UNIT-3 MAGNETIC EFFECTS OF CURRENT AND MAGNETISM

VERY SHORT ANSWERS QUESTIONS (I Mark)

1. Must every magnetic field configuration have a north pole and a south pole? What about the field due to a toroid?

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

3. Show graphically the variation of magnetic field due to a straight conductor of uniform cross-section of radius 'a' and carrying steady currently as a function of distance r ($a > r$) from the axis of the conductor.

4. The force per unit length between two parallel long current carrying conductor is F. If the current in each conductor is tripled, what would be the value of the force per unit length between them?

5. How does the angle of dip vary from equator to poles?

6. What is the effect on the current measuring range of a galvanometer when it is shunted?

7. An electric current flows in a horizontal wire from East to West. What will be the direction of magnetic field due to current at a point (i) North of wire; (ii) above the wire.

8. Suggest a method to shield a certain region of space from magnetic fields.

*9. Why the core of moving coil galvanometer is made of soft iron?

10. Where on the earth's surface, is the vertical component of earth's magnetic field zero?

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

12. Write S.I. unit of (i) Pole strength and (ii) Magnetic dipole moment.

13. If the magnetic field is parallel to the positive y-axis and the charged particle is moving along the positive x-axis, which way would the Lorentz force be for (a) an electron (negative charge), (b) a proton (positive charge)

Sol : When velocity (v) of positively charged particle is along x-axis and the magnetic field ($\vec{B}$) is along y-axis, so $v \times \vec{B}$ is along the z-axis (Flemings left hand rule).

Therefore,

(a) for electron Lorentz force will be along –z axis;

(b) for a positive charge (proton) the force is along +z axis.

14. If a toroid uses Bismuth as its core, will the field in the core be lesser or greater than when it is empty?

Ans : Bismuth is diamagnetic, hence, the overall magnetic field will be slightly less.

15. An electron beam projected along + x-axis, experiences a force due to a magnetic field along the + y-axis. What is the direction of the magnetic field?

Ans : +Z axis.

16. What is the principle of a moving coil galvanometer?

Ans : When a current carrying coil is placed in uniform magnetic field, it experiences a torque.

17. What is the direction of magnetic dipole moment?

Ans : S to N

18. What is the angle of dip at a place where vertical and horizontal component of earth's field are equal?

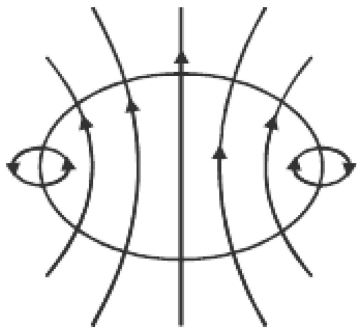
Ans : 45°

19. Is any work done on a moving charge by a magnetic field?

Ans : No, as magnetic field is in perpeudicular direction.

20. Sketch the magnetic field lines for a current carrying circular loop.

Ans :

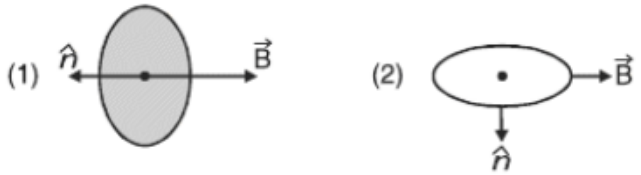


SHORT ANSWERS QUESTIONS (2 MARKS)

1. Write the four measures that can be taken to increase the sensitivity of a galvanometer.

2. A galvanometer of resistance 120Ω gives full scale deflection for a current of 5mA. How can it be converted into an ammeter of range 0 to 5A? Also determine the net resistance of the ammeter.

3. A current loop is placed in a uniform magnetic field in the following orientations (1) and (2). Calculate the magnetic moment in each case.



4. A current of 10A flows through a semicircular wire of radius 2cm as shown in figure (a). What is direction and magnitude of the magnetic field at the centre of semicircle? Would your answer change if the wire were bent as shown in figure (b)?

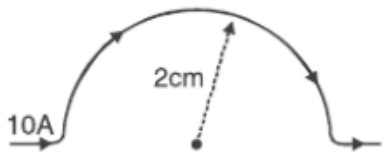


Fig. (a)

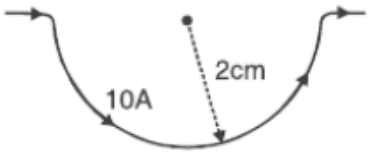


Fig. (b)

5. A proton and an alpha particle of the same enter, in turn, a region of uniform magnetic field acting perpendicular to their direction of motion. Deduce the ratio of the radii of the circular paths described by the proton and alpha particle.

6. Which one of the two an ammeter or milliammeter, has a higher resistance and why?

7. Mention two properties of soft iron due to which it is preferred for making electromagnet.

8. A magnetic dipole of magnetic moment M is kept in a magnetic field B. What is the minimum and maximum potential energy? Also give the most stable position and most unstable position of magnetic dipole.

9. What will be (i) Pole strength (ii) Magnetic moment of each of new piece of bar magnet if the magnet is cut into two equal pieces :

   (a) normal to its length?

   (b) along its length?

10. A steady current I flows along an infinitely long straight wire with circular cross-section of radius R. What will be the magnetic field outside and inside the wire at a point *r* distance far from the axis of wire?

11. A circular coil of *n* turns and radius R carries a current I. It is unwound and rewound to make another square coil of side 'a' keeping number of turns and current same. Calculate the ratio of magnetic moment of the new coil and the original coil.

12. A coil of N turns and radius R carries a current I. It is unwound and rewound to make another coil of radius R/2, current remaining the same. Calculate the ratio of the magnetic moment of the new coil and original coil.

13. At a place horizontal component of the earths magnetic field is B and angle of dip at the place is 60°. What is the value of horizontal component of the earths magnetic field.

    (i) at Equator; (ii) at a place where dip angle is 30°

14. A galvanometer coil has a resistance G. 1% of the total current goes through the coil and rest through the shunt. What is the resistance of the shunt?

15. Prove that the magnetic moment of a hydrogen atom in its ground state is $eh/4\pi m$. Symbols have their usual meaning.

16. Each of eight conductors in figure carries 2A of current into or out of page. Two path are indicated for the line integral $\oint \vec{B} . d\vec{l}$ What is the value of the integral for the path (a) and (b).

(a) (b)

17. What is the radius of the path of an electron (mass 9×10^{-3} kg and charge 1.6×10^{-19} C) moving at a speed of 3×10^{7} m/s in a magnetic field of 6×10^{-4} T perpendicular to it? What is its frequency? Calculate its energy in keV. (1 eV = 1.6×10^{-19} J).

Sol : Radius, $r = mv/(qB)$

$= 9.1 \times 10^{-31}$kg $\times 3 \times 10^{7}$ ms–1/ $(1.6 \times 10^{-19}$ C $\times 10^{-4}$ T) = 26 cm

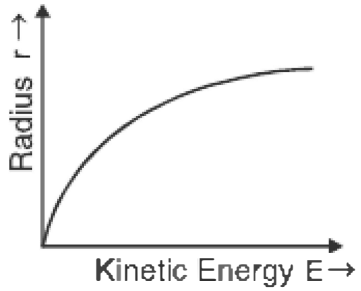
$v = v/(2\pi r) = 2 \times 10^{8}$ s^{-1} $= 2 \times 10^{8}$ Hz = 200 MHz.

$E = (½)mv^2 = (½)\ 9 \times 10^{-31}$ kg $\times\ 9 \times 10^{14}$ m^2/s^2

$= 40.5 \times 10^{17}$ J $= 4 \times 10^{16}$ J = 2.5 keV.

18. A particle of mass m and charge q moves at right angles to a uniform magnetic field. Plot a graph showing the variation of the radius of the circular path described by it with the increase in its kinetic energy, where, other factors remain constant.

Ans : $r \propto \sqrt{K.E}$



19. Magnetic field arises due to charges in motion. Can a system have magnetic moments even though its net charges is zero? Justify.

Ans : Yes; for example the atoms of a paramagnetic substance possess a net magnetic moment though its net charge is zero.

20. Define the term magnetic dipole moment of a current loop. Write the expression for the magnetic moment when an electron revolves at a speed '*v*', around an orbit of radius '*r*' in hydrogen atom.

Ans : The product of the current in the loop to the area of the loop is the magnetic dipole moment of a current loop.
The magnetic moment of electron

$$\vec{\mu} = -\frac{e}{2}(\vec{r} \times \vec{v}) = -\frac{e}{2m_e}(\vec{r} \times \vec{p}) = -\frac{e}{2m_e}\vec{\ell}$$

SHORT ANSWERS QUESTIONS (3 MARKS)

1. Derive the expression for force between two infinitely long parallel straight wires carrying current in the same direction. Hence define 'ampere' on the basis of above derivation.

2. Define (i) Hysteresis (ii) Retentivity (iii) Coercivity

3. Distinguish bet ween diamagnetic, paramagnetic and ferromagneti c substances in terms of susceptibility and relative permeability.

*4. Name all the three elements of earth magnetic field and define them with the help of relevant diagram.

5. Describe the path of a charged particle moving in a uniform magnetic field with initial velocity

   (i) parallel to (or along) the field.

   (ii) perpendicular to the field.

   (iii) at an arbitrary angle θ ($0° < \theta < 90°$).

6. Obtain an expression for the magnetic moment of an electron moving with a speed 'v' in a circular orbit of radius 'r'. How does this magnetic moment change when

   (i) the frequency of revolution is doubled?

   (ii) the orbital radius is halved?

7. State Ampere, circuital law. Use this law to obtain an expression for the magnetic field due to a toroid.

*8 Obtain an expression for magnetic field due to a long solenoid at a point inside the solenoid and on the axis of solenoid.

9. Derive an expression for the torque on a magnetic dipole placed in a magnetic field and hence define magnetic moment.

10. Derive an e xpression fo r mag netic field in tensity due to a b ar ma gnet (magnetic dipole) at any point (i) Along its axis (ii) Perpendicular to the axis.

*11. Derive an expression for the torque acting on a loop of N turns of area A of each turn carrying current I, when held in a uniform magnetic field B.

*12. How can a moving coil galvanometer be converted into a voltmeter of a given range. Write the necessary mathematical steps to obtain the value of resistance required for this purpose.

13. A long wire is first bent into a circular coil of one turn and then into a circular coil of smaller radius having n turns. If the same current passes in both the cases, find the ratio of the magnetic fields produced at the centres in the two cases.

Ans : When there is only one turn, the magnetic field at the centre,

$$B = \frac{\mu_0 I}{2a}$$

$2\pi a^1 xn = 2\pi a \Rightarrow a^1 = a/n$

The magnetic field at its centre, $B_1 = \frac{\mu_0 nI}{2a/n} = \frac{\mu_0 n^2 I}{2a} = n^2 B$

The ratio is, $B_1/B = n^2$

LONG ANSWER QUESTIONS (5 Marks)

1. How will a diamagnetic, paramagnetic and a ferromagnetic material behave when kept in a non-uniform external magnetic field? Give two examples of each of these materials. Name two main characteristics of a ferromagnetic material which help us to decide suitability for making
(i) Permanent magnet (ii) Electromagnet.

2. State Biot-Savart law. Use it to obtain the magnetic field at an axial point, distance d from the centre of a circular coil of radius 'a' and carrying current I. Also compare the magnitudes of the magnetic field of this coil at its centre and at an axial point for which the value of d is $\sqrt{3}a$.

3. Write an expression for the force experienced by a charged particle moving in a uniform magnetic field B. With the help of diagram, explain the principle and working of a cyclotron. Show that cyclotron frequency does not depend on the speed of the particle.

4. Write the principle, working of moving coil galvanometer with the help of neat labelled diagram. What is the importance of radial field and phosphor bronze used in the construction of moving coil galvanometer?