Topicwise Questions

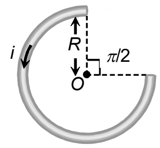
BIOT SAVART LAW

1. The magnetic field $d\vec{B}$ due to a small current element $d\vec{l}$ at a distance $\vec{r}$ and element carrying current *i* is,

(*a*) $d\vec{B} = \frac{\mu_0}{4\pi} i \left(\frac{d\vec{l} \times \vec{r}}{r}\right)$ (*b*) $d\vec{B} = \frac{\mu_0}{4\pi} i^2 \left(\frac{d\vec{l} \times \vec{r}}{r}\right)$

(*c*) $d\vec{B} = \frac{\mu_0}{4\pi} i^2 \left(\frac{d\vec{l} \times \vec{r}}{r^2}\right)$ (*d*) $d\vec{B} = \frac{\mu_0}{4\pi} i \left(\frac{d\vec{l} \times \vec{r}}{r^3}\right)$

2. A current *i ampere* flows in a circular arc of wire whose radius is *R*, which subtend an angle $3\pi/2$ radian at its centre. The magnetic induction *B* at the centre is



(*a*) $\frac{\mu_0 i}{R}$ (*b*) $\frac{\mu_0 i}{2R}$

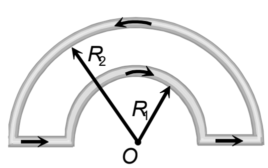
(*c*) $\frac{2\mu_0 i}{R}$ (*d*) $\frac{3\mu_0 i}{8R}$

3. A helium nucleus makes a full rotation in a circle of radius 0.8 *metre* in two seconds. The value of the magnetic field *B* at the centre of the circle will be

(*a*) $\frac{10^{-19}}{\mu_0}$ (*b*) $10^{-19}\mu_0$

(*c*) $2 \times 10^{-10}\mu_0$ (*d*) $\frac{2\times 10^{-10}}{\mu_0}$

4. The magnetic induction at the centre *O* in the figure shown is



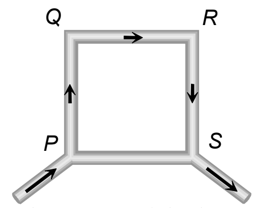
(*a*) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ (*b*) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$

(*c*) $\frac{\mu_0 i}{4}(R_1 - R_2)$ (*d*) $\frac{\mu_0 i}{4}(R_1 + R_2)$

5. A battery is connected between two points *A* and *B* on the circumference of a uniform conducting ring of radius *r* and resistance *R*. One of the arcs *AB* of the ring subtends an angle θ at the centre. The value of the magnetic induction at the centre due to the current in the ring is

(*a*) Proportional to $2(180° - \theta)$
(*b*) Inversely proportional to *r*
(*c*) Zero, only if $\theta = 180°$
(*d*) Zero for all values of θ

6. *PQRS* is a square loop made of uniform conducting wire the current enters the loop at *P* and leaves at *S*. Then the magnetic field will be



(*a*) Maximum at the centre of the loop
(*b*) Zero at the centre of loop
(*c*) Zero at all points inside the loop
(*d*) Zero at all points outside of the loop

Ampere's law and it's Application

7. If a long hollow copper pipe carries a direct current, the magnetic field associated with the current will be

(*a*) Only inside the pipe
(*b*) Only outside the pipe
(*c*) Neither inside nor outside the pipe
(*d*) Both inside and outside the pipe

8. There are 50 turns of a wire in every *cm* length of a long solenoid. If 4 *ampere* current is flowing in the solenoid, the approximate value of magnetic field along its axis at an internal point and at one end will be respectively

(*a*) 12.6×10^{-3} Weber / m^2, 6.3×10^{-3} Weber /m^2
(*b*) 12.6×10^{-3} Weber / m^2, 25.1×10^{-3} Weber /m^2
(*c*) 25.1×10^{-3} Weber / m^2, 12.6×10^{-3} Weber /m^2
(*d*) 25.1×10^{-5} Weber / m^2, 12.6×10^{-5} Weber /m^2

9. A solenoid is 1.0 *metre* long and it has 4250 turns. If a current of 5.0 *ampere* is flowing through it, what is the magnetic field at its centre

[$\mu_0 = 4\pi \times 10^{-7}$ weber / amp – m]

(*a*) 5.4×10^{-2} weber / m^2
(*b*) 2.7×10^{-2} weber / m^2
(*c*) 1.35×10^{-2} weber / m^2
(*d*) 0.675×10^{-2} weber / m^2

Motion of a Charged Particle in Magnetic Field

10. A uniform electric field and a uniform magnetic field are produced, pointed in the same direction. An electron is projected with its velocity pointing in the same direction

(*a*) The electron will turn to its right
(*b*) The electron will turn to its left
(*c*) The electron velocity will increase in magnitude
(*d*) The electron velocity will decrease in magnitude

11. An electron has mass 9×10^{-31} kg and charge 1.6×10^{-19} C is moving with a velocity of 10^6 m /s, enters a region where magnetic field exists. If it describes a circle of radius 0.10 *m*, the intensity of magnetic field must be

(*a*) 1.8×10^{-4} T (*b*) 5.6×10^{-5} T
(*c*) 14.4×10^{-5} T (*d*) 1.3×10^{-6} T

12. A proton is moving along Z-axis in a magnetic field. The magnetic field is along X-axis. The proton will experience a force along

(*a*) X-axis (*b*) Y-axis

(*c*) Z-axis (*d*) Negative Z-axis

13. A deutron of kinetic energy 50 *keV* is describing a circular orbit of radius 0.5 *metre* in a plane perpendicular to magnetic field $\vec{B}$. The kinetic energy of the proton that describes a circular orbit of radius 0.5 *metre* in the same plane with the same $\vec{B}$ is

(*a*) 25 *keV* (*b*) 50 *keV*

(*c*) 200 *keV* (*d*) 100 *keV*

14. Lorentz force can be calculated by using the formula

(*a*) $\vec{F}=q(\vec{E}+\vec{v}\times\vec{B})$ (*b*) $\vec{F}=q(\vec{E}-\vec{v}\times\vec{B})$

(*c*) $\vec{F}=q(\vec{E}+\vec{v}\cdot\vec{B})$ (*d*) $\vec{F}=q(\vec{E}\times\vec{B}+\vec{v})$

15. The charge on a particle Y is double the charge on particle X. These two particles X and Y after being accelerated through the same potential difference enter a region of uniform magnetic field and describe circular paths of radii R_1 and R_2 respectively. The ratio of the mass of X to that of Y is

(*a*) $\left(\frac{2R_1}{R_2}\right)^2$ (*b*) $\left(\frac{R_1}{2R_2}\right)^2$

(*c*) $\frac{R_1^2}{2R_2^2}$ (*d*) $\frac{2R_1}{R_2}$

16. A charged particle enters a magnetic field H with its initial velocity making an angle of 45° with H. The path of the particle will be

(*a*) A straight line (*b*) A circle

(*c*) An ellipse (*d*) A helix

17. An electron enters a region where magnetic (B) and electric (E) fields are mutually perpendicular to one another, then

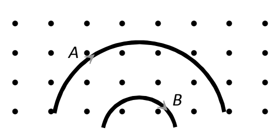
(*a*) It will always move in the direction of B

(*b*) It will always move in the direction of E

(*c*) It always possess circular motion

(*d*) It can go undeflected also

18. Two particles A and B of masses m_A and m_B respectively and having the same charge are moving in a plane. A uniform magnetic field exists perpendicular to this plane. The speeds of the particles are v_A and v_B respectively, and the trajectories are as shown in the figure. Then



(*a*) $m_A v_A < m_B v_B$

(*b*) $m_A v_A > m_B v_B$

(*c*) $m_A < v_B$ and $v_A < v_B$

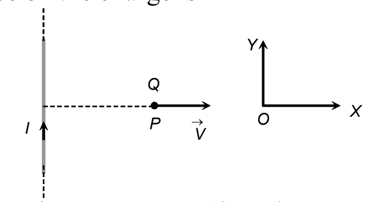
(*d*) $m_A = m_B$ and $v_A = v_B$

19. A particle of mass M and charge Q moving with velocity $\vec{v}$ describes a circular path of radius R when subjected to a uniform transverse magnetic field of induction B. The work done by the field when the particle completes one full circle is

(*a*) $BQv2\pi R$ (*b*) $\left(\frac{Mv^2}{R}\right)2\pi R$

(*c*) Zero (*d*) $BQ2\pi R$

20. A very long straight wire carries a current I. At the instant when a charge +Q at point P has velocity $\vec{V}$, as shown, the force on the charge is



(*a*) Opposite to OX (*b*) Along OX

(*c*) Opposite to OY (*d*) Along OY

Magnetic Force on Current Carrying Wire

21. Two long and parallel wires are at a distance of 0.1 *m* and a current of 5 *A* is flowing in each of these wires. The force per unit length due to these wires will be

(*a*) 5×10^{-5} N/m (*b*) 5×10^{-3} N/m

(*c*) 2.5×10^{-5} N/m (*d*) 2.5×10^{-4} N/m

Torque and Potential Energy of Coil in External Magnetic Field

22. A circular coil of radius 4 cm has 50 turns. In this coil a current of 2A is flowing. It is placed in a magnetic field of 0.1 weber/m^2 perpendicular to the palane of coil. The amount of work done in rotating it through 180° from its equilibrium position will be

(*a*) 0.1 J (*b*) 0.2 J

(*c*) 0.4 J (*d*) 0.8 J

23. The radius of a circular loop is r and a current i is flowing in it. The equivalent magnetic moment will be

(*a*) ir (*b*) $2\pi ir$

(*c*) $i\pi r^2$ (*d*) $\frac{1}{r^2}$

24. To make the field radial in a moving coil galvanometer

(*a*) The number of turns in the coil is increased

(*b*) Magnet is taken in the form of horse-shoe

(*c*) Poles are cylindrically cut

(*d*) Coil is wounded on aluminium frame

25. In a moving coil galvanometer, the deflection of the coil θ is related to the electrical current i by the relation

(*a*) $i\propto\tan\theta$ (*b*) $i\propto\theta$

(*c*) $i\propto\theta^2$ (*d*) $i\propto\sqrt{\theta}$

26. A small coil of N turns has an effective area A and carries a current I. It is suspended in a horizontal magnetic field $\vec{B}$ such that its plane is perpendicular to $\vec{B}$. The work done in rotating it by $180°$ about the vertical axis is

(*a*) $NAIB$ (*b*) $2NAIB$

(*c*) $2\pi NAIB$ (*d*) $4\pi NAIB$

27. A triangular loop of side l carries a current I. It is placed in a magnetic field B such that the plane of the loop is in the direction of B. The torque on the loop is

(*a*) Zero (*b*) IBl

(*c*) $\frac{\sqrt{3}}{2} Il^2B^2$ (*d*) $\frac{\sqrt{3}}{4} Il^2B^2$

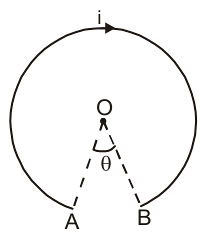
Learning Plus

1. Two parallel, long wires carry currents i_1 and i_2 with $i_1 > i_2$. When the current are in the same direction, the magnetic field at a point midway between the wire is 20μT. If the direction of i_1 is reversed, the field becomes 30μT. The ratio i_1/i_2 is

(*a*) 4 (*b*) 3

(*c*) 5 (*d*) 1

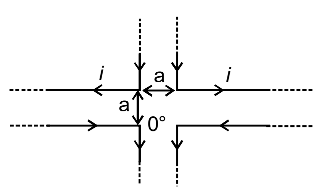
2. A current carrying wire AB of the length $2\pi R$ is turned along a circle, as shown in figure. The magnetic field at the centre O.



(*a*) $\frac{\mu_0 i}{2R}\left(\frac{2\pi-\theta}{2\pi}\right)^2$ (*b*) $\frac{\mu_0 i}{2R}\left(\frac{2\pi-\theta}{2\pi}\right)$

(*c*) $\frac{\mu_0 i}{2R}(2\pi-\theta)$ (*d*) $\frac{\mu_0 i}{2R}(2\pi+\theta)^2$

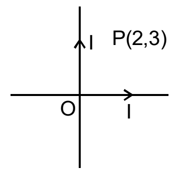
3. Four infinitely long 'L' shaped wires, each carrying a current i have been arranged as shown in the figure. Obtain the magnetic field intensity at the point 'O' equidistant from all the four corners.



(*a*) 1 wb/m^2 (*b*) 0 wb/m^2

(*c*) 2 wb/m^2 (*d*) None of these

4. Two mutually perpendicular insulated long conducting wires carrying equal currents I, intersect at origin. Then the resultant magnetic induction at point P (2m, 3m) will be -



(*a*) $\frac{\mu_0 I}{5a}$ (*b*) $\frac{5\mu_0 I}{2\pi}$

(*c*) $\frac{\mu_0 I}{12\pi}$ (*d*) 0

5. Two parallel straight long conducting wires, which are placed at a distance r from each other, are carrying equal currents i in opposite directions. The value of magnetic induction at a point situated at a point situated x from one wire in between the wires will be :

(*a*) $\frac{\mu_0 i}{2\pi}\left\{\frac{1}{r-x}-\frac{1}{x}\right\}$ (*b*) $\frac{\mu_0 i}{2\pi}\left\{\frac{1}{r-x}+\frac{1}{x}\right\}$

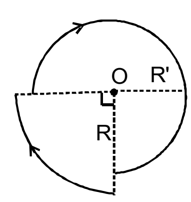
(*c*) $\frac{\mu_0 i}{2\pi(r-x)}$ (*d*) $\frac{\mu_0 i}{2\pi x}$

6. Two circular coils of wire each having a radius of 4 cm and 10 turns have a common axis and are 6 cm apart. If a current of 1 A passess through each coil in the opposite direction find the magnetic induction. At a point on the axis, midway between them.

(*a*) 13×10^{-5} T (*b*) zero

(*c*) 15×10^{-5}T (*d*) none of these

7. A current of i ampere is flowing through each of the bent wires as shown the magnitude and direction of magnetic field at O is



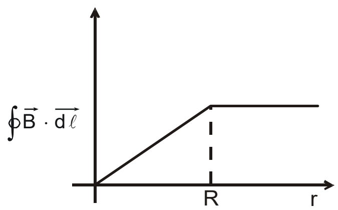
(*a*) $\frac{\mu_0 i}{4}\left(\frac{1}{R}+\frac{2}{R'}\right)$ (*b*) $\frac{\mu_0 i}{4}\left(\frac{1}{R}+\frac{3}{R'}\right)$

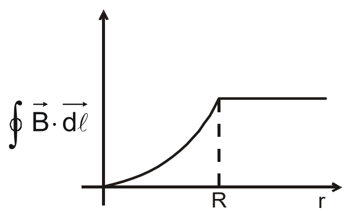
(*c*) $\frac{\mu_0 i}{8}\left(\frac{1}{R}+\frac{3}{2R'}\right)$ (*d*) $\frac{\mu_0 i}{8}\left(\frac{1}{R}+\frac{3}{R'}\right)$

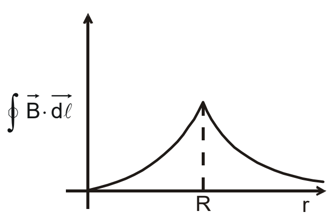
8. A point charge is moving in a circle with constant speed. Consider the magnetic field produced by the charge at a fixed point P (not centre of the circle) on the axis of the circle.

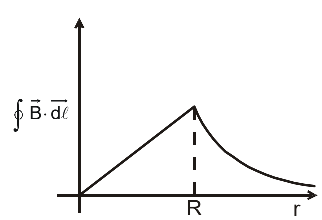
(*a*) it is constant in magnitude only
(*b*) it is constant in direction only
(*c*) it is constant in direction and magnitude both
(*d*) it is not constant in magnitude and direction both.

9. A cylindrical wire of radius R is carrying current i uniformly distributed over its cross-section. If a circular loop of radius 'r' is taken as amperian loop, then the variation value of $\oint \vec{B}\cdot\vec{d\ell}$ over this loop with radius ' r ' of loop will be best represented by:

(*a*) 

(*b*) 

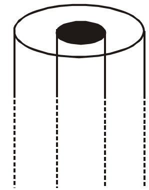
(*c*) 

(*d*) 

10. A current I flows along the length of an infinitely long, straight, thin walled pipe. Then

(*a*) the magnetic field at all points inside the pipe is the same, but not zero
(*b*) the magnetic field at any point inside the pipe is zero
(*c*) the magnetic field is zero only on the axis of the pipe
(*d*) the magnetic field is different at different points inside the pipe.

11. In a coaxial, straight cable, the central conductor and the outer conductor carry equal currents in opposite directions. The magnetic field is zero.



(*a*) outside the cable
(*b*) inside the inner conductor
(*c*) inside the outer conductor
(*d*) in between the two conductors

12. Electric current i enters and leaves a square loop made of homogeneous wire of uniform cross-section through diagonally opposite corners. A charge particle q moving along the axis of the square loop. Passes through centre at speed υ. The magnetic force acting on the particle when it passes through the centre has a magnitude

(*a*) $qv\dfrac{\mu_0 i}{2a}$ (*b*) $qv\dfrac{\mu_0 i}{2\pi a}$

(*c*) $qv\dfrac{\mu_0 i}{a}$ (*d*) zero

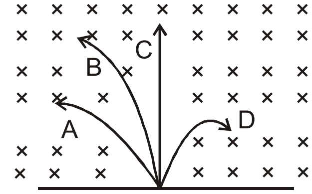
13. A negative charged particle falling freely under gravity enters a region having uniform horizontal magnetic field pointing towards north. The particle will be deflected towards

(*a*) East (*b*) West
(*c*) North (*d*) South

14. A positively charged particle moves in a region having a uniform magnetic field and uniform electric field in same direction. At some instant, the velocity of the particle is perpendicular to the field direction. The path of the particle will be

(*a*) a straight line
(*b*) a circle
(*c*) a helix with uniform pitch
(*d*) a helix with increasing pitch

15. A neutron, a proton, an electron and an a-particle enters a uniform magnetic field with equal velocities. The field is directed along the inward normal to the plane of the paper. Which of these tracks followed are by a - particle.



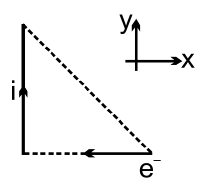
(*a*) A (*b*) B
(*c*) C (*d*) D

16. Electrons moving with different speeds enter a uniform magnetic field in a direction perpendicular to the field. They will move along circular paths.
(*a*) of same radius
(*b*) with larger radii for the faster electrons.
(*c*) with smaller radii for the faster electrons.
(*d*) either (*b*) or (*c*) depending on the magnitude of the magnetic field

17. A particle having charge of 1 C, mass 1 kg and speed 1 m/s enters a uniform magnetic field, having magnetic induction of 1 T, at an angle θ = 30° between velocity vector and magnetic induction. The pitch of its helical path is (in meters)

(*a*) $\frac{\sqrt{3}\pi}{2}$ (*b*) $\sqrt{3}\pi$
(*c*) $\frac{\pi}{2}$ (*d*) p

18. The direction of magnetic force on the electron as shown in the diagram is along

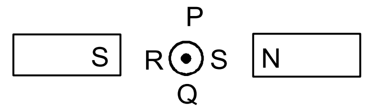


(*a*) y-axis   (*b*) –y-axis
(*c*) z-axis   (*d*) –z-axis

19. An electron is moving along positive x-axis. A uniform electric field exists towards negative y-axis. What should be the direction of magnetic field of suitable magnitude so that net force of electron is zero.
(*a*) positive z-axis   (*b*) negative z-axis
(*c*) positive y-axis   (*d*) negative y-axis

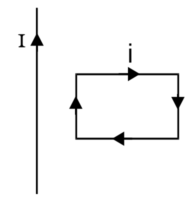
20. Two infinitely long, thin, insulated, straight wires lie in the x-y plane along the x and y-axis respectively. Each wire carries a current I, respectively in the positive x-direction and positive y-direction. The magnetic field will be zero at all points on the straight line:
(*a*) y = x   (*b*) y = – x
(*c*) y = x – 1   (*d*) y = – x + 1

21. A straight current carrying conductor is placed in such a way that the current in the conductor flows in the direction out of the plane of the paper. The conductor is placed between two poles of two magnets, as shown. The conductor will exerience a force in the direction towards



(*a*) P   (*b*) Q
(*c*) R   (*d*) S

22. A rectangular loop carrying a current i is situated near a long straight wire such that the wire is parallel to one of the sides of the loop and the plane of the loop is same of the left wire. If a steady current I is established in the wire as shown in the (fig) the loop will -



(*a*) Rotate about an axis parallel to the wire
(*b*) Move away from the wire
(*c*) Move towards the wire
(*d*) Remain stationary

23. A bar magnet has a magnetic moment 2.5 JT^{-1} and is placed in a magnetic field of 0.2 T. Work done in turning the magnet from parallel to antiparallel position relative to the field direction.
(*a*) 0.5 J   (*b*) 1 J
(*c*) 2.0 J   (*d*) Zero

24. A circular loop of area 1 cm^2, carrying a current of 10 A, is placed in a magnetic field of 0.1 T perpendicular to the plane of the loop. The torque on the loop due to the magnetic field is
(*a*) zero   (*b*) 10^{-4} N-m
(*c*) 10^{-2} N-m   (*d*) 1 N-m

25. The magnetic moment of a circular orbit of radius 'r' carrying a charge 'q' and rotating with velocity v is given by

(*a*) $\frac{qvr}{2\pi}$ (*b*) $\frac{qvr}{2}$
(*c*) $qv\pi r$ (*d*) $qv\pi r^2$

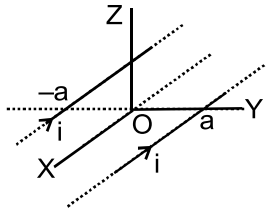
Advanced Level Multiconcept Questions

MCQ/COMPREHENSION/MATCHING/ NUMERICAL

1. A long straight wire carries a current along the x-axis. Consider the points A(0, 1, 0), B (0, 1, 1), C (1, 0, 1) and D (1, 1, 1). Which of the following pairs of points will have magnetic fields of the same magnitude ?
(*a*) A and B   (*b*) A and C
(*c*) B and C   (*d*) B and D

2. In the previous question, if the current is *i* and the magnetic field at D has magnitude B,
(*a*) $B = \frac{\mu_0 i}{2\sqrt{2}\pi}$
(*b*) $B = \frac{\mu_0 i}{2\sqrt{3}\pi}$
(*c*) B is parallel to the x-axis
(*d*) B makes an angle of 45° with the xy plane

3. Two long thin, parallel conductors carrying equal currents in the same direction are fixed parallel to the x-axis, one passing through y = a and the other through y = –a. The resultant magnetic field due to the two conductors at any point is B. Which of the following are correct?



(*a*) B = 0 for all points on the x-axis
(*b*) At all points on the y-axis, excluding the origin, B has only a z-component.
(*c*) At all point of the z-axis, excluding the origin, B has only a y-component.
(*d*) B cannot have an x-component.

4. A hollow tube is carrying an electric current along its length distributed uniformly over its surface. The magnetic field
(*a*) increases linearly from the axis to the surface
(*b*) is constant inside the tube
(*c*) is zero at the axis
(*d*) is non-zero outside the tube at finite distance from surface

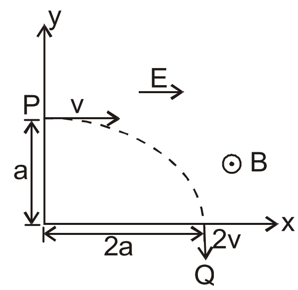
5. Two identical charged particles enter a uniform magnetic field with same speed but at angles 30° and 60° with field. Let a, b and c be the ratio of their time periods, radii and pitches of the helical paths than
(*a*) abc = 1 (*b*) abc > 1
(*c*) abc < 1 (*d*) a = bc

6. Consider the following statements regarding a charged particle in a magnetic field. Which of the statements are true :
(*a*) Starting with zero velocity, it accelerates in a direction perpendicular to the magnetic field.
(*b*) While deflecting in magnetic field its energy gradually increases.
(*c*) Only the component of magnetic field perpendicular to the direction of motion of the charged particle is effective in deflecting it.
(*d*) Direction of deflecting force on the moving charged particle is perpendicular to its velocity.

7. A beam of electrons moving with a momentum p enters a uniform magnetic field of flux density B perpendicular to its motion. Which of the following statement(s) is (are) true?
(*a*) Energy gained is $\frac{p^2}{2m}$
(*b*) Centripetal force on the electron is $Be\frac{m}{p}$
(*c*) Radius of the electron's path is $\frac{p}{Be}$
(*d*) Work done on the electrons by the magnetic field is zero

8. Two ions have equal masses but one is singly-ionized and other is tripply-ionized. They are projected from the same place in a uniform magnetic field with the same velocity perpendicular to the field.
(*a*) Both ions will go along circles of equal radii.
(*b*) The circle described by the single-ionized charge will have a radius tripply that of the other circle
(*c*) The two circles do not touch each other
(*d*) The two circles touch each other

9. A particle of charge +q and mass m moving under the influence of a uniform electric field $E\hat{i}$ and a uniform magnetic field $B\hat{k}$ follows a trajectory from P and Q as shown in figure. The velocities at P and Q are $v\hat{i}$ and $-2v\hat{j}$. Which of the following statement(s) is/are correct?



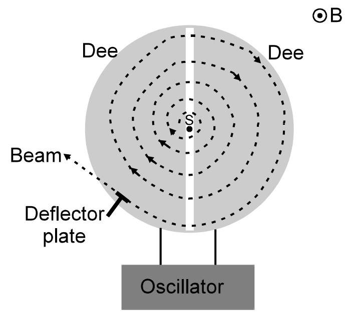
(*a*) $E = \frac{3}{4}\left(\frac{mv^2}{qa}\right)$
(*b*) Rate of work done by the electric field at P is $\frac{3}{4}\left(\frac{mv^3}{a}\right)$
(*c*) Rate of work done by the electric field at P is zero.
(*d*) Rate of work done by both fields at Q is zero.

10. Let $\vec{E}$ and $\vec{B}$ denote the electric and magnetic fields in a certain region of space. A proton moving with a velocity $\vec{v}$ along a straight line enters the region and is found to pass through it undeflected. Indicate which of the following statements are possible for the observation:
(*a*) $\vec{E} = 0$ and $\vec{B} = 0$
(*b*) $\vec{E} \neq 0$ and $\vec{B} = 0$
(*c*) $\vec{E} \neq 0$, $\vec{B} \neq 0$ and both $\vec{E}$ and $\vec{B}$ are parallel to $\vec{v}$
(*d*) $\vec{E}$ is parallel to $\vec{v}$ but $\vec{B}$ is perpendicular to $\vec{v}$

Comprehension–1 (No. 11 to 15)

(Read the following passage and answer the questions. They have only one correct option)

In the given figure of a cyclotron, showing the particle source S and the dees. A uniform magnetic field is directed up from the plane of the page. Circulating protons spiral outward within the hollow dees, gaining energy every time they cross the gap between the dees.



Suppose that a proton, injected by source S at the centre of the cyclotron in Fig., initially moves toward a negatively charged dee. It will accelerate toward this dee and enter it. Once inside, it is shielded from electric field by the copper walls of the dee; that is the electric field does not enter the dee. The magnetic field, however, is not screened by the (nonmagnetic) copper dee, so the proton moves in circular path whose radius, which depends on its speed, is given by

Eq. $r = \dfrac{mv}{qB}$ ...(1)

Let us assume that at the instant the proton emerges into the center gap from the first dee, the potential difference between the dees is reversed. Thus, the proton again faces a negatively charged dee and is again accelerated. Thus, the proton again faces a negatively charged dee and is again accelerated. This process continues, the circulating proton always being in step, with the oscillations of the dee potential, until the proton has spiraled out to the edge of the dee system. There a deflector plate sends it out through a portal.

The key to the operation of the cyclotron is that the frequency f at which the proton circulates in the field (and that does not depend on its speed) must be equal to the fixed frequency f_{osc} of the electrical oscillator, or

$f = f_{osc}$ (resonance condition) ...(2)

This resonance condition says that, if the energy of the circulating proton is to increase, energy must be fed to it at a frequency f_{osc} that is equal to the natural frequency f at which the proton circulates in the magnetic field.

Combining Eq. 1 and 2 allows us to write the resonance condition as

$qB = 2\pi m f_{osc}$. ...(3)

For the proton, q and m are fixed. The oscillator (we assume) is designed to work at a single fixed frequency f_{osc}. We then "tune" the cyclotron by varying B until eq. 3 is satisfied and then many protons circulate through the magnetic field, to emerge as a beam.

11. Ratio of radius of successive semi circular path

(*a*) $\sqrt{1} : \sqrt{2} : \sqrt{3} : \sqrt{4}$ ....

(*b*) $\sqrt{1} : \sqrt{3} : \sqrt{5}$ ....

(*c*) $\sqrt{2} : \sqrt{4} : \sqrt{6}$ ....

(*d*) 1 : 2 : 3 ....

12. Change in kinetic energy of charge particle after every time period is :

(*a*) 2qV (*b*) qV

(*c*) 3qV (*d*) None of these

13. If q/m for a charge particle is 10^6, frequency of applied AC is 10^6 Hz. Then applied magnetic field is:

(*a*) 2π tesla (*b*) π tesla

(*c*) 2 tesla (*d*) can not be defined

14. Distance travelled in each time period are in the ratio of:

(*a*) $\sqrt{1} + \sqrt{3} : \sqrt{5} + \sqrt{7} : \sqrt{9} + \sqrt{11}$

(*b*) $\sqrt{2} + \sqrt{3} : \sqrt{4} + \sqrt{5} : \sqrt{6} + \sqrt{7}$

(*c*) $\sqrt{1} : \sqrt{2} : \sqrt{3}$

(*d*) $\sqrt{2} : \sqrt{3} : \sqrt{4}$

15. For a given charge particle a cyclotron can be "tune" by:

(*a*) changing applied A.C. voltage only

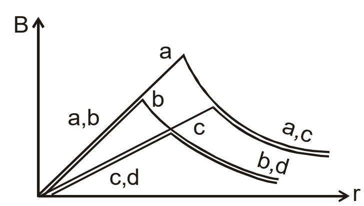
(*b*) changing applied A.C. voltage and magnetic field both

(*c*) changing applied magnetic field only

(*d*) by changing frequency of applied A.C.

Comprehension–2 (No. 16 to18)

Curves in the graph shown give, as functions of radial distance r (from the axis), the magnitude B of the magnetic field (due to individual wire) inside and outside four long wires a, b, c and d, carrying currents that are uniformly distributed across the cross sections of the wires. Overlapping portions of the plots are indicated by double labels. All curves start from the origin.



16. Which wire has the greatest radius?

(*a*) a (*b*) b

(*c*) c (*d*) d

17. Which wire has the greatest magnitude of the magnetic field on the surface?

(*a*) a (*b*) b

(*c*) c (*d*) d

18. The current density in wire a is

(*a*) greater than in wire c.

(*b*) less than in wire c.

(*c*) equl to that in wire c.

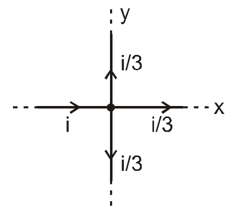
(*d*) not comparable to that of in wire c due to lack of information.

19. Column-II gives four situations in which three (in q,r,s) and four (in p) semi infinite current carrying wires are placed in xy-plane as shown. The magnitude and direction of current is shown in each figure. Column-I gives statements regarding the x and y components of magnetic field at a point P whose coordinates are P (0, 0, d). Match the statements in column-I with the corresponding figures in column-II and indicate your answer by darkening appropriate bubbles in the 4 × 4 matrix given in OMR.

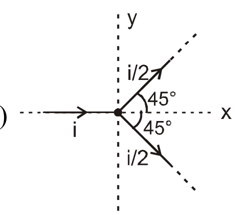
Column I

Column II

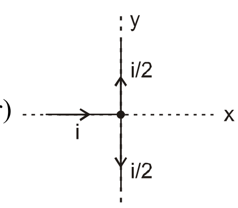
(*a*) The x component of magnetic field at point P is zero in

(p) 

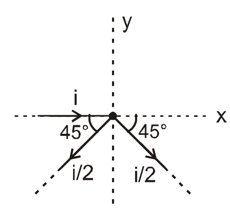
(*b*) The z component of magnetic field at point P is zero in

(q) 

(*c*) The magnitude of magnetic field at point P is $\frac{\mu_0 i}{4\pi d}$ in

(r) 

(*d*) The magnitude of magnetic field at point P is less than $\frac{\mu_0 i}{2\pi d}$ in

(s) 

20. There are four situations given in column I involving a magnetic dipole of dipole moment $\vec{\mu}$ placed in uniform external magnetic field $\vec{B}$. Column II gives corresponding results. Match the situtations in column I with the corresponding results in column II

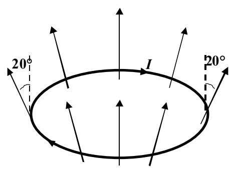
Column - I	**Column - II**
(*a*) Magnetic dipole moment $\vec{\mu}$ is parallel to uniform external magnetic field $\vec{B}$ (angle between both vectors is zero)	(p) force on dipole is zero
(*b*) Magnetic dipole moment $\vec{\mu}$, is perpendicular to uniform external magnetic field $\vec{B}$	(q) torque on dipole is zero
(*c*) Angle between magnetic dipole moment $\vec{\mu}$ and uniform external magnetic field $\vec{B}$ is acute	(r) magnitude of torque is (μB)
(*d*) Angle between magnetic dipole moment $\vec{\mu}$ and uniform external magnetic field $\vec{B}$ is 180°.	(s) potential energy of dipole due to external magnetic field is (μB)

NUMERICAL VALUE BASED

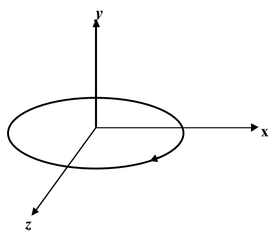
21. A charge $q = -4\ \mu C$ has an instantaneous velocity $\vec{v} = (2 \times 10^6\ \hat{i} - 3 \times 10^6\ \hat{j} + 10^6\ \hat{k})$ m/s in a uniform field $\vec{B} = (2 \times 10^{-2}\ \hat{i} + 5 \times 10^{-2}\ \hat{j} - 3 \times 10^{-2}\ \hat{k})$ T. What is the magnitude of x component of force on the charge in N?

22. An electron accelerated by a potential difference V = 1.0 kV moves in a uniform magnetic field at an angle $\alpha = 30°$ to the vector B whose modulus is B = 29mT . Find the pitch of the helical trajectory of the electron in mm.

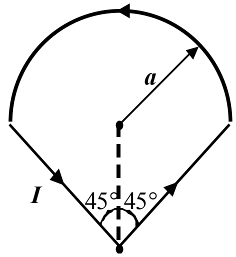
23. A super conducting ring has a radius of 1.4 cm and a mass of 30g. The ring carries a constant I and is placed in a 0.5 T magnetic field with field lines that are tilted at a 20° angle, outward from the vertical at every location around the ring. What must the current I in Ampere be for the ring to float in the magnetic field?
[Given sin20° = 0.34 ; cos20° = 0.94]



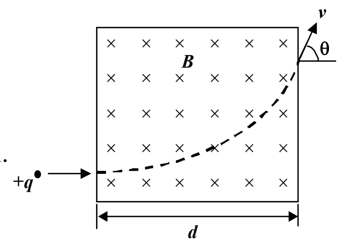
24. A coil of radius 25 cm has 15 turns and lies in the x-z plane. It carries a current of 2A, as in figure. Find magnitude of torque on the coil for $\vec{B} = 0.2\ \hat{i}$ T in N-m.



25. Two perpendicular straight wires join the ends of a semicircular loop of radius a, as shown in the figure. If the current is I, the resultant field at the centre of the circular section is given by $x \times 10^{-7} \dfrac{I}{a}$ then x is -



26. A proton accelerated by a potential difference $V = 500$ kV flies through a uniform transverse magnetic field with induction $B = 0.51$ T. The field occupies a region of space $d = 10$ cm in thickness. Find the angle θ in degree through which the proton deviates from the initial direction of its motion.



27. The magnetic field existing in a region is given by

$$\vec{B} = B_0\left(1 + \frac{x}{l}\right)\hat{k}$$

A square loop of side l and carrying a current I, is placed with its sides parallel to the x and y axes. The magnitude of the net magnetic force experienced by the loop is kBIl then k is

28. A current $I = 10$A flows in a ring of radius $r_0 = 15$ cm made of a very thin wire. The tensile strength of the wire is equal to $T = 1.5$ N. The ring is placed in a magnetic field which is perpendicular to the plane of the ring so that the forces tend to break the ring. Find B in Tesla at which the ring is broken.

Topicwise Questions

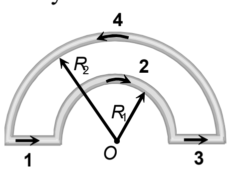
1. (*d*) $dB = \frac{\mu_0}{4\pi} \cdot \frac{idl\sin\theta}{r^2} \Rightarrow d\vec{B} = \frac{\mu_0}{4\pi} \cdot \frac{i(d\vec{l} \times \vec{r})}{r^3}$

2. (*d*) $B = \frac{\mu_0}{4\pi}\frac{(2\pi-\theta)i}{R} = \frac{\mu_0}{4\pi}\frac{\left(2\pi - \frac{\pi}{2}\right)\times i}{R} = \frac{3\mu_0 i}{8R}$

3. (*b*) $i = \frac{q}{T} = \frac{2\times1.6\times10^{-19}}{2} = 1.6\times10^{-19}\,A$

$\therefore\ B = \frac{\mu_0 i}{2r} = \frac{\mu_0 \times 1.6\times10^{-19}}{2\times0.8} = \mu_0 \times 10^{-19}$

4. (*a*) In the following figure, magnetic fields at *O* due to sections 1, 2, 3 and 4 are considered as B_1, B_2, B_3 and B_4 respectively.



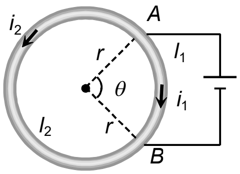
$B_1 = B_3 = 0$

$B_2 = \frac{\mu_0}{4\pi} \cdot \frac{\pi i}{R_1} \otimes$

$B_4 = \frac{\mu_0}{4\pi} \cdot \frac{\pi i}{R_2} \odot$ As $|B_2| > |B_4|$

So $B_{net} = B_2 - B_4 \Rightarrow B_{net} = \frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \otimes$

5. (*d*) Directions of currents in two parts are different, so directions of magnetic fields due to these currents are opposite. Also applying Ohm's law across AB



$i_1R_1 = i_2R_2 \Rightarrow i_1l_2 = i_2l_2$

$\left(\because R = \rho\frac{l}{A}\right)$

Also $B_1 = \frac{\mu_0}{4\pi} \times \frac{i_1 l_1}{r^2}$ and $B_2 = \frac{\mu_0}{4\pi} \times \frac{i_2 l_2}{r^2}$

$(\because l = r\theta)$

$\therefore\ \frac{B_2}{B_1} = \frac{i_1 l_1}{i_2 l_2} = 1$

Hence, two field induction's are equal but of opposite direction. So, resultant magnetic induction at the centre is zero and is independent of θ.

6. (*b*)

7. (*b*) Because for inside the pipe $i = 0$

$\therefore\ B = \frac{\mu_0 i}{2\pi r} = 0$

8. (*c*) The magnetic field in the solenoid along its axis

(i) At an internal point $= \mu_0 ni$

$= 4\pi \times 10^{-7} \times 5000 \times 4 = 25.1 \times 10^{-3}\ Wb/m^2$

(Here n = 50 turns/ cm = 5000 turns / m)

(ii) At one end

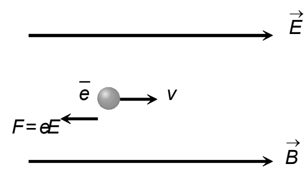
$B_{end} = \frac{1}{2}B_{in}\ \frac{\mu_0 ni}{2} = \frac{25.1\times10^{-3}}{2} = 12.6 \times 10^{-3}\ Wb/m^2$

9. (*b*) Magnetic field at the centre of solenoid (B)= $\mu_0 ni$

Where n = Number of *turns/meter*

$\therefore\ B = 4\pi \times 10^{-7} \times 4250 \times 5 = 2.7 \times 10^{-2}\ Wb/m^2$

10. (*d*) Since electron is moving is parallel to the magnetic field, hence magnetic force on it $F_m = 0$..



The only force acting on the electron is electric force which reduces it's speed.

11. (*b*) $B = \frac{mv}{qr} = \frac{9\times10^{-31}\times10^6}{1.6\times10^{-19}\times0.1} = 5.6\times10^{-5}\,T$

12. (*b*) This is according to the cross product $\vec{F} = q(\vec{v}\times\vec{B})$ otherwise can be evaluated by the left-hand rule of Fleming.

13. (*d*) $r = \dfrac{\sqrt{2mK}}{qB} \Rightarrow K \propto \dfrac{q^2}{m}$

$\Rightarrow \dfrac{K_P}{K_d} = \left(\dfrac{q_p}{q_d}\right) \times \dfrac{m_d}{m_p} = \left(\dfrac{1}{1}\right)^2 \times \dfrac{2}{1} = \dfrac{2}{1}$

$\Rightarrow K_p = 2 \times 50 = 100$ keV.

14. (*a*) Lorentz force is given by

$\vec{F} = \vec{F}_e + \vec{F}_m = q\vec{E} + q(\vec{v} \times \vec{B}) = q[\vec{E} + (\vec{v} \times \vec{B})]$

15. (*c*) $r = \dfrac{1}{B}\sqrt{\dfrac{2mV}{q}} \Rightarrow r \propto \sqrt{\dfrac{m}{p}} \Rightarrow \dfrac{r_x}{r_y} = \sqrt{\dfrac{m_x}{q_x} \times \dfrac{q_y}{m_y}}$

$\Rightarrow \dfrac{R_1}{R_2} = \sqrt{\dfrac{m_x}{m_y} \times \dfrac{2}{1}} \Rightarrow \dfrac{m_x}{m_y} = \dfrac{R_1^2}{2R_2^2}$

16. (*d*) The component of velocity perpendicular to *H* will make the motion circular while that parallel to *H* will make it move along a straight line. The two together will make the motion helical.

17. (*d*) The deflection produced by the electric field may be nullified by that produced by magnetic field.

18. (*b*) $r = \dfrac{m\nu}{qB} \Rightarrow r \propto m\nu$ (*q* and *B* are constant)

$\because \; r_A > r_B \Rightarrow m_A\nu_A > m_B\nu_B$

19. (*c*) $W = F.\,D\cos 90^\circ = 0$

20. (*d*) Magnetic field produced by wire at the location of charge is perpendicular to the paper inwards. Hence by applying Fleming's left hand rule, force is directed along OY.

21. (1) $F = \dfrac{\mu_0}{4\pi}\dfrac{2 \times i_1 i_2}{a} = \dfrac{10^{-7} \times 2 \times 5 \times 5}{0.1} = 5 \times 10^{-5}\ \text{N/m}$

22. (*a*) The magnetic moment of current carrying loop

$M = niA = ni(\pi r^2)$

Hence the work done in rotating it through 180°

$w = MB(1 - \cos\theta) = 2MB = 2(ni\pi r^2)B$

$= 2 \times (50 \times 2 \times 3.14 \times 16 \times 10^{-4}) \times 0.1 = 0.1$ J

23. (*c*) $M = i\pi r^2$

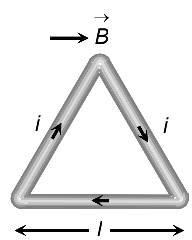
24. (*c*)

25. (*b*) $i = \dfrac{C\theta}{NAB} \Rightarrow i \propto \theta$

26. (*b*) $w = MB(\cos\theta_1 - \cos\theta_2)$

$= (NiA)B(\cos 0^\circ - \cos 180^\circ) = 2\,NAIB$

27. (*d*) Since $\theta = 90°$



Hence $\tau = NIAB = 1 \times I \times \left(\dfrac{\sqrt{3}}{4}l^2\right)B$

$= \dfrac{\sqrt{3}}{4}l^2 BI$

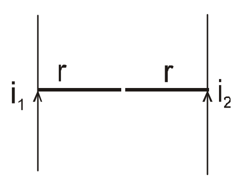
Learning Plus

1. (*c*) $i_1 > i_2$

$\dfrac{\mu_0}{2r}(i_1 - i_2) = 20$

$\dfrac{\mu_0}{2r}(i_1 + i_2) = 30$

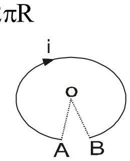
$\dfrac{i_1 + i_2}{i_1 - i_2} = \dfrac{3}{2} \Rightarrow \dfrac{i_1}{i_2} = \dfrac{5}{1}$



2. (*a*) $B = \dfrac{\mu_0 i}{4\pi R'}(2\pi - \theta)$

where; $(2\pi - \theta)R' = 2\pi R$

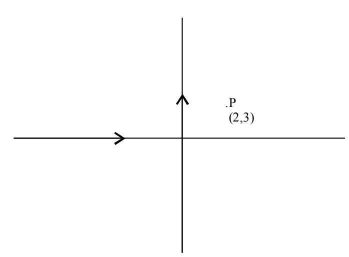
$R' = \dfrac{2\pi R}{2\pi - \theta}$



$B = \dfrac{\mu_0 i}{2R}\left(\dfrac{2\pi - \theta}{2\pi}\right)^2$

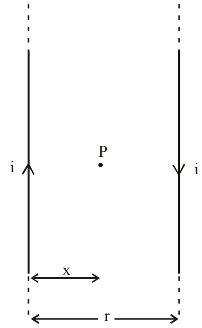
3. (*b*) Zero, because magnetic field due to each wire will be cancelled by another wire.

4. (*c*)



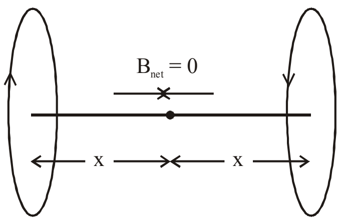
$B_{net} = \dfrac{\mu_0 I}{2\pi(2)} - \dfrac{\mu_0 I}{2\pi(3)}$, $B_{net} = \dfrac{\mu_0 I}{12\pi} \otimes$

5. (*b*)

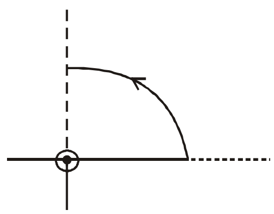


At point P $\dfrac{\mu_0 i}{2\pi}\left[\dfrac{1}{x}+\dfrac{1}{r-x}\right]$

6. (*b*)



7. (*d*)

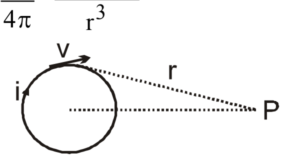


$B = \dfrac{\mu_0 i}{8R}$

from the above in the given Ques.

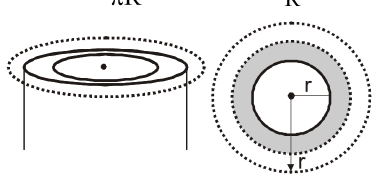
$B = \dfrac{\mu_0 i}{8}\left[\dfrac{1}{R}+\dfrac{3}{R'}\right]$

8. (*a*) $\vec{B} = \dfrac{\mu_0}{4\pi}\dfrac{q(\vec{v}\times\vec{r})}{r^3}$



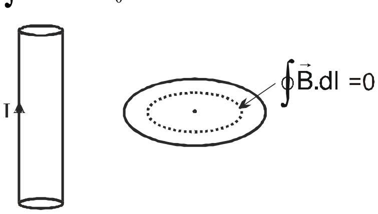
Magnitude fixed but direction keeps on changing

9. (*b*) $\oint \vec{B}.\vec{dl} = \mu_0 \dfrac{i}{\pi R^2}\times \pi r^2 = \dfrac{\mu_0 i r^2}{R^2}$



$\oint \vec{B}.\vec{dl} = \mu_0 i$

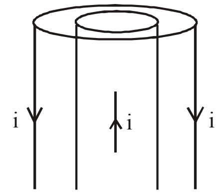
10. (*b*)



$\oint \vec{B}.\vec{dl} = 0$

$B = 0$

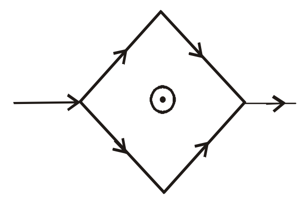
11. (*a*)



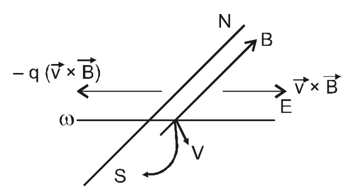
Inside the conductor magnetic field due to both have same direction so we add them.

Out side the conductor magnetic field due to both have opposite direction. so we subtract them.

12. (*d*)



13. (*b*)

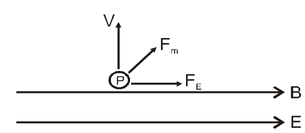


F towards west

So particle will be deflected towards west

14. (*d*) $F_E = qE$, $F_m = qvB$

$R = \dfrac{mv}{qB}$



Pitch $p = V_{\parallel} T$

$T = \dfrac{2\pi R}{V}$

$V_{\parallel} = 0 + \dfrac{qE\ t}{m}$

15. (*b*) $R \propto \dfrac{m}{q}$

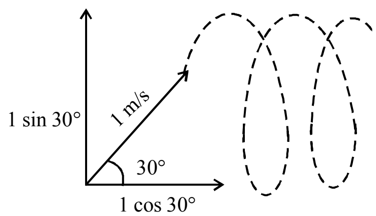
$R_P : R_e : R_\alpha = \dfrac{m_P}{q} : \dfrac{m_e}{q} : \dfrac{4m_P}{2q}$.

$R = \dfrac{mv}{qB}$

α-particle has maximum R, so the path followed is B.

16. (*b*) $R = \dfrac{mv}{qB}$

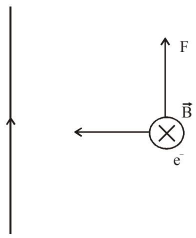
17. (*b*)



Pitch = $V_{\parallel} . T$

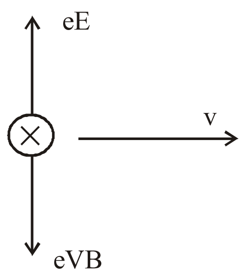
$= V\cos\theta . \dfrac{2\pi m}{qB} = \dfrac{\sqrt{3}}{2} \times 2\pi = \sqrt{3}\pi$

18. (*a*)

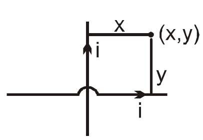


Applying right hand thumb rule.

19. (*b*) Force on electron due to electric field is in positive y-direction so force due to magnetic field should be in negative y-direction. Hence direction of magnetic field should be in –ve z-direction.



20. (*a*) $\dfrac{\mu_0 i}{2\pi x} = \dfrac{\mu_0 i}{2\pi y}$

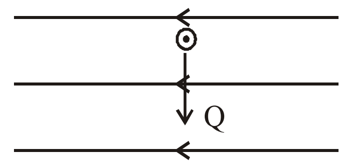


y = x

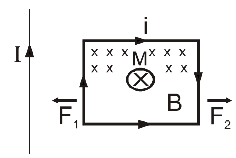
only in first quadrant the fields will be oppositely directed.

21. (*b*) By formula $F = i\left(\vec{\ell} \times \vec{B}\right)$

direction of ℓ in direction of i.



22. (*c*) $\vec{M} \times \vec{B} = 0$



$\tau = 0$

Loop will Not rotate

$F_1 > F_2$

So loop move towards the wire

23. (*b*) $U_i = -MB$

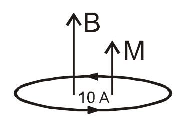
$U_f = MB$

$W = \Delta U = 2\,MB$

$= 2 \times 2.5 \times 0.2$

$= 1$ J

24. (*a*)



$\vec{\tau} = \vec{M} \times \vec{B} = 0$

25. (*b*) $i = qf = \dfrac{qv}{2\pi r}$

$T = \dfrac{2\pi r}{v}$

M.M. $= i\pi r^2 = \dfrac{qvr}{2}$

Advanced Level Multiconcept Questions

1. (*b,d*)

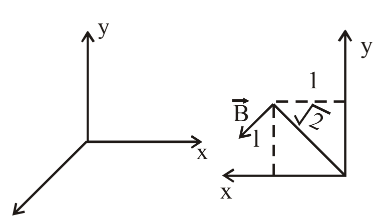
In point A & C

r = 1 m

In point B & D

r = $\sqrt{2}$ m

2. (*a,d*)



$$B = \frac{\mu_0 i}{2\sqrt{2}\pi}$$

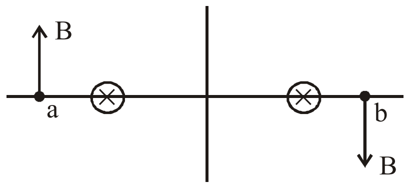
As direction of magnetic field is ⊥ to line joining wire and point hence angle between xy plane & magnetic field is 45º.

3. (*a,b,c,d*)

(*a*) Direction of magnetic field produced due to the two wires on x axis have opposite direction

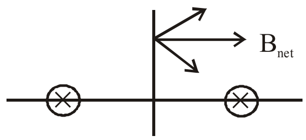
$\Rightarrow B_{net} = 0$.

(*b*)



a & b have only z component.

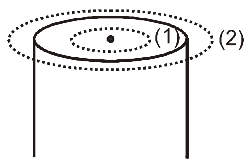
(*c*)



B_{net} has only y component as z component gets cancelled

(*d*) $B_x = 0$ in net B

4. (*b,c,d*)



Loop (1)

$B(2\pi r) = 0$

$B = 0$

Loop (2)

$B(2\pi r) = \mu_0 i$

$$B \propto \frac{1}{r}$$

5. (*a,d*)

$$T = \frac{2\pi m}{qB}\ ;\ \frac{T_1}{T_2} = 1$$

$$r_1 = \frac{mV\sin 30°}{qB}\ ;\ r_2 = \frac{mV\sin 60°}{qB}$$

$$b = \frac{1}{\sqrt{3}}$$

$Pitch_1 = v\cos 30°\ T_1$

$Pitch_2 = v\cos 60°\ T_2$

$abc = 1$

$c = \sqrt{3}$

$a = bc$

6. (*c,d*)

W. D. by mag. field is zero

$$F_{mg} = q\left(\vec{v} \times \vec{B}\right)$$

7. (*c,d*)

$$R = \frac{mv}{eB} = \frac{P}{eB}$$

Energy gained = 0

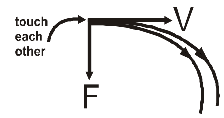
As $W_B = 0$

$$F_C = \frac{mv^2}{r} = evB = \frac{ePB}{m}$$

8. (*b,d*)

$$R = \frac{mv}{qB}$$

More q means less R



$$\left(\frac{R_1}{R_2}\right) = \left(\frac{q_2}{q_1}\right)$$

9. (*a,b,d*)

$\omega_E + \omega_B = \Delta k$

$$\Rightarrow qE(2a) = \frac{1}{2}m(2v)^2 - \frac{1}{2}mv^2$$

$$= \frac{3}{2}mv^2$$

$$E = \frac{3}{4}\frac{mv^2}{qa}$$

At P Rate of work done by $E = qEv = \frac{3}{4}\frac{mv^3}{a}$

At Q Rate of work done by $E = qE(2v)\cos 90° = 0$

At Q Rate of work done by $B = 0$

10. (*a,b,c*)

$\vec{V}$ constant in direction and may be in magnetude

$\vec{a} = 0$

$q\vec{E} + q(\vec{V} \times \vec{B}) = 0$

I[st] posibility

$\vec{E} = 0$ & $\vec{B} = 0$ $\quad \longrightarrow V$

II[nd] posibility

$\vec{E} = 0$ & $\vec{V} \parallel \vec{B}$ i.e. $\vec{B} \neq 0$

III[rd] posibility $\quad \longrightarrow V$

$\longrightarrow E$

$\vec{E} \parallel \vec{V}$ & $B = 0$

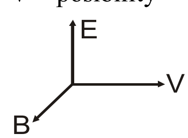
IV[th] posibility

$\longrightarrow B$

$\longrightarrow V$ $\quad \vec{E} \parallel \vec{V} \parallel \vec{B}$

$\longrightarrow E$ $\quad \vec{V} \times \vec{B} = 0$

V[th] posibility



$q\vec{E} = -q(\vec{V} \times \vec{B})$

11. (*b*) When charge is accelerated by electric field it gains

energy for first time $KE_1 = \frac{qV}{2}$

for second time $KE_2 = \frac{3}{2}qV$

for third time $KE_3 = \frac{5}{2}qV$

hence the ratio of radii are

$$r_1 : r_2 : r_3 : .... :: \frac{\sqrt{2m\frac{qv}{2}}}{qB} : \frac{\sqrt{2m\frac{3}{2}qv}}{qB} : ....$$

$$r_1 : r_2 : r_3 .... :: \sqrt{1} : \sqrt{3} : \sqrt{5} ....$$

12. (*a*) In one full cycle it gets accelerated two times so change in KE = 2 qV.

13. (*a*) $f = \frac{qB}{2\pi m} \Rightarrow 10^6 = \frac{10^6 B}{2\pi} \Rightarrow 2\pi T.$

14. (*a*) Distance travelled by particle in one time period :

$\pi(r_1 + r_2) : \pi(r_3 + r_4) : \pi(r_5 + r_6)$ ....

$$:: \frac{\sqrt{2m\frac{qV}{2}}}{qB} + \frac{\sqrt{2m\frac{3qV}{2}}}{qB} : \frac{\sqrt{2m\frac{5qV}{2}}}{qB} + \frac{\sqrt{2m\frac{7qV}{2}}}{qB} : \frac{\sqrt{2m\frac{9qV}{2}}}{qB} + \frac{\sqrt{2m\frac{11qV}{2}}}{qB} ....$$

$$S_1 : S_2 : S_3 ...... :: (\sqrt{1} + \sqrt{3}) : (\sqrt{5} + \sqrt{7}) : (\sqrt{9} + \sqrt{11})$$

15. (*c*) Frequency of A.C. depends on charge and mass only so it can be tuned by magnetic field only.

16. (*c*) Inside the cylinder

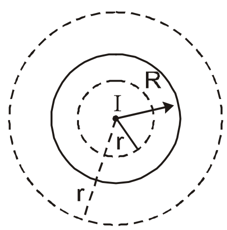
$$B.2\pi r = \mu_0 . \frac{I}{\pi R^2} \pi r^2$$

$$B = \frac{\mu_0 I}{2\pi R^2} . r \quad ....(1)$$

outside the cylinder

$B.2\pi r = \mu_0 I$

$$\therefore B = \frac{\mu_0 I}{2\pi r} \quad ....(2)$$



Inside cylinder B α r and outside B α $\frac{1}{r}$

So at the surface nature of magnetic field changes. Hence clear from graph, wire 'c' has greatest radius.

17. (*a*) Magnitude of magnetic field is maximum at the surface of wire 'a'.

18. (*a*) Inside the wire

$$B(r) = \frac{\mu_0}{2\pi} . \frac{I}{R^2} . r = \frac{\mu_0 J r}{2}$$

$$\frac{dB}{dr} = \frac{\mu_0 J}{2}$$

i.e. slope $\propto J \propto$ current density

It can be seen that slope of curve for wire a is greater than wire C.

19. (*a*)-p,q,r (*b*)-p,q,r,s (*c*)-r (*d*)-p,q,r,s

The magnetic field is along negative y-direction in p,q,r. Hence z-component of magnetic field is zero in all cases.

The magnetic field at P is $\frac{\mu_0}{4\pi}\frac{i}{d}$ for case (r)

The magnetic field at P is less than $\frac{\mu_0}{2\pi}\frac{i}{d}$ for all cases.

20. (*a*)-p,q; (*b*)-p,r; (*c*)-p; (*d*)-p,q,s

The Force on a magnetic dipole placed in uniform magnetic field is zero. Hence option p is common to all the four situations. Torque on magnetic dipole is $\vec{\tau} = \vec{\mu} \times \vec{B}$ and potential energy of dipole in external magnetic $U = -\vec{\mu} \times \vec{B}$

(*a*) Since $\theta = 0$, therefore $\tau = 0$

(*b*) Since $\theta = \pi/2$, therefore $\tau = \mu B$

(*c*) Since θ is acute, torque is non zero and less than μB in magnitude

(*d*) Since $\theta = \pi$, therefore $\tau = 0$ and $U = \mu B$

21. [0.16] $\vec{F} = q\vec{v} \times \vec{B}$,

Where q has a positive or negative sign, on substituting, we get

$$-0.16\hat{i} - 0.32\hat{j} + -0.64\hat{k}$$

22. [19.3] $T = eV = \frac{1}{2}mv^2$

$$v = \sqrt{\frac{2eV}{m}}$$

$$\Rightarrow v_H = \sqrt{\frac{2eV}{m}} \cos\alpha \text{ and}$$

$$v_v = \sqrt{\frac{2eV}{m}} \sin\alpha$$

Now, $\frac{mv_v^2}{r} = Bev_v$ or $r = \frac{mv_v}{Be}$

and $T = \frac{2\pi r}{v_v} = \frac{2\pi m}{Be}$

Pitch

$$P = v_H T = \frac{2\pi m}{Be}\sqrt{\frac{2eV}{m}} \cos\alpha = 0.02m$$

23. [19.5] $\frac{-d\phi}{dt} + \frac{Ldt}{dt} = 0$

$$\Rightarrow \frac{d\phi}{dt} = \frac{Ldt}{dt}$$

$$\therefore \Delta\phi = L\Delta I$$

24. [1.18] $\tau = ni\,\vec{A} \times \vec{B}$

$$\Rightarrow \tau = ni\,AB \sin\theta$$

25. [7.14] Magnetic field induction at 0 due to current through ACB is

$$B_1 = \frac{\mu_0}{4\pi}\frac{I\theta}{r}$$

It is acting perpendicular to the paper downwards. Magnetic field induction at 0 due to current through ABD is

$$B_1 = \frac{\mu_0}{4\pi}\frac{I}{r}(2\pi - \theta)$$

26. [30°] From the figure,

$$\text{Sin}\,\alpha = \frac{d}{R} = \frac{dqB}{mv},$$

As radius of the arc $R = \frac{mv}{qB}$, where v is the velocity of the particle, when it enteres into the field. From intial condition of the problem,

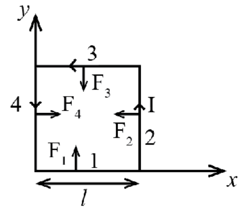
$$qV = \frac{1}{2}mv^2 \text{ or, } v = \sqrt{\frac{2qV}{m}}$$

$$\text{Hence, } \sin\alpha = \frac{dqB}{m\sqrt{\frac{2qV}{m}}} = dB\sqrt{\frac{q}{2mV}}$$

and $\alpha = \sin^{-1}\left(dB\sqrt{\frac{q}{2mV}}\right) = 30°$, on putting the values.

27. Given, [0001] $\vec{B} = B_0\left(1+\frac{x}{1}\right)\widehat{K}$

To find Magnetic force at loop=?



sol^N $F_1 = F_3$

$F_4 = IBl.$ $\{B \text{ at } x = 0 \Rightarrow B_0)$

$= IBol$

$F1 = IBl.$ $\{B \text{ at } x = 1 = 2B_0$

$= I2B_0l.$

$F_{NCI} = 2B_0lI - IB_0lI = B_0lI$

28. [0001]