UNIT-III MAGNETIC EFFECT OF CURRENT AND MAGNETISM

FORMULA AT A GLANCE

Magnetic Flux, $\phi = \vec{B} \cdot \Delta\vec{S}$

Bohr Magneton,

$$(\mu_e)_{min} = \frac{eh}{4\pi m_e} = 9.27 \times 10^{-24}\ \text{Am}^2$$

Magnetic inclination (or Dip)

$$\tan\delta = \frac{B_V}{B_H};\ \delta \rightarrow \text{angle of dip}$$

Intensity of magnetization $I_m = \frac{M}{V}$

Relative permeability (μ)

$$\frac{\mu}{\mu_0} = \mu_r = (1 + \chi_m)$$

Magnetic Dipole Moment (Am^2)

$$\vec{M} = I\vec{A} = m \times (2\vec{l})$$

Magnetic field due to a **Bar Magnet**

Axial, $B_{axial} = \frac{\mu_0}{4\pi}\left[\frac{2Mr}{(r^2 - l^2)^2}\right]$

If, $l << r$, $B_{axial} = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$

Equatorial, $B_{eq} = \frac{\mu_0}{4\pi}\left[\frac{M}{(r^2 + l^2)^{\frac{3}{2}}}\right]$

If, $l << r$, $B_{eq} = \frac{\mu_0}{4\pi}\frac{M}{r^3}$

Gyromagnetic ratio,

$$\frac{\mu_e}{l} = \frac{e}{2m_e} = 8.8 \times 10^{10}\ \text{C/kg}$$

Motion of Charged Particle

Displacement due to

Electric field, $y = \frac{qE}{2m}\left(\frac{x}{v_x}\right)^2$

Magnetic force,

$$\vec{F} = q\left(\vec{v} \times \vec{B}\right) \text{ or } F = Bqv\sin\theta$$

Lorentz Force (Electric & magnetic)

$$\vec{F} = q\vec{E} + q\left(\vec{v} \times \vec{B}\right)$$

Magnetic Field Tesla (T)

10^4 Gauss = 1 T

Straight current carrying conductor

$$B = \frac{\mu_0 I}{2\pi R}$$

At a point on the axis of a current carrying loop

$$B = \frac{\mu_0 I}{4\pi}\frac{2\pi a^2}{\left(a^2 + x^2\right)^{\frac{3}{2}}}$$

For $a << x$, $B = \frac{\mu_0 I a^2}{2x^3}$

For n loops, $B = \frac{\mu_0 n I a^2}{2x^3}$

When, $x = 0$, (*i.e.* at the centre of a circular loop) $B = \frac{\mu_0 I}{2a}$

For n loops, $B = \frac{\mu_0 n I}{2a}$

Magnetic intensity (or magnetic field strength)

$$H = \frac{B_0}{\mu_0} = nI$$

$n \rightarrow$ no. of turns/length

Biot-Savart Law

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,d\vec{l} \times \vec{r}}{r^3}$$

$$|d\vec{B}| = \frac{\mu_0}{4\pi}\frac{I\,dl\sin\theta}{r^2}$$

The Cyclotron

Radius of circular path, $r = \frac{mv}{qB}$

Period of circular motion $T = \frac{2\pi m}{Bq}$

Frequency, $\nu = \frac{1}{T} = \frac{Bq}{2\pi m}$

Maximum energy of the positive ions,

$$\frac{1}{2}mv_{max}^2 = \frac{B^2 q^2 r^2}{2m} = qV$$

Radius w.r.t. maximum velocity,

$$r = \frac{1}{B}\left(\frac{2mV}{q}\right)^{\frac{1}{2}}$$

Maximum velocity, $v_{max} = \frac{Bqr}{m}$

Radius of helical path when $\vec{v}$ and $\vec{B}$ are inclined to each other by and angle θ

$$r = \frac{mv\sin\theta}{qB}$$

Current loop as a magnetic dipole

$$B = \frac{\mu_0}{4\pi}\frac{2M}{x^3}$$

Ampere's Circuital Law

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I$$

Magnetic Field

Long straight solenoid, $B = \mu_0 nI$

At the end of solenoid, $B = \frac{1}{2}\mu_0 nI$

If solenoid is filled with of material of permeability (μ_r) $B = \mu_0\mu_r nI$

Inside toroidal solenoid, $B = \mu_0 nI$

Gauss' Law in magnetism $\oint_S \vec{B} \cdot d\vec{S} = 0$

Period of oscillation of bar magnet if external magnetic field

$$T = 2\pi\sqrt{\frac{I}{MB}}$$

Current Carrying Conductor

Placed in a Magnetic Field, $\vec{F} = I\vec{l} \times \vec{B}$

Force/length b/w 2 Parallel

Conductors $\phi = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r}$

Torque on a rectangular current carrying loop

$$\tau = BIA\sin\theta$$

$\theta \rightarrow$ angle b/w wire & B

If coil has n turns, $\tau = nBIA\sin\theta$

$$\vec{\tau} = \vec{M} \times \vec{B},\ \tau = nBIA\cos\alpha$$

$\alpha \rightarrow$ angle b/w plane of loop & B

Potential energy in magnetic field

$$U = -\vec{M} \cdot \vec{B}$$

Magnetic induction (or Magnetic flux density or Magnetic field)

$$B = B_0 + \mu_0 I_m = \mu_0(H + I_m)$$

Magnetic permeability, $\mu = \frac{B}{H}$

Current in Galvanometer

$$I = \frac{k}{nBA}\phi = G\phi$$

$G \rightarrow$ galvanometer constant

$\phi \rightarrow$ Angle by which coil rotates

Galvanometer Sensitivity

(or Current Sensitivity) $\frac{\phi}{I} = \frac{nBA}{k} = \frac{1}{G}$

Voltage sensitivity $\frac{\phi}{V} = \frac{nBA}{kR} = \frac{1}{GR}$

Curie's Law, $\frac{I_m}{H} = \chi_m = \frac{C}{T}$

Magnetic susceptibility

$$\chi_m = \frac{I_m}{H}$$

SYNOPSIS

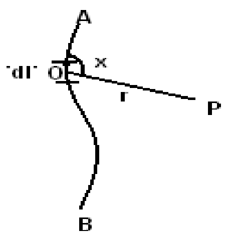
A magnetic field is a region or space around a current carrying conductor or a magnet where a magnetic force can be experienced.

Biot- Savart's Law

Consider a conductor AB carrying current 'I'. Let 'dl' be the small section of the conductor at a distance 'r' from point 'P', 'dl' making an angle 'x' with OP.

$dB \propto I\, dl \sin x / r^2$

$$dB = \frac{\mu_0 I\, dl \sin x}{4\pi r^2}$$ where dB is the magnetic field at point P due to segment dl.



μ_0 is the absolute magnetic permeability of air or vacuum.

$\mu_0 = 4\pi \times 10^{-7}$ Tm/ A

Case 1: $x = 90^0$, dB is maximum.

Case 2: $x = 0^{0,}$ dB is minimum.

Ampere's Circuital Law states that the line integral of magnetic field around any closed path in free space is equal to μ_0 times the net current passing through the closed path. $\int B.dl = \mu_0 I$

Magnetic Lorentz force is the force experienced by the charge q moving with velocity v in magnetic field B such that v makes an angle 'θ' with B **$F = q\,(v \times B)$**

Case 1: When charge is at rest **$v = 0$, $F = 0$**

Case 2: Charge is moving parallel to the direction of the magnetic field, **$\theta = 0$, $F = 0$**

Case 3: Charge is moving perpendicular to the direction of the magnetic field, **$\theta = 90^0$ $F = qvB = mv^2/r$** takes a circular path with radius **$r = mv/qB$**

Time period of the charged particle is **$T = 2\pi m/qB$**

Cyclotron Frequency, **$\nu = qB/2\pi m$**

Torque on a current loop in a magnetic field. **$\tau_N = NIAB \sin\theta$**

Moving coil galvanometer is a device used to detect/ measure small electric current.

Principle: when a current carrying loop or coil is placed in the uniform magnetic field, it experiences a torque.

Sensitivity of a galvanometer.

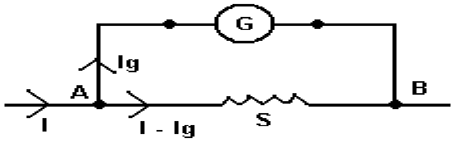
Current Sensitivity can be defined as the deflection produced in the galvanometer per unit current flowing through it.

Current Sensitivity= $\alpha/I = NAB/k$

Voltage Sensitivity of a galvanometer is defined as the deflection produced in the galvanometer per unit voltage applied to it. **Voltage sensitivity= α/ V= NBA/kR**

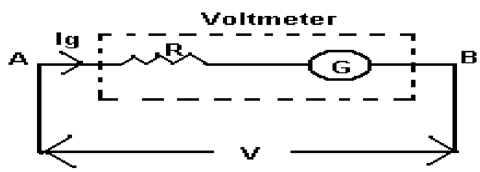
Conversion of galvanometer into ammeter

A galvanometer can be converted into an ammeter by connecting a low resistance called shunt S parallel to the galvanometer. **S= I_g G/(I - I_g)**



Conversion of galvanometer into a voltmeter.

A galvanometer can be converted into a voltmeter by connecting a large resistance R in series to the galvanometer. **R = V/ I_g - G**



Cyclotron is a device used to accelerate positively charged particles (like protons, α- particles, deutron etc.) to acquire enough energy to carry out nuclear disintegrations etc**.**

Principle: When a positively charged particle is made to move time and again in a high frequency electric field and using strong magnetic field, it gets accelerated and acquires sufficiently large amount of energy.

MAGNETISM-SYNOPSIS

Coulomb's Law In Magnetism states that the force between two magnetic poles of strengths 'm_1' and 'm_2' lying at a distance 'r' is proportional to the product of pole strengths and inversely proportional to the square of distance between their centers.

Magnetic Dipole is an arrangement of two magnetic poles of equal and opposite strength separately by a finite distance.

Magnetic dipole moment (M) is numerically defined as the product of the one of the pole strengths and the magnetic length of the magnet is called magnetic dipole moment.

It is a vector quantity, and its direction is from South pole to North pole.

Unit of magnetic dipole moment **is** Am^2

Properties of magnetic lines of force

-Magnetic field lines are continuous and closed curves traveling from North pole to South pole outside the magnet and from South pole to the North pole outside the magnet.

-The tangent at any point on the magnetic field lines gives the direction of the magnetic field (B) at that point.

-Two magnetic field lines of force do not intersect or cross each other. If they cross each other, then at the point of intersection there will be two directions of the magnetic field which is not possible.
-Widely spaced magnetic lines of force represent weak magnetic field and closely spaced lines of force represent strong magnetic field.

Torque on a bar magnet in uniform magnetic field $\tau = MB \sin\theta$

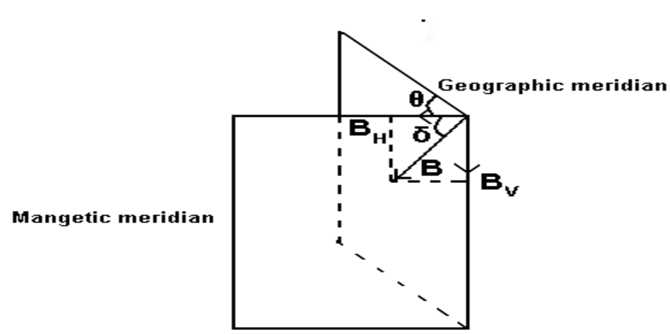
Potential energy of a bar magnet placed in a magnetic field. Work done in rotating a bar magnet in uniform magnetic field $U = MB (\cos\theta_1 - \cos\theta_2)$

Magnetic dipole moment of a revolving electron [Atom as a magnetic dipole]
In an atom, electrons revolve around the nucleus and as such the circular orbits of electrons may be considered as a small circular loop. Due to this, an atom possesses magnetic dipole moment and behave as magnetic dipole. $M = -(e / 2m)L$

Bohr magneton: The magnetic dipole moment associated with an atom due to orbital motion of an electron in the first orbit of hydrogen atom.
1 Bohr magneton, $\mu_B = eh/ 4\pi m$ $\mu_B = 9.2 \times 10^{-24}\ Am^2$

Gauss law in magnetism $\int B. ds = 0$

Terms relating to Geomagnetism
Geographical Meridian is the vertical plane with passes through geographic axis .
Magnetic meridian is the vertical plane which passes through magnetic axis is called magnetic meridian.
Magnetic elements of the earth
The physical quantity which determines completely the magnitude and direction of the magnetic field of the earth at that place.
a)Magnetic Declination 'θ': Angle between the geographic meridian and the magnetic meridian.
b)Magnetic inclination or dip 'δ': Angle between the direction of total intensity of magnetic field of earth and the horizontal component of B



c)Horizontal component of earth's magnetic field: The component of total intensity of magnetic field of earth in the horizontal direction in magnetic meridian.
Horizontal component, $B_H = B \cos \delta$

Vertical component, $B_V = B \sin \delta$

$\tan \delta = B_V / B_H$

Permanent Magnets: Steel is a common material used to make permanent magnets because,
It has high retentivity.,
high coercivity.

Electromagnets: Soft iron is used to make electromagnets.
High retentivity.
Low coercivity.
The hysteresis loop is thin and long which shows during magnetization and demagnetization, energy loss is small.

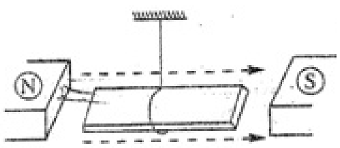
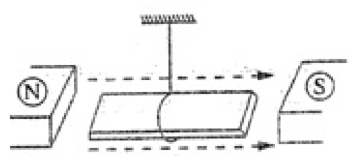
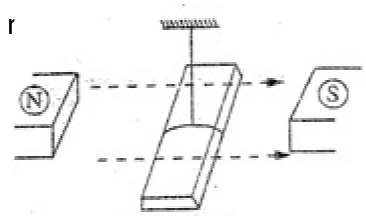
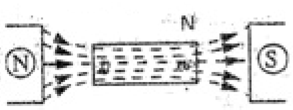
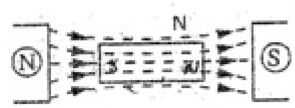
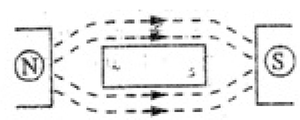
Retentivity: The value of intensity of magnetization (I) of the magnetic material, when the magnetizing field (H) is reduced to zero.

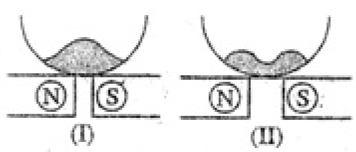
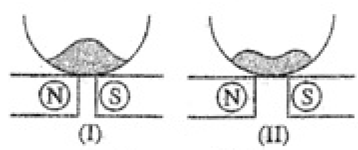
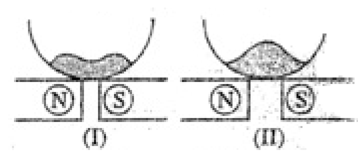
Coercivity: The value of reverse magnetizing field, which has been applied to the magnetic material so as retentivity (residual magnetization) becomes zero.

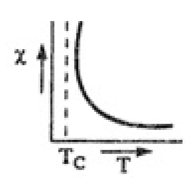
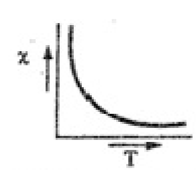
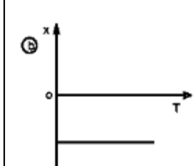
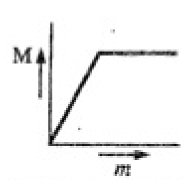
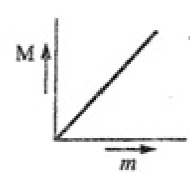
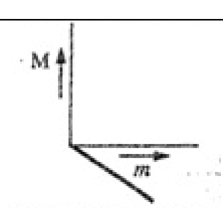
Curie's Law: Magnetic susceptibility of material is inversely proportional to absolute temperature. $\chi_m \alpha 1 / T$, $\chi_m = C / T$ Where C is known as Curie's constant. **Curie Temperature:** The temperature for a ferro- magnetic substance above which it behaves as a para- magnetic substance.

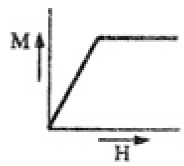
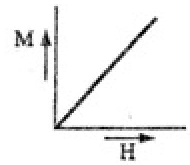
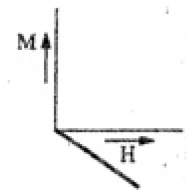
[Type here]

Properties of magnetic materials

Sl. No	Ferro- Magnetic Material	Para- Magnetic Material	Diamagnetic Material
1	They are strongly attracted by a magnet.	They a weakly attracted by a magnet.	They are weakly repelled by a magnet.
2	A freely suspended ferromagnetic rod quickly sets itself along the direction of external magnetic field as shown . 	A freely suspended para-magnetic rod slowly sets itself along the direction of external magnetic field as shown 	A freely suspended diamagnetic rod quickly sets itself at right angle to the direction of external r 
3	When they are placed in a magnetic field, most of the lines of force prefer to pass through them 	When they are placed in a magnetic field, the lines of force prefer to pass through them 	When they are placed in a magnetic field, the lines of force do not prefer to pass through them 
4	B >> H B / H >>1 $\mu >> 1$	B > H B / H >1 $\mu > 1$	B << H B / H <<1 $\mu << 1$
5	Flux density (B) inside a ferro-magnetic material is much larger than in air.	Flux density (B) inside a para-magnetic material is larger than in air.	Flux density (B) inside a diamagnetic material is less than in air.
6	The sample gets strongly magnetized in the direction of magnetizing field.	The sample gets weakly magnetized in the direction of magnetizing field.	The sample gets weakly magnetized in the direction opposite to the field.
7	Intensity of magnetization (I) has large positive value.	Intensity of magnetization (I) has small positive value.	Intensity of magnetization (I) has small negative value.
8	Susceptibility has large positive value.	Susceptibility has small positive value.	Susceptibility has small negative value.
9	They obey Curie's law. At a certain temperature i.e, Curie point ferromagnetic properties disappear and material starts behaving as	They obey Curie's law. They are badly affected with the rise in temperature they lose magnetic property.	They do not obey Curie's law. Normally their magnetic properties do not change with temperature.

	paramagnetic.		
	Iron, Steel, Nickel, Cobalt etc.	Aluminum, Chromium, Manganese, Platinum, Antimony, Sodium.	Gold, Silver, Water, Alcohol, Air, Zinc, Lead, Bismuth, Mercury, Glass, Helium, Argon, Hydrogen.
	Liquids and gases do not show ferromagnetism. If a finely powdered ferromagnetic material in a watch glass is placed on closely spaced magnetic poles and then widely placed magnet poles the effect is observed as shown It shows that such material move from weaker to stronger magnetic field. 	If a paramagnetic liquid in a watch glass is placed on closely spaced magnetic poles and then widely placed magnetic poles the effect is observed as shown in figure. In the first case there is a rise in the middle but in the second case. There is a depression in the middle. It shows that such material move from weaker to stronger magnetic field. 	If a magnetic liquid in a watch glass is closely spaced magnetic poles and then widely placed magnetic poles, the effect is observed as shown in figure. In the first case there is a depression in the middle but in the second case.There is a rise in the middle. It shows that such materials move from stronger to weaker magnetic field. 

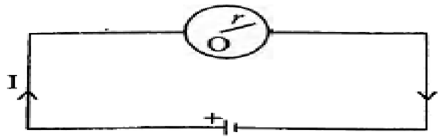
Curve	Ferromagnetic Material	Paramagnetic Material	Diamagnetic Material
Magnetic susceptibility (x)-temperature (T) Curves			
Magnetisation (M)-Magnetic moment (m) Curves			

		Magnetization -- (M) Magnetic Intensity (H)			

S.No.	Question Details	Marks
	MULTIPLE CHOICE QUESTIONS	
1.	A short bar magnet placed with its axis at 30 degrees with a uniform magnetic field of 0.35 T. A torque of 0.055 J is experienced by the magnet. The magnetic moment is: a)0.31J/T b) 0.41J/T c)0.21J/T d)0.51J/T	1
2.	The plane of the coil of a tangent galvanometer is vertical and perpendicular to the magnetic meridian. When a current is passed through the coil of the galvanometer, the magnetic needle deflects by: a)0^0 b) 180^0 c) 60^0 d)either 0^0or 180^0	1
3.	Examples of diamagnetic, paramagnetic and ferromagnetic materials are respectively. a) copper, aluminum, iron b) aluminum, copper, iron c)copper, iron, aluminum d)aluminum, iron, copper	1

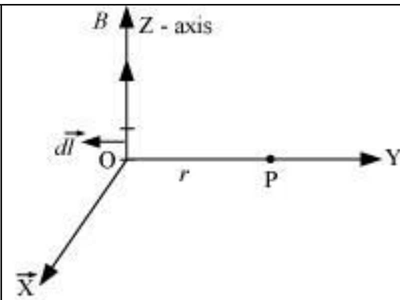
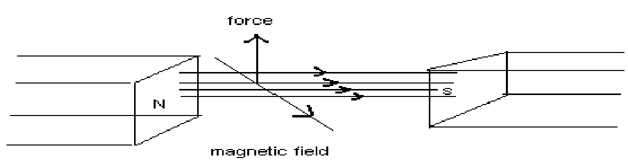
4.	Electromagnets are made of soft iron because sof iron has : a) low susceptibility and low retentivity b) low susceptibility and high retentivity c) high permeability and low retentivity d) low permeability and low retentivity	1
5.	In a certain place, the horizontal component of magnetic field is $1/\sqrt{3}$times the vertical component. The angle of dip at this place is a)0 b) $\pi/3$ c)$\pi/6$ d)$\pi/4$	1
6.	A proton and an alpha particle having the same initial speed enter a region of uniform magnetic field and describe circular paths. If the radii of the circles are R_1 and R_2respectiely, the ratio $R_1:R_2$ is a) 1:1 b) 1:2 c)1:4 d)2:1	1
7.	A proton, a deuteron and an α–particle with the same kinetic energy enter a region of uniform magnetic field moving at right angles to B. What is the ratio of the radii of their circular paths? **a)1: $\sqrt{2}$: 1** **b)1: 1: 1** **c)2: 1: 1** **d)$\sqrt{2}$: $\sqrt{2}$: 1**	1

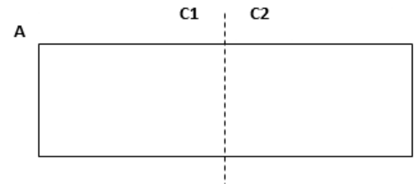
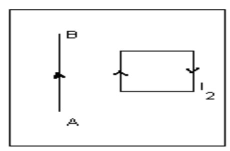
8.	A shunt resistance required to allow 4% of the main current through the galvanometer of resistance 48Ω is a)1 Ω b)2 Ω c)3 Ω d)4 Ω	1
9.	Biot _Savart law can be expressed alternatively as: a) Coulomb's law b) Ampere's circuital law c)Ohm's law d)Gauss' law	1
10)	If the number of turns in a moving coil galvanometer of current sensitivity C and voltage sensitivity V is doubled, then a) C remains unchanged, but V is doubled b) Both C and V are halved c)Both C and V are doubled d)C is doubled and V remains unchanged	1
11)	A galvanometer of resistance G is converted into an ammeter using a Shunt of resistance R. If the ratio of the heat dissipated through the galvanometer and shunt is 3:4, then R equals: a)4/3G b)3/4G c)16/9G d)9/16 G	1

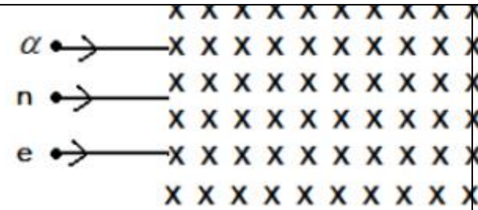
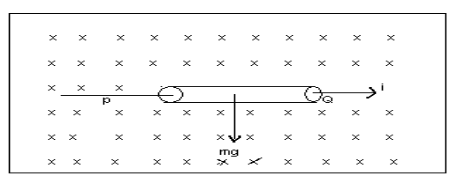
12)	A single turn circular coil is connected to a cell as shown. Magnetic field at the centre O of the coil is:  a) $2\pi I/r$ b) $2\pi Ir$ c)zero d)$I/\pi r$	1
13.	To protect galvanometer from possible damages due to large current, which of the following is connected to its coil: a) low resistance wire in series b) low resistance wire in parallel c)high resistance wire is series d)high resistance wire in parallel	1
14.	A circular loop of magnetic moment M is in an arbitrary orientation in an external magnetic field B. The work done to rotate the loop by 30°about an axis perpendicular to its plane is: a) MB b) MB/2 c) $\sqrt{3}$ MB/2 d) zero	1
15.	Biot -savart law indicates that the moving electrons (velocity v) produce a magnetic field B such that a) it obeys inverse cube law b) it is along the line joining the electron and point of observation c) $\vec{B} \perp \vec{v}$ d) $\vec{B} \parallel \vec{V}$	1
	FILL IN THE BLANKS	
1.	The earth's magnetic field at the equator is approximately 0.4G, the earth's diploe moment is ………..	1

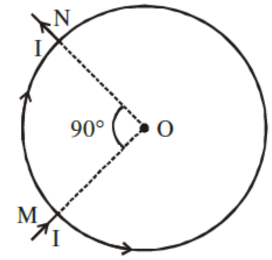
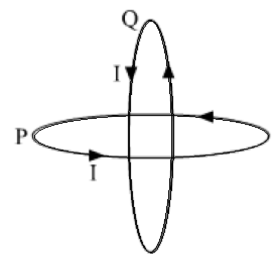
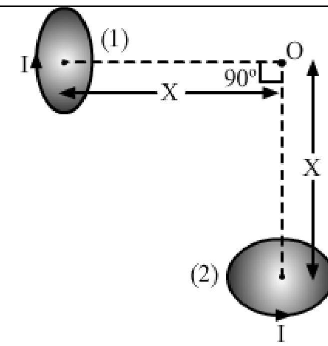
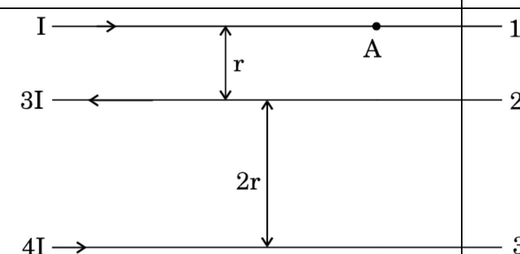
2.	The relative permeability of a substance is 0. 9999.The nature of the substance will be ……………	1
3.	The suspension wire in a moving coli galvanometer has ……. torsional constant	1
4.	At a place, horizontal and vertical components of earth's magnetic field are equal. The angle of dip at that place is ……….	1
5.	SI unit of magnetic pole strength is …….	1
6.	The resistance of the ideal ammeter is ………and ideal voltmeter is……….	1
7.	When a coil carrying current is set with its plane perpendicular to the direction of magnetic field, then torque on the coil is…….	1
8.	A moving charge is a source of ……as well as …….	1
9.	The magnetic field induction is ……for a point on the surface of a solid cylinder carrying current and is ……. for a point on the axis of the cylinder	1
10.	Ampere's law is applicable for …………. current distribution whereas the Biot Savart's law is applicable for ………. current distribution	1
	Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below. **a) Both A and R are true and R is the correct explanation of A** **b) Both A and R are true and R is NOT the correct explanation of A 1** **c) A is true but R is false** **d) A is false and R is also false**	
1.	**Assertion:** Free electrons always keep on moving in a conductor even then no magnetic force act on them in magnetic field unless a current is passed through it. **Reason:** The average velocity of free electron is zero.	
2.	**Assertion:** A proton and an alpha particle having the same kinetic energy are moving in circular paths in a uniform magnetic field. The radii of their circular paths will be equal. **Reason:** Any two charged particles having equal kinetic energies and entering a region of uniform magnetic field B in a direction	

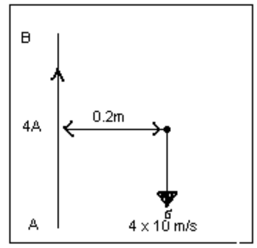
	perpendicular to B, will describe circular trajectories of equal radii.	
3.	**Assertion:** A charge, whether stationary or in motion produces a magnetic field around it. **Reason :** Moving charges produce only electric field in the surrounding space.	
4.	**Assertion:** To convert a galvanometer into an ammeter a small resistance is connected in parallel with it. **Reason:** The small resistance increases the combined resistance of the combination.	
5.	**Assertion:** Ferro-magnetic substances become paramagnetic above Curie temp. **Reason:** Domains are destroyed at high temperature.	
	VERY SHORT ANSWER QUESTIONS	
1.	Why do magnetic lines of force form continuous closed loops?	**1**
2.	A solenoid tends to contract when a current passed through it. Justify the given statement.	**1**
3.	An electron does not suffer any deflection while passing through a region of uniform magnetic field, what is the direction of magnetic field?	**1**
4.	Equal currents are flowing through two infinitely long parallel wires. What will be the magnetic field at a point midway when the currents are flowing in the same direction?	**1**
5.	Why are the field lines repelled when diamagnetic material is placed in an external uniform magnetic field?	**1**
6.	Mention two characteristics properties of the material suitable for making the core of the transformer?	**1**
7.	What is the nature of magnetic field in a moving coil galvanometer?	**1**

8.	In what condition a charged particle moving through a magnetic field follow a circular path?	**1**
9.	The magnetic field lines prefer to pass through the iron bar. Why?	**1**
10.	A magnetic needle free to rotate in a vertical plane, orients itself vertically at a certain place on earth. what are the values of horizontal component of earth's mag field and angle of dip at that place?	**1**
11.	A current I flows in a conductor placed perpendicular to the plane of the paper. Indicate the direction of the magnetic field due to a small element d $\vec{l}$ at point P situated at distance $\vec{r}$ from the element as shown in the figure. 	**1**
12.	What is the magnetic field intensity due to a current carrying toroidal solenoid (i) inside the toroid and (ii) outside the toroid?	**1**
13.	How will the magnetic field intensity at the center of a circular coil change, if the current through the coil is doubled and the radius of the coil is halved?	**1**
14.	A charged particles enters into a uniform magnetic field and experiences an upward force as indicated in the figure. What is the charge sign on the particle? 	**1**
15.	State two properties of the wire used for suspension of the coil in a moving coil galvanometer?	**1**
16.	What is the magnetic field intensity due to a current carrying toroidal solenoid (i) inside the toroid and (ii) outside the toroid?	**1**
17.	A proton and an electron travelling along parallel paths enter a region of uniform magnetic field, acting perpendicular to their paths. Which of them will move in a circular path with higher frequency ?	**1**
18.	An ammeter and a milliammeter are converted from the same galvanometer. Out of the two, which current measuring instrument has higher resistance?	**1**

19.	Which one of the following will describe the smallest circle when projected with the same velocity v perpendicular to the magnetic field B (i) α-particle ,and (ii) β-particle?	**1**
20.	What is the angle of dip at a place where the horizontal and vertical components of earth's magnetic field are equal?	**1**
21.	A bar magnet (AB)is cut into two equal parts .One part is now kept over the other ,so that **C2** is above **C1**. If **M** is the magnetic moment of the original magnet, what would be the magnetic moment of the combination so formed ? 	**1**
	2 MARK QUESTIONS	
22.	Two wires of equal lengths are bent in the form of two loops. One of the loop is square shaped whereas the other loop is circular .These are suspended in a uniform magnetic field and the same current is passed through them. Which loop will experience greater torque?	**2**
23.	In the figure, the straight wire AB is fixed while the loop is free to move under the influence of the electric currents flowing in them. In which direction does the loop begin to move? Give reason for your answer. 	**2**
24.	A charged particle, having a charge ***q***, is moving with a speed v along the x-axis. It enters a region of space where an electric field ***E(= Ej***) and a magnetic field B are both present. The particle, on emerging from this region, is observed to be moving along the x-axis only. Obtain an expression for the magnitude of B in terms of **v** and E**.** Give the direction of B.	**2**
25.	Two identical circular coils, p and q each of radius r, carrying current 1 a and √3 a respectively, are placed concentrically and perpendicular to each other lying in the xy and yz planes. find the magnitude and direction of the net magnetic field at the centre of the coils	**2**
26.	An electron and a proton, moving parallel to each other in the same direction with equal momenta, enter into a uniform magnetic field which is at right angles to their velocities. Trace their trajectories in the magnetic field.	**2**

27.	A neutron, an electron and an alpha particle moving with equal velocities enter a uniform magnetic field directed into the plane of the paper as shown. Trace their paths in the field and justify your answer 		**2**
28.	A magnetic needle free to rotate in a horizontal position orients itself with its axis vertical at a certain place on the earth. What are the values of (i)angle of dip and (ii)horizontal component of earth's field at this place? Where will this place be on earth?		**2**
29.	The susceptibility of a magnetic material is -0. 085.Identify the magnetic type of the material kept in a non-uniform magnetic field. Draw the modified field pattern.		**2**
30.	A short bar magnet of magnetic moment 0.9 JT^{-1}, is placed with its axis at 45^0 to a uniform magnetic field .If it experiences a torque of 0.063 joule,(i)Calculate the magnetic field and (ii) When orientation of the bar magnet corresponds to the stable equilibrium in the magnetic field ? [B= 0.099 T]		**2**
31.	What should be the orientation of a magnetic dipole in a uniform magnetic field so that its potential energy is (i) maximum and (ii) minimum?		**2**
32.	How does the (i) pole strength and (ii) magnetic moment, of each part of a bar magnet change, if it is cut into two equal pieces transverse to its length?		**2**
	3 MARK QUESTIONS		
33.	A coil of 200 turns has a cross sectional area $900mm^2$. It carries a current of 2 ampere. The plane of the coil is perpendicular to a uniform magnetic field 0.5 T. Calculate (i) the magnetic moment of the coil and (ii) the torque acting on the coil. [0.36 Am^2,0.18Nm]		**3**
34.	A current carrying conductor PQ of length 1 m, mass$4.4x10^{-3}$ kg and resistance 50 milli-ohm is kept in a uniform magnetic field of 1.8 mT as shown in the figure. A) State the rule for finding the direction of the force experienced by the conductor in the magnetic field. Indicate the direction of the force on PQ. B)Calculate the potential difference V that must be applied to the conductor PQ so that it remains in equilibrium in the magnetic field.[1.2V]		**3**

35.	A current 'I' enters a uniform circular loop of radius 'R' at point M and flows out at N as shown in the figure. Obtain the net magnetic field at the centre of the loop.		
36.	Find the magnitude and direction of the net magnetic field at the common centre of the two coils.		
37.	Two very small identical circular loops, (1) and (2), carrying equal currents I are placed vertically (with respect to the plane of the paper) with their geometrical axes perpendicular to each other as shown in the figure. Find the magnitude and direction of the net magnetic field produced at the point O.		
38.	The figure shows three infinitely long straight parallel current carrying conductors. Find the (i) magnitude and direction of the net magnetic field at point A lying on conductor 1, (ii) magnetic force on conductor 2.		
39.	State the principle of a moving coil galvanometer? Prove that the current flowing through the coil of a moving coil galvanometer is directly proportional to its deflection.		**3**

<table>
<tr>
<td>40.</td>
<td>A long straight wire AB carries a current of 4A. A proton A travels at $4x10^6$ m/s parallel to the wire,0.2 m from it and in a direction opposite to the current as shown in the figure .Calculate the force which the magnetic field of current exerts on the proton also specify the direction of the force.[$2.56x10^{-11}$N away from wire AB]</td>
<td>
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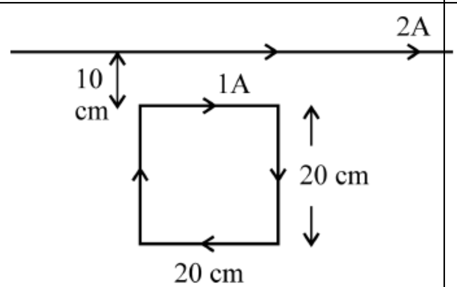
<td>41.</td>
<td>A square loop of side 20 cm carrying current of 1A iskept near an infinite long straight wire carrying a current of 2A in the same plane as shown in the figure.Calculate the magnitude and direction of the net force exerted on the loop due to the current carrying conductor</td>
<td>
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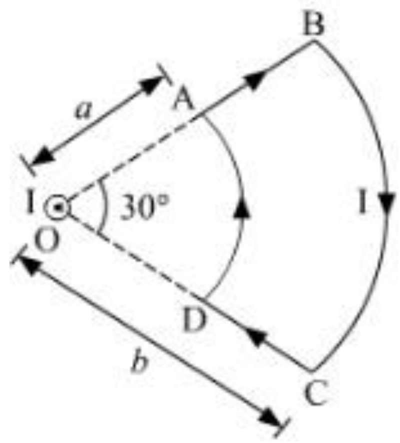
<tr>
<td>42.</td>
<td>A current loop ABCD is held fixed on the plane of the paper as shown in the figure. The arcs BC (radius = b) and DA (radius = a) of the loop are joined by two straight wires AB and CD. A steady current I is flowing in the loop. Angle made by AB and CD at the origin O is 30^o.Another straight thin wire with steady current I_1 flowing out of the plane of the paper is kept at the origin. The magnitude of the magnetic field (B) due to loop ABCD at the origin (O) is</td>
<td>
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<td>3</td>
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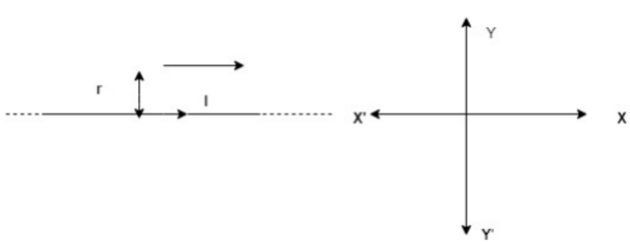
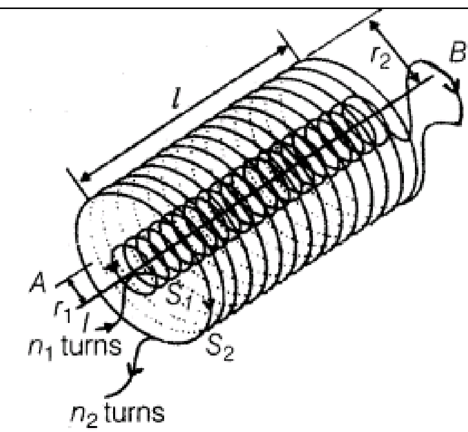
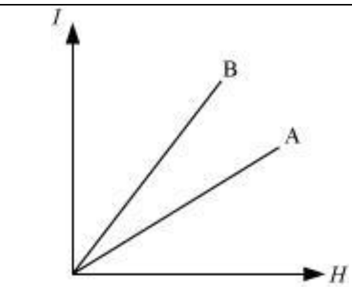
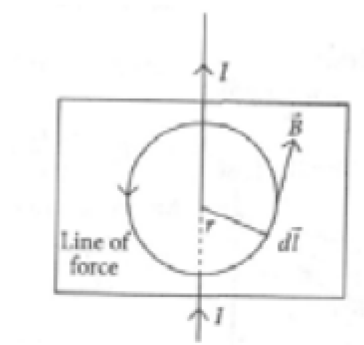
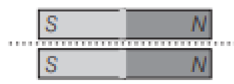
<tr>
<td>43.</td>
<td colspan="2">A particle of mass m and charge q is in motion at speed v parallel to a long straight conductor carrying current I as shown below. Find magnitude and direction of electric field required so that the particle goes undeflected.

</td>
<td>3</td>
</tr>
</table>

44.	State the Lorenz's force and express it in vector form. Which pair of vectors are always perpendicular to each other ? Derive the expression for the force acting on a current carrying conductor of length L in a uniform magnetic field 'B'.	**3**
45.	A beam of alpha particles and of protons, enter a uniform magnetic field B at right angles to the field lines. The particles describe circular paths. Calculate the ratio of the radii of their paths, when they enter the field with the a) same momentum b) same kinetic energy?	**3**
46.	State Ampere's circuital law expressing it in the integral form, (ii) Two long co-axial insulated solenoids and S_2 of equal length are wound one over the other as shown in the figure.A steady current / flows through the inner solenoid S_x to the other end B which is connected to the outer solenoid through which the some current / flows in the opposite direction so, as to come out at end A. If n_x and n_2 are the number of turns per unit length, find the magnitude and direction of the net magnetic field at a point (a)inside on the axis b)outside the combined system 	**3**
47.	How can a moving coil galvanometer by converted in to an ammeter? To increase the current sensitivity of a moving coil galvanometer by 50% , its resistance becomes twice its initial resistance. By what factor does its voltage sensitivity change?	3
48.	A square shaped plane coil of area 100 cm^2 of 200 turns carries a steady current of 5A. It is placed in a uniform magnetic field of 0.2 T acting perpendicular to the plane of the coil. Calculate the torque on the coil when its plane makes an angle of 60° with the direction of the field. In which orientation will the coil be in stable equilibrium?	3
49.	A galvanometer of resistance 'G' can be converted into a voltmeter of range (0-V) volts by connecting a resistance 'R' in series with it. How much resistance will be required to change its range from 0 to V/2 ?	3
50.	A galvanometer of resistance G is converted into a voltmeter to measure upto V volts by connecting a resistance R1 in series with the coil. If a resistance R2 is connected in series with it, then it can measure upto V/2 volts. Find the resistance, in terms of R1 and R2, required to be connected to convert it into a voltmeter that can read upto 2 V. Also find the resistance G of the galvanometer in terms of R1 and R2.	3

51.	A bar magnet of magnetic moment 6 J/T is aligned at 60dgree with a uniform external magnetic field of 0·44 T. Calculate (a) the work done in turning the magnet to align its magnetic moment (i) normal to the magnetic field, (ii) opposite to the magnetic field, and (b) the torque on the magnet in the final orientation in case (ii).	3
52.	(a)An iron ring of relative permeability μr has windings of insulated copper wire of n turns per meter. When the current in the windings is I, find the expression for the magnetic field in the ring. (b) The susceptibility of a magnetic material is 0·9853. Identify the type of magnetic material. Draw the modification of the field pattern on keeping a piece of this material in a uniform magnetic field.	**3**
53.	A coil of 400 turns has a cross sectional area $100mm^2$. It carries a current of 4 ampere. The plane of the coil is perpendicular to a uniform magnetic field 1 T. Calculate (i) the magnetic moment of the coil and (ii) the torque acting on the coil.	**3**
54.	The following figure shows the variation of intensity of magnetization versus the applied magnetic field intensity, H_j for two magnetic materials A and B:a) Identify the materials A and B. (b) Why does the material B have a larger susceptibility than A for a given field at constant temperature? 	**3**
	5 MARK QUESTIONS	
55.	With the help of a neat labeled diagram, state the principle of moving coil galvanometer? Show that the current in the coil is directly proportional to the deflection of the coil? A galvanometer with a coil of resistance 12 ohms shows a full scale deflection for a current of 2.5mA. How will you convert the galvanometer int an ammeter of range 0 to 7.5A? [s= 0.004 Ω connected in parallel to the galvanometer]	**5**
56.	(a)State Biot-savart law. (b)Two parallel coaxial circular coils of equal coils of equal radius R and equal number of turns N carry equal currents I in the same direction and are separated by a distance 2R.Find the magnitude and direction of the net magnetic field produced at the mid-point of the line joining their centers.	**5**
57.	(a) Write the expression for the equivalent magnetic moment of a planer current loop of area A, having N turns and carrying a current i. Use the expression to find the magnetic dipole moment of a revolving electron. (b) A circular loop of radius r, having N turns and carrying current I, is kept in the XY plane. It is then subjected to a uniform magnetic field B = Bx i + By j + Bz k. Obtain expression for the magnetic potential energy of the coil-magnetic field system.	**5**

58.	Distinguish the magnetic properties of dia-, para- and ferro-magnetic substances in terms of (i) susceptibility (ii) magnetic permeability and (iii) coercivity. Give one example of each of these materials. Draw the field lines due to an external magnetic field near a (i) dia-magnetic (ii) paramagnetic substance.	**5**
	CASE STUDY	
59.	Ampere's law gives a method to calculate the magnetic field due to given current distribution. According to it, the circulation $\oint \vec{B} \cdot d\vec{l}$ 'of the resultant magnetic field along a closed plane curve is equal to μ 0 times the total current crossing the area bounded by the closed curve provided the electric field inside the loop remains constant. Ampere's law is more useful under certain symmetrical conditions. Consider one such case of a long Straight wire with circular cross-section (radius R) carrying current I uniformly distributed across this cross-section.  (i) Find the magnetic field at a radial distance r from the center of the wire in the region r >R (ii) The magnetic field at a distance r in the region r <R (iii) A long straight wire of a circular cross section (radius a) carries a steady current I and the current I is uniformly distributed across this cross-section. Draw a graph which represents the variation of magnitude of magnetic field B with distance r from the centre of the wire? OR A long straight wire of radius R carries a steady current I . The current is uniformly distributed across its cross-section. Find the ratio of magnetic field at R/2 and 2R.	**4**

60.	Magnets A magnet is a material or object that produces a magnetic field. This magnetic field is invisible but is responsible for the most notable property of a magnet which is a force that pulls on other ferromagnetic materials, such as iron, steel, nickel, cobalt, etc., and attracts or repels other magnets. An everyday example is a refrigerator magnet used to hold notes on a refrigerator door. Magnet's magnetic moment (also called magnetic dipole moment and usually denoted by m) is a vector that characterizes the magnet's overall magnetic properties. For a bar magnet, the direction of the magnetic moment points from the magnet's south-pole to its north-pole and the magnitude relates to how strong and how far apart these poles are. (I) A magnetic dipole which is the arrangement of two magnetic poles of equal and opposite strength separated by some distance is placed in a uniform magnetic field. What will be the net magnetic force on the given dipole? (ii) A magnet of magnetic moment M and pole strength m is divided in two equal parts shown below, then what will be the magnetic moment of each part?  (iii) What is the magnitude of net magnetic flux passing through a hypothetical closed surface enclosing a bar magnet ? justify your answer OR Derive the expression for the magnetic moment of an electron orbiting in a circular orbit of radius r with a speed v	**4**

ANSWER KEY - MCQ

1	2	3	4	5	6
A	D	A	C	B	B
7	**8**	**9**	**10**	**11**	**12**
A	B	B	D	B	C
13	**14**	**15**			
B	D	C			

ANSWER KEY – FILL IN THE BLANKS

1	2	3	4	5

1.05 X $10^{23}Am^2$	Diamagnetic	low	45^0	Ampere metre
6	**7**	**8**	**9**	**10**
Zero, infinite	Zero.	Electric field, magnetic field	Maximum, zero	Symmetrical: asymmetrical

ANSWER KEY – ASSERTION AND REASON

1	2	3	4	5
b	c	d	c	a