that should be sent through the solenoid is

1) 2A 2) 4A 3) 6A 4) 8A

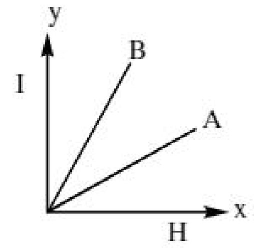
5. A rod of cross sectional area 10 cm^2 is placed with its length parallel to a magnetic field of intensity 1000 A/M the flux through the rod is 10^4webers. Then the permeability of material of rod is

1) 10^4 wb/Am 2) 10^3 wb/Am 3) 10^2 wb/Am 4) 10 wb/Am

6. Find the percentage increase in the magnetic field B. When the space with in the current carrying magnetic field source is filled with aluminium. The susceptability of aluminium is 2.1×10^{-5}

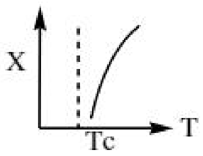
1) 1.1×10^{-3} 2) 3.1×10^{-3} 3) 2.1×10^{-3} 4) none

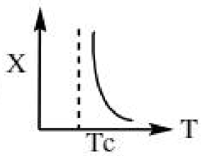
7. The following figure shows the variation of intensity of magnetisation verses the applied magnetic field intenisty H for the two magnetic materials A and B indentify the materials A and B

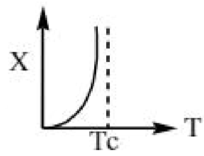


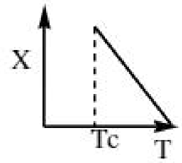
1) both are para 2) both are dia 3) both are ferro 4) A is para B is ferro

8. The variation of magnetic susceptability with temperature of ferro magnetic material can be plotted as

1) 

2) 

3) 

4) 

9. An iron sample having mass 8.4kg repeatedly taken over cycles of magnetisation and demagnetisation at the rate 50cps. It is found that 3.2×10^4 J of energy is dissipated as heat in 30min. Find energy dissipated perunit volume per cycle in the iron sample (density fo iron 7200 kg/m^3)

1) 304.8 2) 404.8 3) 504.8 4) 804.8

Numerical Value Type Questions

10. The magnetic induction and the intensity of magnetic field inside an iron core of an electromagnet are 1 Wbm^{-2} and 150 Am^{-1} respectively. The relative permeability of iron is $\frac{10^{2n+1}}{3n\pi}$ then n is

11. A bar magnet of magnetic moment $10Am^2$ has a cross sectional area of 2.5×10^{-4} m^2. If the intensity of magnetisation of the magnet is 10^6 A/m, then the length of magnet is

KEY SHEET (PRACTICE SHEET)

EXERCISE-I	1) **2**	2) **4**	3) **2**	4) **1**	5) **2**	6) **2**	7) **1**	8) **4**
	9) **3**	10) **5.76**	11) **4**					
EXERCISE-II	1) **4**	2) **1**	3) **3**	4) **3**	5) **2**	6) **1**	7) **4**	8) **5**
EXERCISE-III	1) **1**	2) **2**	3) **1**	4) **4**	5) **2**	6) **1**	7) **1**	8) **4**
	9) **2**	10) **2**	11) **2**					
EXERCISE-IV	1) **4**	2) **3**	3) **1**	4) **3**	5) **3**	6) **3**	7) **3**	8) **1**
	9) **0.01 T**		10) **4**					
EXERCISE-V	1) **1**	2) **2**	3) **1**	4) **4**	5) **1**	6) **2**		
EXERCISE-VI	1) **2**	2) **2**	3) **1**	4) **4**	5) **1**	6) **3**	7) **4**	8) **2**
	9) **1**	10) **2**	11) **0.04m**					