CLASS – 12

WORKSHEET- MOVING CHARGES AND MAGNETISM

A. BIOT-SAVART LAW

(1 Mark Questions)

1. A circular coil of wire consisting of 100 turns each of radius 8.0 cm carries a current of 0.40A, what is the magnitude of magnetic field $\vec{B}$ at the centre of the coil?
[Ans. 3.1×10^{-4}T]

2. A long straight wire carries a current of 35A. What is the magnitude of the field $\vec{B}$ at a point 20cm from the wire? [Ans. 3×10^{-5} T]

3. A long straight wire in the horizontal plane carries a current of 50A in the north to south direction. Give the magnitude and direction of $\vec{B}$ at a point 2.5m east of the wire.
[Ans. 4×10^{-6} T]

4. A horizontal overhead power line carries a current of 90A in an east to west direction. What is the magnitude and direction of magnetic field due to the current 1.5m below the line? [Ans. 1.2×10^{-5} T]

5. State Biot-Savart's law.

6. What is SI unit of μ_0?

7. What is the effect of increasing number of turns n magnetic field produced to a circular coil?

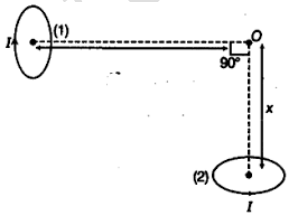
8. What is force experienced by a stationary charge in a magnetic field?

9. What is the work done by magnetic field on a moving charge?

10. Biot-Savart Law indicates that the moving electrons (velocity v) produce a magnetic field B such that
(a) B $\perp$ v (b) B||v (c) it obeys inverse cube law
(d) It is along the line joining the electron and point of observation

(2 Marks Questions)

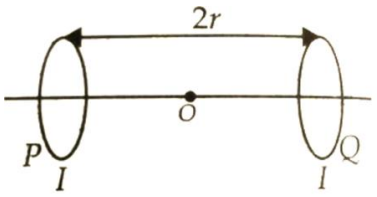
11. Two very small identical circular loops,(1) and (2), carrying equal currents I are placed vertically (with respect to the plane of the paper) with their geometrical axes perpendicular to each other as shown in the magnitude and direction of the net magnetic field produced at the point O.



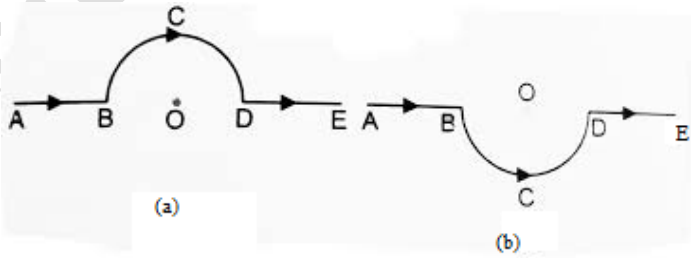
(3 Marks Questions)

12. (a) State biot-savart law and express this law in the vector form.
(b) Two identical circular coils, P and Q each of radius R, carrying current 1 A and $\sqrt{3}$ 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.

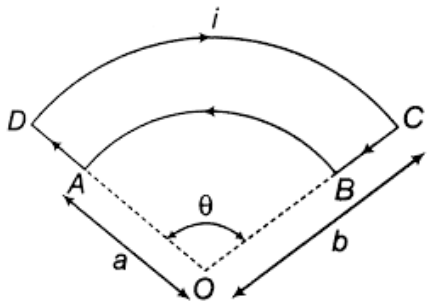
13. Two identical circular loops P and Q each of radius r and carrying equal currents I are kept in the parallel planes having a common axis passing through O. the direction of current in P is clockwise and in Q is anti- clockwise as seen from O which is equidistant from the loops P and Q . find the magnitude of the net magnetic field at O.



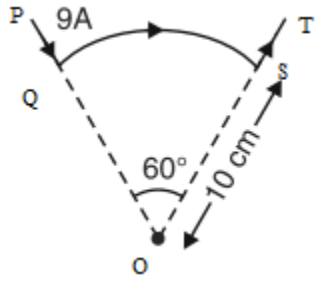
14. A straight wire carrying a current of 12A is bent into a semicircular arc of radius 2.0 as shown in the figure (a). What is the direction and magnitude of **B** at the centre of the arc? Would your answer change if the wore were bent into a semicircular arc of same radius but in the opposite way as shown in the figure (b)?



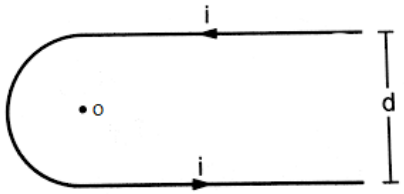
15. Figure shows a current loop having two circular segments and joined by two radial lines. Find the magnetic field at the centre O.



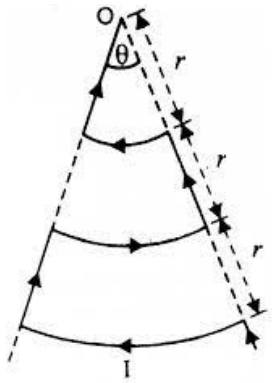
16. A circular segment of radius10cm subtends an angle of 60° at its centre. A current of 9A is flowing through it. Find the magnitude and direction of the magnetic field produced at the centre. [Ans. 9.42×10^{-6} T]



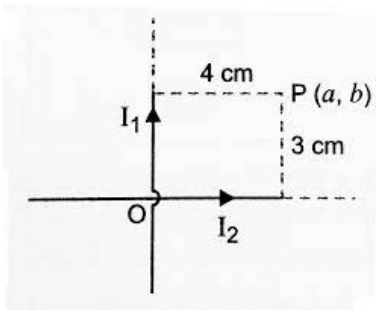
17. In the figure, the curved portion is a semicircle and the straight wires are long. Find the magnetic field at the point O.



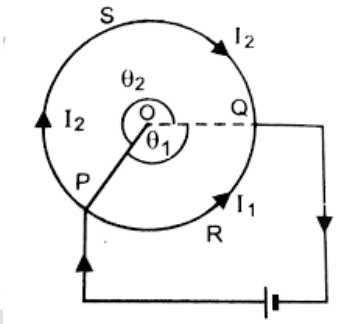
18. A metallic wire is bent into the shape shown in the figure and carries a current I. If O is the common centre of all the three circular arcs of radii r, 2r and 3r, find the magnetic field at the point O.



19. Two insulating infinitely long conductors carrying currents I_1 and I_2 lie mutually perpendicular to each other in the same plane as shown in figure. Find the locus of the point at which the net magnetic field is zero.

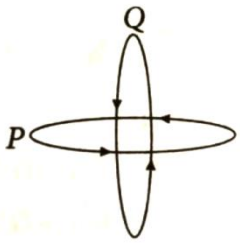


20. As shown in the figure, a cell is connected across two points A and B of a uniform circular conductor. Prove that the magnetic field at its centre O will be zero.



(5 Marks Questions)

21. Two identical coils P and Q each of radius R are lying in perpendicular planes such that they have a common center. Find the magnitude and direction of the magnitude and direction of the magnetic field at the common center of the two coils, if they carry currents equal to I $\sqrt{3}$ I respectively.



22. A circular loop of radius R carries a current I. obtain an expression for the magnetic field at a point on its axis at a distance x from its center.

23. Two concentric circular coils X and Y of radii 16cm and 10cm respectively lie in the same vertical plane containing the north-south direction. Coil X has 20 turns and carries a current of 16A; coil Y has 25 terms and carries a current of 18A. The sense of current in X is anticlockwise, and in Y clockwise, for an observer looking at the coils facing west.

Give the magnitude and direction of the net magnetic field due to the coils at their centre. [Ans. 1.6×10^{-3} T]

B. AMPERE'S CIRCUITAL LAW

(1 Mark Question)

1. Show the magnetic lines of force around a straight current carrying conductor.

2. How does current carrying coil behave like a bar magnet?

(2 Marks Questions)

3. A closely wound solenoid 80cm long has 5 layers of windings of 400 turns each. The diameter of the solenoid is 1.8cm. If the current carried is 8.0A, estimate the magnitude of $\vec{B}$ inside the solenoid near its centre. [Ans. 2.5×10^{-2} T]

(3 Marks Questions)

4. Explain how biot-savart law enables one to express the Ampere's circuital law in the integral form, viz.

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

where I is the total current passing through the surface.

5. A toroid has a core (non-ferromagnetic) of inner radius 25cm and outer radius 26cm around which 3500 turns of a wire are wound. If the current is in the wire is 11A, what is the magnetic field (a) outside the toroid (b) inside the core of the toroid (c) in the empty space surrounded by the toroid? [Ans. Zero, 3.02×10^{-2}T, zero]

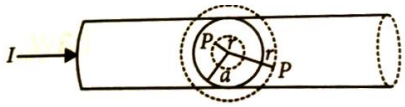
6. State Ampere's circuital law and prove this law for a circular path around a long current carrying conductor.

7. Using Ampere's circuital law, derive an expression for the magnetic field along the axis of a current carrying toroidal solenoid of N number of turns having radius r.

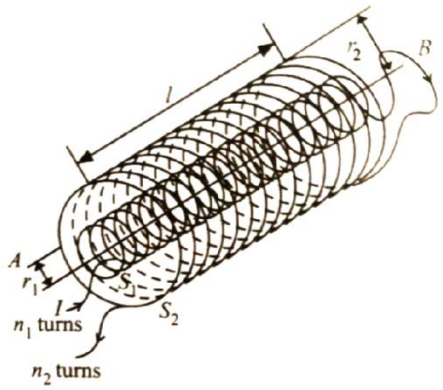
8. Using Ampere's circuital theorem, calculate magnetic field due to an infinitely long wire carrying current I.

(5 Marks Questions)

9. Figure shows a long straight wire of a circular cross –section of radius 'a' carrying steady current I. the current I is uniformly distributed across the cross-section. Derive the magnetic field in the region $r \leq a$ and $\geq a$.



10. Two long coaxial insulated solenoid, S_1 and S_2equal length are wound one over the other as shown in the figure. A steady current 'I' flow through the inner solenoid $s_1$to the other end B, which is connected to the outer solenoid S_2through which the same current 'I' flows in the opposite direction so as to come out at end A. if n_1 and $n_2$are the number of turns per unit length, find the magnitude and directions of the net magnetic field at the point (i)inside on the axis and (ii)outside the combined system .



C. LORENTZ FORCE AND MOTION OF A CHARGED PARTICLE INSIDE THE MAGENTIC FIELD

(1 Mark Questions)

1. Write the expression, in a vector form, for the Lorentz magnetic force $\vec{F}$ due to a charge moving with velocity $\vec{V}$ in a magnetic field B. what is the direction of the magnetic force?

2. Define one tesla using the expression for the magnetic force acting on a particle of charge 'q' moving with velocity $\vec{V}$ in a magnetic field B.

3. A charge particle after being accelerated through a potential difference 'V' enters in a uniform magnetic field and moves in a circle of radius r. if V is doubled, the radius of the circle will become.

(a) 2 r (b) $\sqrt{2}$r (c) 4r (d) $\frac{r}{\sqrt{2}}$

4. A long straight wire carries a steady current I along the positive y-axis in a coordinate system. A particle of charge +Q is moving with a velocity $\vec{v}$ along the x-axis. In which direction will the particle experience a force?

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5. A narrow beam of protons and deuterons, each having the same momentum, enters a region of momentum. What would be the ratio of the circular paths describe by them?

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6. Write the condition under which an electron will move undefeated in the presence of crossed electric and magnetic fields.

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7. A uniform magnetic field B is set up along the positive x-axis. A particle of charge 'q' and mass 'm' moving with a velocity v enter the field at the origin in x-y plane such that it has velocity components both along and a perpendicular to the magnetic field B. trace, giving reason, the trajectory followed by the particle. Find out of expression for the distance moved by the particle along the magnetic field in one rotation.

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8. Answer the following questions: (1 mark each)

(a) A magnetic field that varies in magnitude from point ort point but has a constant direction (east to west) is set up in a chamber. A charged particle enters the chamber and travels undeflected along a straight path with constant speed. What can you say about the initial velocity of the particle?

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(b) A charged particle enters an environment of a strong and non-uniform magnetic field varying from point to point both in magnitude and direction and comes out of it following a completed trajectory. Would its final speed equal the initial speed if it suffered no collisions with the environment?

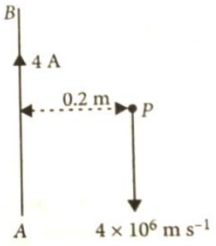
(c) An electron travelling west to east enters a chamber having a uniform electrostatic field in a north to south direction. Specify the direction in which a uniform magnetic field should be set up to prevent the electron from deflecting from its straight line path.

9. Two charged particles traverse identical helical paths in a completely opposite sense in a uniform magnetic field $B = B_0\hat{k}$
(a) They have equal z-components of moment a (b) They must have equal charges
(c) They necessarily represent a particle antiparticle pair.
(d) The charge to mass ratio satisfy: $(e/m)_1 + (e/m)_2 = 0$

10. Show that a force that does no work must be a velocity dependent force.

(2 Marks Questions)

11. A long straight wire AB carries a current of 4A. A proton P travels at 4×10^6 M s^{-1}parallel to the wire 0.2 m from it a direction opposite to the current as shown in the current as shown in the figure. Calculate the force which the magnetic field due to the current carrying wire exert on the proton. Also specify its direction.



(3 Marks Questions)

12. Two particles A and B of masses m and 2m have charges q and 2q respectively. Both these particle moving with velocity v_1 and v_2 respectively in the same direction enter the same magnetic field B acting normally to their direction of motion. If the two forces F_A and F_B acting on them are in the ration of 1:2, find the ratio of their velocities.

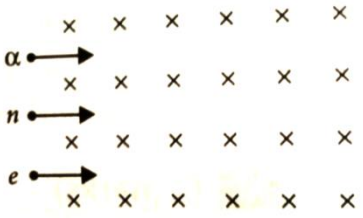
13. A proton a deuteron and an alpha particle, are accelerated through the same potential difference and then subjected to a uniform magnetic field B, perpendicular to the direction of their motions. Compare

(i) their kinetic energies, and

(ii) if the radius of the circular path described by proton is 5 cm, determine the radii of the path described by deuteron and alpha particles.

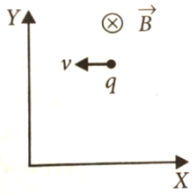
14. (a) Write the expression for the magnetic force acting on a charged particles moving with velocity v in the presence of magnetic field B.

(b) A neutron, an electron and an alpha particle moving with equal velocities enter a uniform magnetic field going into the plane of the paper as shown. Trace their paths in the field and justify your answer?



15. State the underlying principle of a cyclotron. Write briefly how this machine is used to accelerate charged particle to high energies.

16. (a) A point charge q moving with speed v enters a uniform magnetic field B that is acting into the plane of paper as shown. What is the path followed by the Charge q and in which plane does it moves?



(b) How does the path followed by the charge get affected if its velocity has a component parallel?

(c) if an electric field E is also applied such that the particle continuous moving along the original straight line path, what should be the magnitude and direction of the electric field E.

17. In a chamber a uniform magnetic field of 6.5G ($1G = 10^{-4}T$) is maintained. An electron is shot into the field with a speed of 4.8×10^{6} ms^{-1} normal to the field. Explain why the path of the electron is a circle. Determine the radius of the circular orbit. Given that $e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$kg. [Ans. 4.2 cm]

18. In previous question, obtain the frequency of revolution of the electron in its circular orbit. Does the answer depend on the speed of the electron? Explain. [Ans. 18 MHz]

19. An electron emitted by a heated cathode and accelerated through a potential difference of 2.0 kV, enters a region with uniform magnetic field of 0.15T. Determine the trajectory of the electron if the field (i) is transverse to its initial velocity, (ii) makes and angle of 30° with the initial velocity. [Ans. 1mm, 0.50mm]

20. A magnetic field set up using Helmholtz coils is uniform in a small region and has a magnitude of 075 T. In the same region, a uniform electrostatic field is maintained in a direction normal to the common axis of the coils. A narrow beam of (single species) charged particles all accelerated through 15kV enters this region in a direction perpendicular to both the axis of the coils and the electrostatic field. If the beam remains undeflected when the electrostatic field is 9.0×10^5 Vm^{-1}, make a simple guess as to what the beam contains. Why is the answer not unique? [Ans. 4.8×10^7 C kg^{-1}]

(5 Marks Questions)

21. Particles of mass 1.6×10^{-27} kg and charge1.6×10^{-19}C are accelerated in a cyclotron of dee radius 40cm. it employs a magnetic field 0.4 t. find the kinetic energy (in me v) of the particle beam imparted by the accelerator.

22. An α-particle is accelerated through a potential difference of 10 kV and moves along x-axis. It enters in a region of uniform magnetic field $B=2\times10^{-3}T$ acting along y-axis. Find the radius of its path.

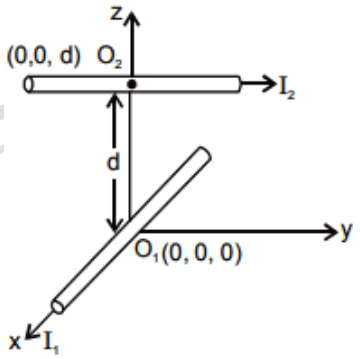
23. (a) Draw a schematic sketch of a cyclotron. Explain clearly the role of closed electric and magnetic field in accelerating the charge. Hence derive the expression for the kinetic energy acquired by the particles.
(b) An α-particles and a proton are released from the center of the cyclotron and made to accelerate.
(i) Can both be accelerate at the same cyclotron frequency? Give reason to justify your answer?
(ii) When they are accelerate in turn, which of the two will have higher velocity at the exit slit of the dees

D. FORCE ON CURRENT CARRYING CURRENT CONDUCTOR

(1 Mark Questions)

1. What is the magnitude of magnetic force per unit length on a wire carrying a current of 8A and making an angle of 30° with the direction of a uniform magnetic field of 0.15T? [Ans. 0.6 Nm^{-1}]

2. Two long wires carrying current I_1 and I_2 are arranged as shown in Fig. The one carrying current I_1 is along is the x-axis. The other carrying current I_2 is along a line parallel to the y-axis given by x = 0 and z = d. Find the force exerted at O_2 because of the wire along the x-axis.



(2 Marks Questions)

3. A 3.0 cm wire carrying a current of 10A is placed inside a solenoid perpendicular to its axis. The magnetic field inside the solenoid is given to be 0.27T. What is the magnetic force on the wire? [Ans. 8.1×10^{-2} N]

4. Two long and parallel straight wires A and B carrying currents 8.0A and 5.0A in the same direction are separated by a distance of 4.0cm. Estimate the force on a 10cm section of wire A. [Ans. 2×10^{-5} N]

(3 Marks Questions)

5. Two infinitely long straight wires A_1 and A_2 carrying currents I and 2I following in the same direction are kept 'd' distance apart. Where should a third straight wire A_3 carrying current 1.5 I be placed between A_1 and A_2 so that is experience no net force due to A_1 and A_2? Does the net force acting on A_3 depend on the current flowing through it?

6. (a) Write an expression of magnetic moments associated with a current (I) carrying circular coil of radius r having N turns.
(b)Concede the above mentioned coil placed in YZ plane with its center at the origin. Derive expression for the value of fields due to it at point.

7. A straight horizontal conducting rod of length 0.45 m and mass 60g is suspended by two vertical wires at its ends. A current of 5.0A is set up in the rod through the wires.
(a) What magnetic field should be set up normal to the conductor in order that the tension in the wires is zero?

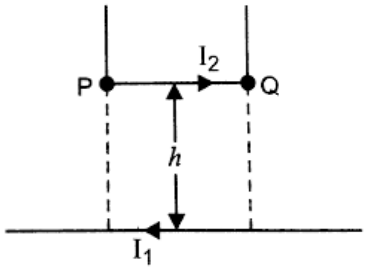
(b) What will be the total tension in the wires if the direction of current is reversed, keeping the magnetic field same as before? (Ignore the mass of the wires) $g = 9.8\ ms^{-2}$. [Ans. 0.26T, 1.176 N]

8. The wires which connect the battery of an automobile to its starting motor carry a current of 300A (for a short time). What is the force per unit length between the wires if they are 70cm long and 1.5cm apart? Is the force attractive or repulsive? [Ans. 0.84 N, repulsive]

9. A circular coil of 20 turns and radius 10cm is placed in a uniform magnetic field of 0.10T normal to the plane of the coil. If the current in the coil is 5.0A, what is the
(a) total torque on the coil.
(b) total force on the coil
(c) average force on each electron in the coil due to the magnetic field?
(The coil is made of copper wire of cross-sectional area $10^{-5}\ m^2$ and the free electron density in copper is given to be about ($10^{29}\ m^{-3}$)). [Ans. 0, 5×10^{-25} N]

10. A solenoid 60cm long and of radius 4.0cm has 3 layers of windings of 300 turns each. A 2.0 cm long wire of mass 2.5g lies inside the solenoid near its centre normal to its axis; both the wire and the axis of the solenoid are in the horizontal plane. The wire is connected through two leads parallel to the axis of the solenoid to an external battery which supplies a current of 6.0A in the wire. What value of current (with appropriate sense of circulation) in the windings of the solenoid can support the weight of the wire? $G = 9.8\ ms^{-2}$ [Ans. 108.3A]

11. A long straight wire carrying current of 25A rests on a table as shown in Fig. Another wire PQ of length 1m, mass 2.5 g carries the same current but in the opposite direction. The wire PQ is free to slide up and down. To what height will PQ rise?



(5 Marks Questions)

12. Two long straight parallel conductor carrying steady current I_1 and I_2 are secreted by a distance 'd'. Explain briefly with the help of suitable diagram. How the magnetic field due to one conductor acts on the other. Hence deduce the expression for the forcing acting between the two conductors. Mention the nature of this force.

13. A uniform magnetic field of 1.5T exists in a cylindrical region of radius 10.0 cm, its direction being parallel to the axis along east to west. A wire carrying current of 7.0A in the north to south direction passes through this region. What is the magnitude and direction of the force on the wire if
(i) the wire intersects the axis

(ii) the wire is turned from N-S to north east or north west direction
(iii) the wire in the N-S direction is lowered from the axis by a distance of 6.0 cm?
[Ans. 2.1N, 2.1 N, 1.68N]

E. MAGNEITC DIPOLE MOMENT

(3 Marks Questions)

1. An electron of mass m_e revolves around a nucleus of charge +Ze . show that it behaves like a tiny magnetic moments associated with it is expressed as $\vec{\mu} = -\frac{e}{2m_e}\vec{L}$ where l is the orbital angular momentum of the electron. Give the signification of negative sign.

2. (a) show that the planner loop carrying a current I, having N closely wound turns and area of cross-sectional A, possesses a magnetic moment $\vec{m} = NI\,\vec{A}$.
(b) when this loop is placed in a magnetic field $\vec{B}$, find out the expression for the torque acting on it.

3. A current carrying circular loop of radius R is placed in the x-y plane with centre at the origin. Half of the loop with x>0 is now bent so that it now lies in the y-z plane.
(a) The magnitude of the magnetic moment now diminishes
(b) The magnetic moment does not change.
(c) The magnitude of B at (0, 0, z), z>>R increases
(d) The magnitude of B at (0, 0, z), z>>R is unchanged.

F. TORQUE ON COIL AND GALVANOMETER

(1 Mark Questions)

1. A circular current 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) √3 MB/2 (c) Mb/2 (d) zero

2. How are figure of merit and current sensitivity of galvanometer related to each other?

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3. If the current is increased by 1% in a moving coil galvanometer, what will be the percentage increase in deflection?

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(2 Marks Questions)

4. A square coil of the side 10cm consists of 20 turns and carries a current of 12A. The coil is suspended vertically and normal to the plane of the coil and makes an angle of 30° with the direction of a uniform horizontal magnetic field of magnitude 0.80T. What is the magnitude of torque experienced by the coil? [Ans 0.96 Nm]

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(3 Marks Questions)

5. (a) Define current sensitivity of a galvanometer. Write its expression.
(b) A galvanometer has resistance G and shows full scale deflection for current I_g
(i)how can it be converted into an ammeter to measure current up to I_0
(ii) what is the effective resistance of this ammeter?

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6. Two moving coils galvanometers M_1 and M_2 have the following particulars:

$R_1 = 10\Omega, N_1 = 30, A_1 = 3.6\times10^{-3} m^2, B_1 = 0.25T$

$R_2 = 14\Omega, N_2 = 42, A_2 = 1.8\times10^{-3} m^2, B_2 = 0.25T$

The spring constants are identical for the two springs. Determine the ratio of (i) current sensitivity and (ii) voltage sensitivity of M_2 and M_1. [Ans. 1.4, 1]

7. (a) A circular coil of 30 turns and radius 8.0 cm carrying a current of 6.0A is suspended vertically in a uniform horizontal magnetic field of magnitude 1.0T. The field lines make an angle 60° with the normal to the coil. Calculate the magnitude of the counter torque that must be applied to prevent the coil from turning.

(b) Would your answer change if the circular coil in (a) were replaced by a planar coil of some irregular shape that encloses the same area? [Ans. 3.1 Nm, No]

8. A galvanometer coil has resistance of 12Ω and meter shows full scale deflection for a current of 3 mA. How will you convert the meter into a voltmeter of range 0 to 18V? [Ans. 5988Ω]

9. A galvanometer of resistance of 15W and the meter shows full scale deflection for a current of 4mA. How will you convert the meter into an ammeter of range 0 to 6A?

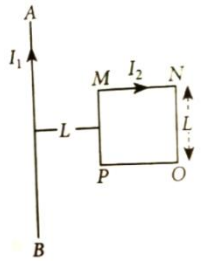
[Ans. 10mΩ]

10. A galvanometer needs 50mV for a full scale deflection of 50 divisions. Find its voltage sensitivity. What must be its resistance if its current sensitivity is 1 division/ μA?

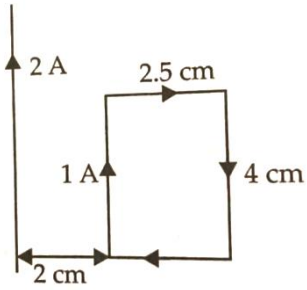
[Ans. 10^{-3} div V^{-1}, 1000Ω]

(5 Marks Questions)

11. A square shaped current carrying loop MNOP is placed near a straight long current carrying wire AB as shown in the figure the wire and the loop lie in the loop experience a net force F toward the wire, find the magnitude of the force on the side NO of the loop.



12. A rectangular loop of wire of size 2.5 cm ×4cm carriers a steady current of 1 A. A straight wire carrying 2A currents is kept near the loop as shown. If the loop and wire are coplanar, find the (i) torque acting on the loop and (ii) the magnitude and direction of the force on the loop due to the current carrying wire.



13. (a) define the current sensitivity of a galvanometer.
(b) the coil area of a galvanometer is 16×10^{-4} m^2it consist of 200 turns of a wire and is in a magnetic field of 0.2T. the restoring torque constant of the suspension fiber is 10^{-6} N m per degree. Assuming the magnetic field to be radial, calculate the maximum current that can be measured by the galvanometer if the scale can accommodate 30 deflections.

14. (a) Explain using a labeled diagram, the principle and working of a moving coil galvanometer. What is the function of (i) soft iron core?
(b) define the terms (i) current sensitivity and (ii)voltage sensitivity of a galvanometer why does increasing the current sensitivity not necessarily increase voltage sensitivity.

15. The scale of a galvanometer is divided into 150 equal divisions. The galvanometer has the current sensitivity of 10 divisions per mA and the voltage sensitivity of 2 divisions per mV. How the galvanometer can be designed to read (i) 6A division^{-1} and (ii) 1V per division^{-1}? [Ans. (i) 8.33×10^{-5} Ω in parallel (ii) 9995 Ω in series]

G. CHALLENGING PROBLEMS

1. A magnetic field of 100 G ($1G = 10^{-4}$ T) is required which is uniform in a region of linear dimension about 10cm and area of cross-section about 10^{-3} m^2. The maximum current carrying capacity of a given coil of wire is 15A and the number of turns per unit length that can be wound round a core is at most 1000 turns m^{-1}, Suggest some appropriate design particulars of a solenoid for the required purpose. Assume the core is not ferromagnetic.

2. For a circular coil of radius R and N turns carrying current I, the magnitude of the magnetic field at a point on its axis at a distance x from its centre is given by

$$B = \frac{\mu_0 I R^2 N}{2(x^2 + R^2)^{3/2}}$$

(a) Show that this reduces to the familiar result for field at the centre of the coil.

(b) Consider two parallel co-axial circular coils of equal radius R, and number of turns N, carrying equal currents in the same direction, and separated by a distance R. Show that the field on the axis around the mid-point between the coils is uniform over a distance that is small as compared to R and is given by

$$B = 0.72 \frac{\mu_0 NI}{R}$$

Such an arrangement used to produce a nearly uniform magnetic field over a small region is known as Helmholtz coils.

3. A galvanometer with a coil of resistance 12.0 Ω shows full scale deflection for a current of 25 mA. How will you convert the meter into: (i) an ammeter of range 0 to 7.5A (ii) a voltmeter of range 0 to 10.0V.
Determine the net resistance of the meter in each case. When an ammeter is put in a circuit, does it read (slightly) less or more than the actual current in the original circuit? When a voltmeter is put across a part of the circuit, does it read (slightly) less than or more than the original voltage drop? Explain.

[Ans. (i) $4.0\times10^{-3}\Omega$, 4×10^{-3} Ω (ii) 3988 Ω, 4000 Ω]

SPACE FOR ROUGH WORK

SPACE FOR NOTES