JEE Mains & Advanced Past Years Questions

JEE-MAIN
PREVIOUS YEAR'S

1. Two identical wires A and B, each of length 'l', carry the same current I. Wire A is bent into a circle of radius R and wire B is bent to form a square of side 'a'. If B_A and B_B are the values of magnetic field at the centres of the circle and square respectively, then the ratio $\frac{B_A}{B_B}$ is:

[*JEE Main-2016*]

(*a*) $\frac{\pi^2}{8}$ (*b*) $\frac{\pi^2}{16\sqrt{2}}$

(*c*) $\frac{\pi^2}{16}$ (*d*) $\frac{\pi^2}{8\sqrt{2}}$

2. An electron, a proton and an alpha particle having the same kinetic energy are moving in circular orbits of radii r_e, r_p, r_α respectively in a uniform magnetic field B. The relation between r_e, r_p, r_α is: **[*JEE Main-2018*]**

(*a*) $r_e < r_p = r_\alpha$ (*b*) $r_e < r_p < r_\alpha$

(*c*) $r_e < r_\alpha < r_p$ (*d*) $r_e > r_p = r_\alpha$

3. The dipole moment of a circular loop carrying a current I, is m and the magnetic field at the centre of the loop is B_1. When the dipole moment is doubled by keeping the current constant, the magnetic field at the centre of the loop is B_2. The ratio $\frac{B_1}{B_2}$ is: **[JEE Main-2018]**

(*a*) $\sqrt{3}$ (*b*) $\sqrt{2}$
(*c*) $\frac{1}{\sqrt{2}}$ (*d*) 2

4. The region between y = 0 and y = d contains a magnetic field $\vec{B} = B\hat{z}$. A particle of mass m and charge q enters the region with a velcoity $\vec{v} = v\hat{i}$. If $d = \frac{mv}{2qB}$, the acceleration of the charged particle at the point of its emergence at the other side is :

[JEE Main - 2019 (January)]

(*a*) $\frac{qvB}{m}\left(\frac{1}{2}\hat{i} - \frac{\sqrt{3}}{2}\hat{j}\right)$ (*b*) $\frac{qvB}{m}\left(\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\right)$
(*c*) $\frac{qvB}{m}\left(\frac{-\hat{j}+\hat{i}}{\sqrt{2}}\right)$ (*d*) $\frac{qvB}{m}\left(\frac{\hat{j}+\hat{i}}{\sqrt{2}}\right)$

5. In an experiment, electrons are accelerated, from rest by applying a voltage of 500 V. Calculate the radius of the path if a magnetic field 100 mT is then applied. [Charge of electron = 1.6×10^{-19} C, Mass of electron = 9.1×10^{-31} kg]

[JEE Main - 2019 (January)]

(*a*) 7.5×10^{-3}m (*b*) 7.5×10^{-2}m
(*c*) 7.5 m (*d*) 7.5×10^{-4}m

6. A particle having the same charge as of electron moves in a circular path of radius 0.5 cm under the influence of a magnetic field of 0.5 T. If an electric field of 100 V/m makes it to move in a straight path, then the mass of the particle is (given charge of electron = 1.6×10^{-19}C)

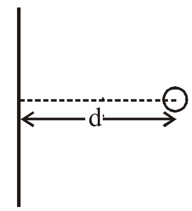
[JEE Main - 2019 (January)]

(*a*) 9.1×10^{-31} kg (*b*) 1.6×10^{-27} kg
(*c*) 1.6×10^{-19} kg (*d*) 2.0×10^{-24} kg

7. One of the two identical conducting wires of length L is bent in the form of a circular loop and the other one into a circular coil of N identical turns. If the same current is passed in both, the ratio of the magnetic field at the centre of the loop (B_L) to that at the centre of the coil (B_C), i.e. $\frac{B_L}{B_C}$ will be **[JEE Main - 2019 (January)]**

(*a*) N (*b*) $\frac{1}{N}$
(*c*) N^2 (*d*) $\frac{1}{N^2}$

8. An infinitely long current carrying wire and a small current carrying loop are in the plane of the paper as shown. The radius of the loop is a and distance of its centre from the wire is d (d >> a). If the loop applies a force F on the wire then: **[JEE Main - 2019 (January)]**



(*a*) F = 0 (*b*) $F \propto \left(\frac{a}{d}\right)$
(*c*) $F \propto \left(\frac{a^2}{d^3}\right)$ (*d*) $F \propto \left(\frac{a}{d}\right)^2$

9. A hoop and a solid cylinder of same mass and radius are made of a permanent magnetic material with their magnetic moment parallel to their respective axes. But the magnetic moment of hoop is twice of solid cylinder. They are placed in a uniform magnetic field in such a manner that their magnetic moments make a small angle with the field. If the oscillation periods of hoop and cylinder are T_h and T_c respectively, then: **[JEE Main - 2019 (January)]**

(*a*) $T_h = T_c$ (*b*) $T_h = 2T_C$
(*c*) $T_h = 1.5T_C$ (*d*) $T_h = 0.5T_C$

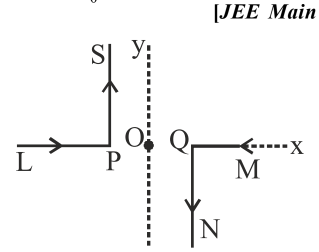
10. An insulating thin rod of length ℓ has a linear charge density $\rho(x) = \rho_0 \frac{x}{\ell}$ on it. The rod is rotated about an axis passing through the origin (x = 0) and perpendicular to the rod. If the rod makes n rotations per second, then the time averaged magnetic moment of the rod is:

[JEE Main - 2019 (January)]

(*a*) $\pi n \rho_0 \ell^3$ (*b*) $\frac{\pi}{3} n \rho_0 \ell^3$
(*c*) $\frac{\pi}{4} n \rho_0 \ell^3$ (*d*) $n \rho_0 \ell^3$

11. As shown in the figure, two infinitely long, identical wires are bent by 90° and placed in such a way that the segments LP and QM are along the x-axis, while segments PS and QN are parallel to the y-axis. If OP = OQ = 4 cm, and the magnitude of the magnetic field at O is 10^{-4} T, and the two wires carry equal current (see figure), the magnitude of the current in each wire and the direction of the magnetic field at O will be ($\mu_0 = 4\pi \times 10^{-7}$ NA^{-2}):

[JEE Main - 2019 (January)]



(*a*) 20 A, perpendicular out of the page
(*b*) 40 A, perpendicular out of the page
(*c*) 20 A, perpendicular into the page
(*d*) 40 A, perpendicular into the page

12. A proton and an α-particle (with their masses in the ratio of 1 : 4 and charges in the ratio of 1:2) are accelerated from rest through a potential difference V. If a uniform magnetic field (B) is set up perpendicular to their velocities, the ratio of the radii $r_p : r_\alpha$ of the circular paths described by them will be:

[*JEE Main-2019 (January)*]

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

13. A moving coil galvanometer has a coil with 175 turns and area 1 cm^2. It uses a torsion band of torsion constant 10^{-6} N–m/rad. The coil is placed in a magnetic field B parallel to its plane. The coil deflects by 1° for a current of 1 mA. The value of B (in Tesla) is approximately :-

[*JEE Main-2019 (April)*]

(*a*) 10^{-3} (*b*) 10^{-1}
(*c*) 10^{-4} (*d*) 10^{-2}

14. A circular coil having N turns and radius r carries a current I. It is held in the XZ plane in a magnetic field $B\hat{i}$. The torque on the coil due to the magnetic field is

[*JEE Main-2019 (April)*]

(*a*) $B\pi r^2 IN$ (*b*) $\frac{Br^2 I}{\pi N}$
(*c*) Zero (*d*) $\frac{B\pi r^2 I}{N}$

15 The magnitude of the magnetic field at the center of an equilateral triangular loop of side l m which is carrying a current of 10 A is : [Take $\mu_0 = 4\pi \times 10^{-7}$ NA^{-2}]

[*JEE Main-2019 (April)*]

(*a*) 18 μT (*b*) 3μT
(*c*) 1 μT (*d*) 9 μT

16. A square loop is carrying a steady current I and the magnitude of its magnetic dipole moment is m. If this square loop is changed to a circular loop and it carries the same current, the magnitude of the magnetic dipole moment of circular loop will be :

[*JEE Main-2019 (April)*]

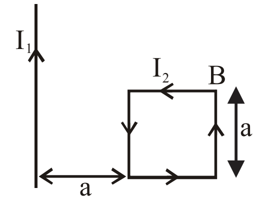
(*a*) $\frac{3m}{\pi}$ (*b*) $\frac{4m}{\pi}$
(*c*) $\frac{2m}{\pi}$ (*d*) $\frac{m}{\pi}$

17. Two very long, straight and insulated wires are kept at 90° angle from each other in xy-plane as shown in the figure. These wires carry currents of equal magnitude I, whose directions are shown in the figure. The net magnetic field at point P will be :

[*JEE Main-2019 (April)*]

(*a*) Zero (*b*) $\frac{+\mu_0 I}{\pi d}(\hat{z})$
(*c*) $-\frac{\mu_0 I}{2\pi d}(\hat{x}+\hat{y})$ (*d*) $\frac{\mu_0 I}{2\pi d}(\hat{x}+\hat{y})$

18. A rigid square loop of side 'a' and carrying current I_2 is lying on horizontal surface near a long current I_1 carrying wire in the same plane as shown in figure. The net force on the loop due to wire will be: **[*JEE Main-2019 (April)*]**



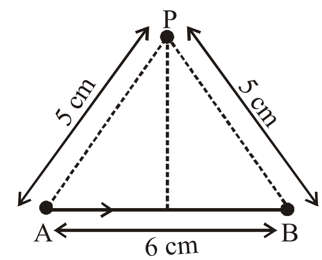
(*a*) Attractive and equal to $\frac{\mu_0 I_1 I_2}{3\pi}$
(*b*) Repulsive and equal to $\frac{\mu_0 I_1 I_2}{4\pi}$
(*c*) Repulsive and equal to $\frac{\mu_0 I_1 I_2}{2\pi}$
(*d*) Zero

19. A rectangular coil (dimension 5 cm × 2.5 cm) with 100 turns, carrying a current of 3 A in the clock-wise direction is kept centered at the origin and in the X-Z plane. A magnetic field of 1 T is applied along X-axis. If the coil is tilted through 45° about Z-axis, then the torque on the coil is:

[*JEE Main-2019 (April)*]

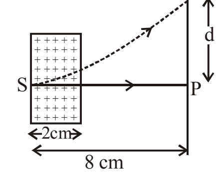
(*a*) 0.55 Nm (*b*) 0.27 Nm
(*c*) 0.38 Nm (*d*) 0.42 Nm

20. Find the magnetic field at point P due to a straight line segment AB of length 6 cm carrying a current of 5 A. in figure ($\mu_0 = 4\pi \times 10^{-7}$ N-A^{-2}) **[*JEE Main-2019 (April)*]**



(*a*) 3.0×10^{-5} T (*b*) 2.5×10^{-5} T
(*c*) 2.0×10^{-5} T (*d*) 1.5×10^{-5} T

21. An electron, moving along the x-axis with an initial energy of 100 eV, enters a region of magnetic field $\vec{B} = (1.5 \times 10^{-3}\,T)\hat{k}$ at S (See figure). The field extends between x = 0 and x=2 cm. The electron is detected at the point Q on a screen placed 8 cm away from the point S. The distance d between P and Q (on the screen) is :(Electron's charge = 1.6×10^{-19} C, mass of electron = 9.1×10^{-31} kg) **[*JEE Main-2019 (April)*]**



(*a*) 12.87 cm (*b*) 1.22 cm
(*c*) 11.65 cm (*d*) 2.25 cm

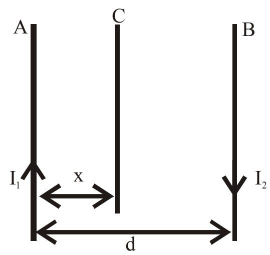
22. A proton, an electron, and a Helium nucleus, have the same energy. They are in circular orbits in a plane due to magnetic field perpendicular to the plane. Let r_p, r_e and r_{He} be their respective radii, then,

[*JEE Main-2019 (April)*]

(*a*) $r_e > r_p > r_{He}$ (*b*) $r_e < r_p < r_{He}$

(*c*) $r_e < r_p = r_{He}$ (*d*) $r_e > r_p = r_{He}$

23. Two wires A & B are carrying currents I_1 & I_2 as shown in the figure. The separation between them is d. A third wire C carrying a current I is to be kept parallel to them at a distance x from A such that the net force acting on it is zero. The possible values of x are: **[*JEE Main-2019 (April)*]**



(*a*) $x = \left(\frac{I_1}{I_1 - I_2}\right)d$ and $x = \frac{I_2}{(I_1 + I_2)}d$

(*b*) $x = \pm\frac{I_1 d}{(I_1 - I_2)}$

(*c*) $x = \left(\frac{I_1}{I_1 + I_2}\right)d$ and $x = \frac{I_2}{(I_1 - I_2)}d$

(*d*) $x = \left(\frac{I_2}{I_1 + I_2}\right)d$ and $x = \left(\frac{I_2}{I_1 - I_2}\right)d$

24. The electric field of a plane electromagnetic wave is given by $\vec{E} = E_0\frac{\hat{i}+\hat{j}}{\sqrt{2}}\cos(kz + \omega t)$. At t = 0, a positively charged particle is at the point $(x, y, z) = \left(0, 0, \frac{\pi}{k}\right)$. If its instantaneous velocity at (t = 0) is $v_0\hat{k}$, the force acting on it due to the wave is: **[*JEE Main-2020 (January)*]**

(*a*) Zero (*b*) parallel to $\hat{k}$

(*c*) antiparallel to $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$ (*d*) parallel to $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

25. A particle of mass m and charge q has an initial velocity $\vec{v} = v_0\hat{j}$. If an electric field $\vec{E} = E_0\hat{i}$ and magnetic field $\vec{B} = B_0\hat{i}$ act on the particle, its speed will double after a time: **[*JEE Main-2020 (January)*]**

(*a*) $\frac{2mv_0}{qE_0}$ (*b*) $\frac{3mv_0}{qE_0}$

(*c*) $\frac{\sqrt{2}mv_0}{qE_0}$ (*d*) $\frac{\sqrt{3}mv_0}{qE_0}$

26. Proton with kinetic energy of 1 MeV moves from south to north. It gets an acceleration of $10^{12} m/s^2$ by an applied magnetic field (west to east). The value of magnetic field. (Rest mass of proton is 1.6×10^{-27} kg)

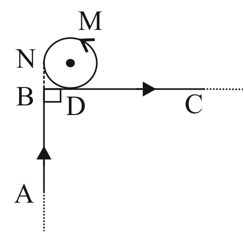
[*JEE Main-2020 (January)*]

(*a*) 7.1 mT (*b*) 71 mT

(*c*) 0.71 mT (*d*) 0.071 mT

27. A very long wire ABDMNDC is shown in figure carrying current I. AB and BC parts are straight, long and at right angle. At D wire forms a circular turn DMND of radius R. AB, BC parts are tangential to circular turn at N and D. Magnetic field at the centre of circle is :

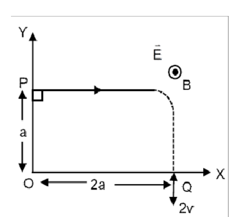
[*JEE Main-2020 (January)*]



(*a*) $\frac{\mu_0 I}{2\pi R}\left(\pi + \frac{1}{\sqrt{2}}\right)$ (*b*) $\frac{\mu_0 I}{2R}$

(*c*) $\frac{\mu_0 I}{2\pi R}\left(\pi - \frac{1}{\sqrt{2}}\right)$ (*d*) $\frac{\mu_0 I}{2\pi R}(\pi + 1)$

28. A charged particle of mass 'm' and charge 'q' moving under the influence of uniform electric field $E\vec{i}$ and a uniform magnetic field $B\hat{k}$ follows a trajectroy from point P to Q as shown in figure. The velocities at P and Q are respectively, $v\vec{i}$ and $-2v\vec{j}$. Then which of the following statements (A,B,C,D) are the correct ? (Trajectroy shown is schematic and not to scale)



(*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 both the fields at Q is zero

(*D*) The difference between the magnitude of angular momentum of the particle at P and Q is 2mav.

[*JEE Main-2020 (January)*]

(*a*) (A), (B), (C) (*b*) (A), (B), (C), (D)

(*c*) (A), (C), (D) (*d*) (B), (C), (D)

29. A long, straight wire of radius a carries a current distributed uniformly over its cross–section. The ratio of the magnetic fields due to the wire at distance $\frac{a}{3}$ and 2a, respectively from the axis of the wire is:

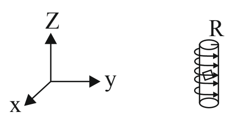
[JEE Main-2020 (January)]

(*a*) $\frac{1}{2}$ (*b*) 2

(*c*) $\frac{3}{2}$ (*d*) $\frac{2}{3}$

30. An electron gun is placed inside a long solenoid of radius R on its axis. The solenoid has n turns/length and carries a current l. The electron gun shoots an electron along the radius of the solenoid with speed v. If the electron does not hit the surface of the solenoid, maximum possible value of v is (all symbols have their standard meaning)

[JEE Main-2020 (January)]



(*a*) $\frac{e\mu_0 nIR}{2m}$ (*b*) $\frac{e\mu_0 nIR}{m}$

(*c*) $\frac{2e\mu_0 nIR}{m}$ (*d*) $\frac{e\mu_0 nIR}{4m}$

31. A small circular loop of conducting wire has radius a and carries current I. It is placed in a uniform magnetic field B perpendicular to its plane such that when rotated slightly about its diameter and released, it starts performing simple harmonic motion of time period T. If the mass of the loop is m then :

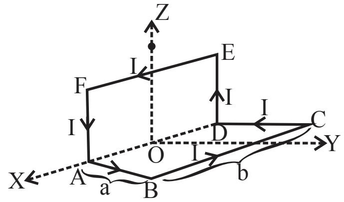
[JEE Main-2020 (January)]

(*a*) $T=\sqrt{\frac{\pi m}{IB}}$ (*b*) $T=\sqrt{\frac{2m}{IB}}$

(*c*) $T=\sqrt{\frac{\pi m}{2IB}}$ (*d*) $T=\sqrt{\frac{2\pi m}{IB}}$

32. A wire carrying current I is bent in the shape ABCDEFA as shown, where rectangle ABCDA and ADEFA are perpendicular to each other. If the sides of the rectangles are of lengths a and b, then the magnitude and direction of magnetic moment of the loop ABCDEFA is

[JEE Main-2020 (September)]



(*a*) abl, along $\left(\frac{\hat{j}}{\sqrt{5}}+\frac{2\hat{k}}{\sqrt{5}}\right)$

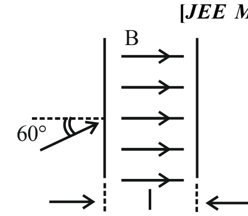
(*b*) $\sqrt{2}$ abl, along $\left(\frac{\hat{j}}{\sqrt{2}}+\frac{\hat{k}}{\sqrt{2}}\right)$

(*c*) abl, along $\left(\frac{\hat{j}}{\sqrt{2}}+\frac{\hat{k}}{\sqrt{2}}\right)$

(*d*) $\sqrt{2}$ abl, along $\left(\frac{\hat{j}}{\sqrt{5}}+\frac{2\hat{k}}{\sqrt{5}}\right)$

33. The figure shows a region of length 'l' with a uniform magnetic field of 0.3 T in it and a proton entering the region with velocity 4×10^5 ms^{-1} making an angle 60° with the field. If the proton completes 10 revolution by the time it cross the region shown, 'l' is close to (mass of proton $=1.67 \times 10^{-27}$ kg, charge of the proton $= 1.6 \times 10^{-19}$ C)

[JEE Main-2020 (September)]



(*a*) 0.22 m (*b*) 0.11 m

(*c*) 0.88 m (*d*) 0.44 m

34. A beam of protons with speed 4×10^5 enters a uniform magnetic field of 0.3 T at an angle of 60° to the magnetic field. The pitch of the resulting helical path of protons is close to (Mass of the proton $= 1.67 \times 10^{-27}$ kg, charge of the proton $= 1.69 \times 10^{-19}$ C)

[JEE Main-2020 (September)]

(*a*) 2 cm (*b*) 12 cm

(*c*) 5 cm (*d*) 4 cm

35. A galvanometer coil has 500 turns and each turn has an average area of 3×10^{-4} m^2. If a torque of 1.5 Nm is required to keep this coil parallel to a magnetic field when a current of 0.5 A is flowing through it, the strength of the field (in T) is __________.

[JEE Main-2020 (September)]

36. Magnitude of magnetic field (in SI units) at the centre of a hexagonal shape coil of side 10 cm, 50 turns and carrying current I (Ampere) in units of $\frac{\mu_0 I}{\pi}$ is

[JEE Main-2020 (September)]

(*a*) $500\sqrt{3}$ (*b*) $250\sqrt{3}$

(*c*) $50\sqrt{3}$ (*d*) $5\sqrt{3}$

37. A charged particle carrying charge 1 μC is moving with velocity $(2\hat{i}+3\hat{j}+4\hat{k})$ ms^{-1}. If an external magnetic field of $(5\hat{i}+3\hat{j}-6\hat{k})\times 10^{-3}$ T exists in the region where the particle is moving then the force on the particle is $\vec{F}\times 10^{-9}$ N. The vector $\vec{F}$ is **[*JEE Main-2020 (September)*]**

(*a*) $-3.0\hat{i}+3.2\hat{j}-0.9\hat{k}$

(*b*) $-300\hat{i}+320\hat{j}-90\hat{k}$

(*c*) $-0.30\hat{i}+0.32\hat{j}-0.09\hat{k}$

(*d*) $-30\hat{i}+32\hat{j}-9\hat{k}$

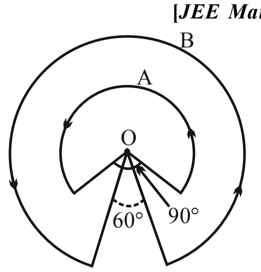
38. A circular coil has moment of inertia 0.8 kg m^2 around any diameter and is carrying current to produce a magnetic moment of 20 Am^2. The coil is kept initially in a vertical position and it can rotate freely around a horizontal diameter. When a uniform magnetic field of 4 T is applied along the vertical, it starts rotating, around its horizontal diameter. The angular speed the coil acquires after rotating by 60° will be **[*JEE Main-2020 (September)*]**

(*a*) 10 rad s^{-1} (*b*) 10π rad s^{-1}

(*c*) 20 rad s^{-1} (*d*) 20π rad s^{-1}

39. A wire A, bent in the shape of an arc of a circle, carrying a current of 2 A and having radius 2 cm and another wire B, also bent in the shape of arc of a circle, carrying a current of 3 A and having radius of 4 cm, are placed as shown in the figure. The ratio of the magnetic fields due to the wires A and B at the common centre O is

[*JEE Main-2020 (September)*]



(*a*) 2 : 5 (*b*) 6 : 5

(*c*) 4 : 6 (*d*) 6 : 4

40. A square loop of side 2a, and carrying current I, is kept in XZ plane with its centre at origin. A long wire carrying the same current I is placed parallel to the z-axis and passing through the point (0, b, 0), (b > > a). The magnitude of the torque on the loop about z-axis is given by

[*JEE Main-2020 (September)*]

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

(*c*) $\frac{\mu_0 I^2 a^3}{2\pi b^2}$ (*d*) $\frac{2\mu_0 I^2 a^3}{\pi b^2}$

41. An electron is constrained to move along the y-axis with a speed of 0.1 c (c is the speed of light) in the presence of electromagnetic wave, whose electric field is $\vec{E}=30\hat{j}$ $\sin(1.5\times10^7 t-5\times10^{-2}x)$ V/m. The maximum magnetic force experienced by the electron will be (**Given** $c=3\times10^8$ ms^{-1} and Electron charge $=1.6\times10^{-19}$ C)

[*JEE Main-2020 (September)*]

(*a*) 4.8×10^{-19} N (*b*) 2.4×10^{-18} N

(*c*) 3.2×10^{-18} N (*d*) 1.6×10^{-19} N

42. A charged particle going around in a circle can be considered to be a current loop. A particle of mass m carrying charge q is moving in a plane with speed v under the influence of magnetic field $\vec{B}$. The magnetic moment of this moving particle :

[*JEE Main-2020 (September)*]

(*a*) $-\frac{mv^2\vec{B}}{2B^2}$ (*b*) $\frac{mv^2\vec{B}}{2B^2}$

(*c*) $-\frac{mv^2\vec{B}}{2\pi B^2}$ (*d*) $-\frac{mv^2\vec{B}}{B^2}$

43. A particle moving in the xy plane experiences a velocity dependent force $\vec{F}=k(v_y\hat{i}+v_x\hat{j})$, where v_x and v_y are the x and y components of its velocity $\vec{v}$. If $\vec{a}$ is the acceleration of the particle, then which of the following statements is true for the particle?

[*JEE Main-2020 (September)*]

(*a*) Quantity $\vec{v}\cdot\vec{a}$ is constant in time

(*b*) Kinetic energy of particle is constant in time

(*c*) Quantity $\vec{v}\times\vec{a}$ is constant in time

(*d*) $\vec{F}$ arises due to a magnetic field

44. A square loop of side 2a and carrying current I is kept in xz plane with its centre at origin. A long wire carrying the same current I is placed parallel to z-axis and passing through point (0, b, 0), (b >> a). The magnitude of torque on the loop about z-axis will be

[*JEE Main-2020 (September)*]

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

(*c*) $\frac{\mu_0 I^2 a^2 b}{2\pi(a^2+b^2)}$ (*d*) $\frac{2\mu_0 I^2 a^2}{\pi b}$

45. A particle of charge q and mass m is moving with a velocity $-v\hat{i}(v\neq0)$ towards a large screen placed in the Y - Z plane at a distance d. If there is a magnetic field $\vec{B}=B_0\hat{k}$, the minimum value of v for which the particle will not hit the screen is

[*JEE Main-2020 (September)*]

(*a*) $\frac{2qdB_0}{m}$ (*b*) $\frac{qdB_0}{3m}$

(*c*) $\frac{qdB_0}{2m}$ (*d*) $\frac{qdB_0}{m}$

46. An electron is moving along + x direction with a velocity of $6 \times 10^6\ ms^{-1}$. It enters a region of uniform electric field of 300 V/cm pointing along + y direction. The magnitude and direction of the magnetic field set up in this region such that the electron keeps moving along the x direction will be **[*JEE Main-2020 (September)*]**

(*a*) 5×10^{-3} T, along + z direction
(*b*) 5×10^{-3} T, along – z direction
(*c*) 3×10^{-4} T, along + z direction
(*d*) 3×10^{-4} T, along – z direction

47. Which of the following statements are correct? **[*JEE Main-2021 (March)*]**

(A) Electric monopoles do not exist whereas magnetic monopoles exist.
(B) Magnetic field lines due to a solenoid at its ends and outside cannot be completely straight and confined.
(C) Magnetic field lines are completely confined within a toroid.
(D) Magnetic field lines inside a bar magnet are not parallel.
(E) $\chi = -1$ is the condition for a perfect diamagnetic material, where x is its magnetic susceptibility.

Choose the correct answer from the options given below:

(*a*) (A) and (B) only
(*b*) (B) and (C) only
(*c*) (C) and (E) only
(*d*) (B) and (D) only

48. A plane electromagnetic wave propagating along y -direction can have the following pair of electric field $(\vec{E})$ and magnetic field $(\vec{B})$ components. **[*JEE Main-2021 (March)*]**

(*a*) $E_{x_1}\ \mathrm{B}_z$ or $E_{z_1}\ \mathrm{B}_x$ (*b*) $E_{x_1} B_y$ or $E_{y!} B_x$
(*c*) $E_{y,1} B_y$ or $E_{z,} B_z$ (*d*) $E_{y'} B_x$ or $E_{x'} B_y$

49. A loop of flexible wire of irregular shape carrying current is placed in an external magnetic field. Identify the effect of the field on the wire. **[*JEE Main-2021 (March)*]**

(*a*) Loop assumes circular shape with its plane normal to the field.
(*b*) Loop assumes circular shape with its plane parallel to the field.
(*c*) Wire gets stretched to become straight.
(*d*) Shape of the loop remains unchanged.

50. A plane electromagnetic wave of frequency $100\mathrm{MHz}$ is travelling in vacuum along the x -direction. At a particular point in space and time, $\vec{B} = 2.0 \times 10^{-8} \hat{k} T$. (where, $\hat{k}$ is unit vector along z-direction) What is $\vec{E}$ at this point? **[*JEE Main-2021 (March)*]**

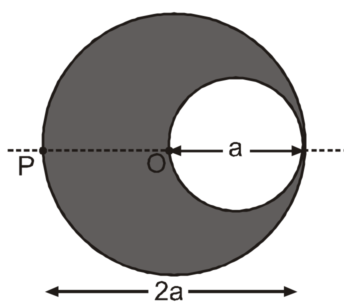
(*a*) $0.6\hat{j}\ \mathrm{V/m}$ (*b*) $6.0\hat{k}\ \mathrm{V/m}$
(*c*) $6.0\hat{j}\ \mathrm{V/m}$ (*d*) $0.6\hat{k}\ \mathrm{V/m}$

JEE-ADVANCED PREVIOUS YEAR'S

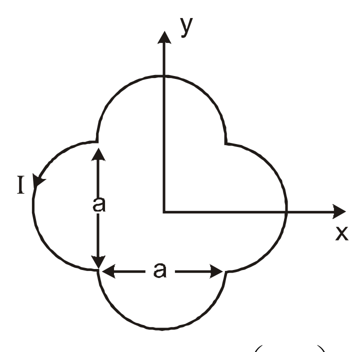
1. Consider the motion of a positive point charge in a region where there are simultaneous uniform electric and magnetic fields $\vec{E} = E_0\hat{j}$ and $\vec{B} = B_0\hat{j}$. At time t = 0, this charge has velocity $\vec{v}$ in the x-y plane, making an angle θ with x-axis. Which of the following option(s) is(are) correct for time t > 0 ? **[*IIT JEE-2012*]**

(*a*) If θ = 0°, the charge moves in a circular path in the x-z plane.
(*b*) If θ = 0°, the charge undergoes helical motion with constant pitch along the y-axis.
(*c*) If θ = 10°, the charge undergoes helical motion with its pitch increasing with time, along the y-axis.
(*d*) If θ = 90°, the charge undergoes linear but accelerated motion along the y-axis.

2. A cylindrical cavity of diameter a exists inside a cylinder of diameter 2a shown in the figure. Both the cylinder and the cavity are infinitely long. A uniform current density J flows along the length. If the magnitude of the magnetic field at the point P is given by $\frac{N}{12}\mu_0$ aJ, then the value of N is: **[*IIT JEE-2012*]**

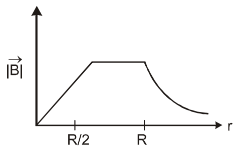


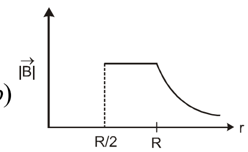
3. A loop carrying current I lies in the x-y plane as shown in the figure. the unit vector $\hat{k}$ is coming out of the plane of the paper. the magnetic moment of the current loop is: **[*IIT JEE-2012*]**

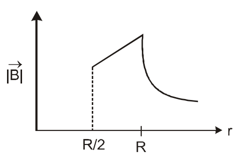


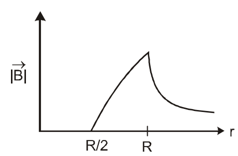
(*a*) $a^2 I\hat{k}$ (*b*) $\left(\frac{\pi}{2}+1\right)a^2 I\hat{k}$
(*c*) $-\left(\frac{\pi}{2}+1\right)a^2 I\hat{k}$ (*d*) $(2\pi+1)a^2 I\hat{k}$

4. An infinitely long hollow conducting cylinder with inner radius R/2 and outer radius R carries a uniform current density along is length. The magnitude of the magnetic field, $|\vec{B}|$ as a function of the radial distance r from the axis is best represented by: **[*IIT JEE-2012*]**

(*a*) 

(*b*) 

(*c*) 

(*d*) 

5. A particle of mass M and positive charge Q, moving with a constant velocity $\vec{u}_1 = 4\hat{i}\ \text{ms}^{-1}$, enters a region of uniform static magnetic field normal to the x-y plane. The region of the magnetic field extends from x = 0 to x = L for all values of y. After passing through this region, the particle emerges on the other side after 10 milliseconds with a velocity $\vec{u}_2 = 2\left(\sqrt{3}\,\hat{i} + \hat{j}\right)$ ms^{-1}. The correct statement(s) is (are): **[*JEE Advanced-2013*]**

(*a*) The direction of the magnetic field is –z direction.

(*b*) The direction of the magnetic field is +z direction

(*c*) The magnitude of the magnetic field $\frac{50\pi M}{3Q}$ units.

(*d*) The magnitude of the magnetic field is $\frac{100\pi M}{3Q}$ units.

6. A steady current I flows along an infinitely long hollow cylindrical conductor of radius R. This cylinder is placed coaxially inside an infinite solenoid of radius 2R. The solenoid has n turns per unit length and carries a steady current I. Consider a point P at a distance r from the common axis. The correct statement(s) is (are): **[*JEE Advanced -2013*]**

(*a*) In the region 0 < r < R, the magnetic field is non–zero.

(*b*) In the region R < r < 2R, the magnetic field is along the common axis.

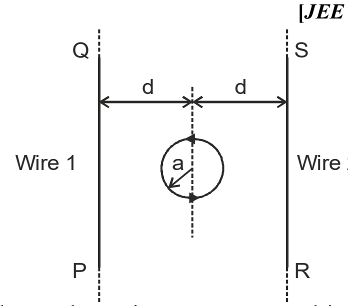
(*c*) In the region R < r < 2R, the magnetic field is tangential to the circle of radius r, centered on the axis.

(*d*) In the region r > 2R, the magnetic field is non–zero.

7. Two parallel wires in the plane of the paper are distance X_0 apart. A point charge is moving with speed u between the wires in the same plane at a distance X_1 from one of the wires. When the wires carry current of magnitude I in the same direction, the radius of curvature of the path of the point charge is R_1. In contrast, if the currents I in the two wires have direction opposite to each other, the radius of curvature of the path is R_2. If $\frac{x_0}{x_1} = 3$, the value of $\frac{R_1}{R_2}$ is. **[*JEE Advanced -2014*]**

Paragraph For Questions 11 to 12

The figure shows a circular loop of radius a with two long parallel wires (numbered 1 and 2) all in the plane of the paper. The distance of each wire from the centre of the loop is d. The loop and the wires are carrying the same current I. The current in the loop is in the counterclockwise direction if seen from above. **[*JEE Advanced -2014*]**



8. When d $\approx$ a but wires are not touching the loop, it is found that the net magnetic filed on the axis of the loop is zero at a height h above the loop. In that case **[*JEE Advanced -2014*]**

(*a*) current in wire 1 and wire 2 is the direction PQ and RS, respectively and h $\approx$ a

(*b*) current in wire 1 and wire 2 is the direction PQ and SR, respectively and h $\approx$ a

(*c*) current in wire 1 and wire 2 is the direction PQ and SR, respectively and h $\approx$ 1.2 a

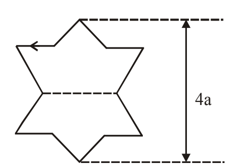
(*d*) current in wire 1 and wire 2 is the direction PQ and RS, resepectively and h $\approx$ 1.2 a

9. Consider d >> a, and the loop is rotated about its diameter parallel to the wires by 30º from the position shown in the figure. If the currents in the wires are in the opposite directions, the torque on the loop at its new position will be (assume that the net field due to the wires is constant over the loop) **[*JEE Advanced-2014*]**

(*a*) $\frac{\mu_0 I^2 a^2}{d}$ (*b*) $\frac{\mu_0 I^2 a^2}{2d}$

(*c*) $\frac{\sqrt{3}\mu_0 I^2 a^2}{d}$ (*d*) $\frac{\sqrt{3}\mu_0 I^2 a^2}{2d}$

10. A symmetric star shaped conducting wire loop is carrying a steady state current I as shown in the figure. The distance between the diametrically opposite vertices of the star is 4a. The magnitude of the magnetic field at the center of the loop is: **[*JEE Advanced -2017*]**

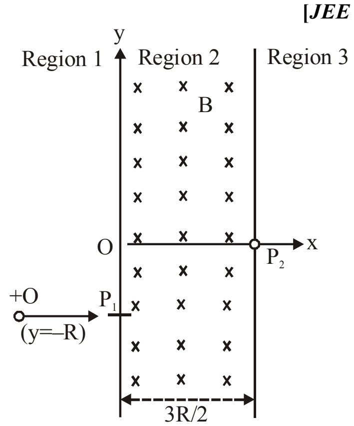


(*a*) $\frac{\mu_o I}{4\pi a} 6\left[\sqrt{3} - 1\right]$ (*b*) $\frac{\mu_o I}{4\pi a} 6\left[\sqrt{3} + 1\right]$

(*c*) $\frac{\mu_o I}{4\pi a} 3\left[2 + \sqrt{3}\right]$ (*d*) $\frac{\mu_o I}{4\pi a} 3\left[\sqrt{3} - 1\right]$

11. A uniform magnetic field B exists in the region between $x = 0$ and $x = \frac{3R}{2}$ (region 2 in the figure) pointing normally into the plane of the paper. A particle with charge +Q and momentum p directed along x-axis enters region 2 from region 1 at point P_1 ($y = -R$). Which of the following option(s) is /are correct?

[*JEE Advanced-2017*]



(*a*) When the particle re-enters region 1 through the longest possible path in region 2, the magnitude of the change in its linear momentum between P_1 and the farthest point from y-axis is $p/\sqrt{2}$.

(*b*) For a fixed B, particles of same charge Q and same velocity v, the distance between the point P_1 and the point of re-entry into region 1 is inversely proportional to the mass of the particle.

(*c*) For $B = \frac{8}{13}\frac{p}{QR}$, the particle will enter region 3 through the point P_2 on x-axis

(*d*) For $B > \frac{2}{3}\frac{p}{QR}$, the particle will re-enter region 1.

12. Two infinitely long straight wires lie in the xy-plane along the lines $x = \pm R$. The wire located at $x = +R$ carries a constant current I_1 and the wire located at $x = -R$ carries a constant current I_2. A circular loop of radius R is suspended with its centre $(0, 0, \sqrt{3}R)$ and in a plane parallel to the xy-plane. This loop carries a constant I in the clockwise direction as seen from above the loop. The current in the wire is taken to be positive if it is in the $+\hat{j}$ direction.Which of the following statements regardint the magnetic field $\vec{B}$ is (are) true?

[*JEE Advanced - 2018*]

(*a*) If $I_1 = I_2$ then $\vec{B}$ cannot be equal to zero at the origin (0, 0, 0).

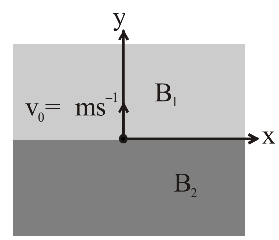
(*b*) If $I_1 > 0$ and $I_2 < 0$. then $\vec{B}$ can be equal to zero at the origin (0, 0, 0).

(*c*) If $I_1 < 0$ and $I_2 > 0$ then $\vec{B}$ can be equal to zero at the origin (0, 0, 0).

(*d*) If $I_1 = I_2$ then the z -component of the magnetic field at the centre of the centre of the loop is $\left(-\frac{\mu_0 I}{2R}\right)$.

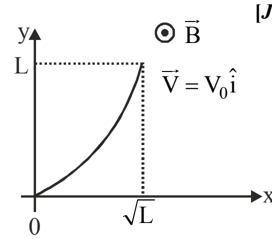
13. In the x-y plane, the region $y > 0$ has a uniform magnetic field $B,\hat{k}$ and the region $y < 0$ has a another uniform magnetic field $B,\hat{k}$. A positively charged particle is projected from the origin along the positive y-axis with speed $v_0 = \pi ms^{-1}$ at $t = 0$, as shown in the figure. Neglect gravity in this problem. Let $t = T$ be the time when the particle crosses the x-axis from below for the first time. If $B_2 = 4B_1$, the average speed of the particle, in ms^{-1}, along the x-axis in the time interval T is______.

[*JEE Advanced - 2018*]



14. A conducting wire of parabolic shape, initially $y = x^2$, is moving with velocity $\vec{V} = V_0\hat{i}$ in a non -uniform magnetic field $\vec{B} = B_0\left(1+\left(\frac{y}{L}\right)^{\beta}\right)\hat{k}$, as shown in figure. If V_0, B_0, L and β are positive constants and Δϕ is the potential difference developed between the ends of the wire, then the correct statement(s) is/are :

[*JEE Advanced - 2019*]



(*a*) $|\Delta\phi|$ remains the same if the parabolic wire is replaced by a straight wire, $y = x$ initially, of length $\sqrt{2}L$

(*b*) $|\Delta\phi|$ is proportional to the length of the wire projected on the y-axis.

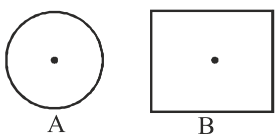
(*c*) $|\Delta\phi| = \frac{1}{2}B_0V_0L$ for $B = 0$

(*d*) $|\Delta\phi| = \frac{4}{3}B_0V_0L$ for $\beta = 2$

JEE Mains & Advanced Past Years Questions

JEE-MAIN
PREVIOUS YEAR'S

1. (*d*) $\dfrac{B_A}{B_B} = \dfrac{\dfrac{\mu_0 i}{2R}}{4\times\dfrac{\mu_0 i}{4\pi\frac{a}{2}}(\sin 45° + \sin 45°)}$



(where $R = \dfrac{l}{2\pi}$ and $a = \dfrac{l}{4}$)

$\Rightarrow \dfrac{B_A}{B_B} = \dfrac{1}{2R}\dfrac{\pi a}{2}\dfrac{1}{\sqrt{2}} = \dfrac{\pi}{4\sqrt{2}}\left(\dfrac{a}{R}\right)$

$= \dfrac{\pi}{4\sqrt{2}}\left(\dfrac{l}{4}\right)\left(\dfrac{2\pi}{l}\right) = \dfrac{\pi^2}{8\sqrt{2}}$

2. (*a*) Radius of circular path in magnetic field is given

by $R = \dfrac{\sqrt{2Km}}{qB}$

where K = kinetic energy of particle
m = mass of particle
q = charge on particle
B = magnetic field intensity
R = radius of path

For electron

$r_e = \dfrac{\sqrt{2Km_e}}{eB}$ ...(i)

For proton

$r_p = \dfrac{\sqrt{2Km_p}}{eB}$ ...(ii)

For α particle

$r_\alpha = \dfrac{\sqrt{2Km_\alpha}}{q_\alpha B} = \dfrac{\sqrt{2K4m_p}}{2eB} = \dfrac{\sqrt{2Km_p}}{eB}$ ...(iii)

as $m_e < m_p$ so $r_e < r_p = r_\alpha$

3. (*b*) Dipole moment of circular loop is m

$m_1 = I.A = I.\pi R^2$ {R = radius of the loop}

$B_1 = \dfrac{\mu_0 I}{2R}$

As moment becomes double ⇒ radius becomes $\sqrt{2}$ R (keeping current constant)

$m_2 = I.\pi(\sqrt{2}R)^2 = 2.I\pi R^2 = 2m_1$

$B_2 = \dfrac{\mu_0 I}{2(\sqrt{2}R)} = \dfrac{B_1}{\sqrt{2}}$

$\Rightarrow \dfrac{B_1}{B_2} = \sqrt{2}$

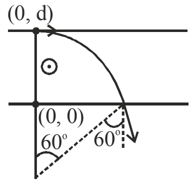
4. (Bonus)

Assuming particle enters from (0, d)

$F = qvB\left(-\sin 60^{\circ}\hat{i} - \cos 60^{\circ}\hat{j}\right)$

$F = -\frac{qvB}{2}\left(\sqrt{3}\hat{i} + \hat{j}\right)$

$a = -\frac{qvB}{2m}\left(\sqrt{3}\hat{i} + \hat{j}\right)$



None of the option is correct.

5. (*d*) $r = \frac{mv}{Bq} = \frac{\sqrt{2mqV}}{Bq} = \frac{\sqrt{2\times 9.1\times 10^{-31}\times V}}{B\sqrt{q}}$

$= \frac{\sqrt{2\times 9.1\times 10^{-31}\times 500}}{100\times 10^{-3}\sqrt{1.6\times 10^{-19}}}$

$= \frac{1}{100\times 10^{-3}}\frac{\sqrt{2\times 9.1\times 500\times 10^{-12}}}{\sqrt{1.6}}$

$= \frac{75.4\times 10^{-6}}{100\times 10^{-3}} = 7.5\times 10^{-4}\,\text{m}$

6. (*d*) $eE = evB$

$\Rightarrow E = \left(\frac{eBr}{m}\right)B$

$\Rightarrow m = \frac{eB^2 r}{E}$

$\Rightarrow m = \frac{(1.6\times 10^{-19})(0.5)^2(0.5\times 10^{-2})}{100} = 2\times 10^{-24}\,\text{kg}$

7. (*d*) $B_L = \frac{\mu_0 i}{2R}$

$B_C = \frac{\mu N i}{2(R/N)}$

$\therefore \frac{B_L}{B_C} = \frac{1}{N^2}$

8. (*d*) For shifting of loop along x-direction $PE(x) = -\vec{\mu}\cdot\vec{B}$

$\therefore PE(x) = -\pi a^2 i\frac{\mu_0 I_0}{2\pi x}$

$\therefore U(x) = -\frac{\mu_0 i I_0 a^2}{2x}$ (PE decreases as it comes closer to wire)

So, attractive force $F(x) = \frac{-dU}{dx} = \frac{\mu_0 i I_0 a^2}{2}\left(\frac{-1}{x^2}\right)$

$\therefore F(x) = \frac{\mu_0 i I_0 a^2}{2d^2}$ (Attractive)

$\therefore F \propto \frac{a^2}{d^2}$

9. (*a*) $\because T = 2\pi\sqrt{\frac{I}{\mu B}}$

$\frac{T_h}{T_c} = \sqrt{\frac{I_h}{I_c}\times\frac{\mu_c}{\mu_h}}$

$= \sqrt{2\times\frac{1}{2}} = 1$

$T_h = T_c$

10. (*c*) $dM = di\,A$

$= \left(\frac{dq\omega}{2\pi}\right)\pi x^2 = (\rho dx)\frac{\omega}{2\pi}\pi x^2$

$M = \int_0^{\ell} dM = \int_0^{\ell}\frac{\rho_0 x}{\ell}(x^2 dx)\left(\frac{\omega}{2}\right) = \frac{\rho_0}{2\ell}(2\pi n)\left(\frac{\ell^4}{4}\right) = \frac{\rho_0(\pi n)\ell^3}{4}$

11. (*c*) $B = 2\left[\frac{\mu_0 i}{4\pi d}(\cos\theta_1 - \cos\theta_2)\right]$

$B = 10^{-4}$

$\mu_0 = 4\pi\times 10^{-7}$, $\theta_1 = 90^{\circ}$, $\theta_2 = 180^{\circ}$

$d = 4\times 10^{-2}$

$\Rightarrow$ = 20 A (into the page)

12. (*a*) $m_p = m$ $\quad q_p = q$ $\quad K_p = qV = K$

$m_\alpha = 4m$ $\quad q_\alpha = 2q$ $\quad K_\alpha = 2qV = 2K$

Radius of circular path,

$r = \frac{mv}{qB} = \frac{\sqrt{2Km}}{qB} = \sqrt{\frac{2mV}{qB^2}} \Rightarrow \frac{r_P}{r_\alpha} = \frac{1}{\sqrt{2}}$

13. (*a*) $\vec{\tau} = \vec{M}\times\vec{B}$

$\Rightarrow |\vec{\tau}| = MB\sin 90^{\circ} = C\theta$

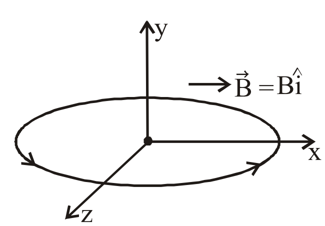
$\Rightarrow MB = C\theta$

$\Rightarrow C\theta = iNAB$

$\Rightarrow 10^{-6}\times\frac{\pi}{180} = 10^{-3}\times 10^{-4}\times 175\times B$

$\Rightarrow B = 10^{-3}$ Tesla.

14. (*a*)

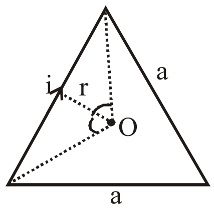


Magnetic moment of coil = $NIA\,\hat{j} = NI(\pi r^2)\hat{j}$

Torque on loop (coil) = $\vec{M}\times\vec{B} = NI(\pi r^2)B\sin 90^{\circ}(-\hat{k})$

$= NI\pi r^2 B(-\hat{k})$

15. (*a*) $B = 3\left[\frac{\mu_0 i}{4\pi r}(\sin 60^o + \sin 60^o)\right]$



Here, $r = \frac{a}{2\sqrt{3}} = \frac{1}{2\sqrt{3}}$

$$B = 3\left[\frac{4\pi\times 10^{-7}\times 10\times 2\sqrt{3}}{4\pi\times 1}\left[\frac{\sqrt{3}}{2}+\frac{\sqrt{3}}{2}\right]\right]$$

$B = 18 \times 10^{-6} = 18\mu T$

16. (*b*) $m = NIA = 1\times I\times a^2 = Ia^2$

here a = side of square

Now, $4a = 2\pi r$

$r = \frac{2a}{\pi}$

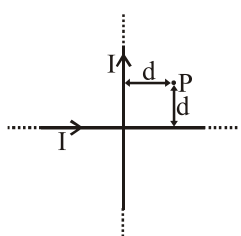
For circular loop

$m' = 1\times I\times \pi r^2$

$= 1\times I\times \pi\times\left(\frac{2a}{\pi}\right)^2 = \left(Ia^2\right)\frac{4}{\pi}$

$m' = \frac{4m}{\pi}$

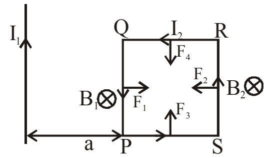
17. (*a*)



Magnetic field at point P

$$\vec{B}_{net} = \frac{\mu_0 i}{2\pi d}\left(-\hat{k}\right) + \frac{\mu_0 i}{2\pi d}\left(\hat{k}\right) = 0$$

18. (*b*)



F_3 & F_4 cancel each other

Force on PQ will be $F_1 = I_2 B_1 a$

$= I_2\,\frac{\mu_0 I_1}{2\pi a}a = \frac{\mu_0 I_1 I_2}{2\pi}$

Force on RS will be $F_2 = I_2 B_2 a$

$= I_2\,\frac{\mu_0 I_1}{2\pi 2a}a$

$= \frac{\mu_0 I_1 I_2}{4\pi}$

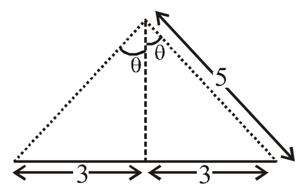
Net force $= F_1 - F_2 = \frac{\mu_0 I_1 I_2}{4\pi}$ repulsion

19. (*b*) $|\vec{\tau}| = |\vec{M}\times\vec{B}|$

$\tau = NI \times A \times B \times \sin 45^o$

$\tau = 0.27\,Nm$

20. (*d*)



$\sin\theta = \frac{3}{5}$, $d = 4$ cm

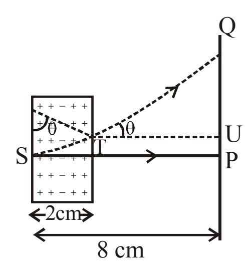
$$B = \frac{\mu_0 I}{4\pi d}2\sin\theta = \frac{10^{-7}\times 5\times 2\times 3}{4\times 10^{-2}\times 5} = \frac{3}{2}\times 10^{-5}$$

$= 15\times 10^{-6} = 15\,\mu T$

21. (*a*) $R = \frac{mv}{qB} = \frac{\sqrt{2m(K.E.)}}{qB}$

$$R = \frac{\sqrt{2\times 9.1\times 10^{-31}\times\left(100\times 1.6\times 10^{-19}\right)}}{1.6\times 10^{-19}\times 1.5\times 10^{-3}}$$

$R = 2.248$ cm



$\sin\theta = \frac{2}{2.248} = 0.89$

$\tan\theta = \frac{QU}{TU}$

$\frac{2}{1.026} = \frac{QU}{6}$

$QU = 11.69$

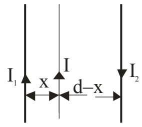
$PU = R(1-\cos\theta) = 1.22$

$d = QU + PU$

22. (*c*) $r = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$

$\Rightarrow r_{He} = r_p > r_e$

23. (*b*)



Net force on wire carrying current I per unit length is

$$\frac{\mu_0 I_1 I}{2\pi x}+\frac{\mu_0 I_2 I}{2\pi(d-x)}=0$$

$$\frac{I_1}{x}=\frac{I_2}{(x-d)} \Rightarrow x=\frac{I_1 d}{I_1-I_2}$$

24. (*c*) Force due to electric field is in direction $-\frac{(\hat{i}+\hat{j})}{\sqrt{2}}$

because at t = 0, $E=-\frac{(\hat{i}+\hat{j})}{\sqrt{2}}E_0$

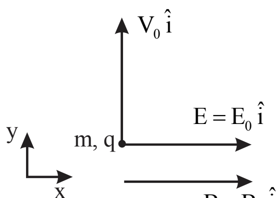
Force due to magnetic field is in direction $q(\vec{v}\times\vec{B})$

and $\vec{v}\parallel\hat{k}$

∴ it is parallel to $\vec{E}$

∴ net force is antiparallel to $\frac{(\hat{i}+\hat{j})}{\sqrt{2}}$.

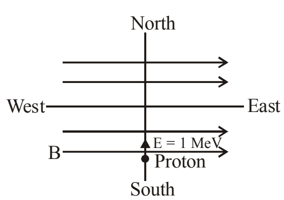
25. (*d*)



$(2V_0)^2 = v_0^2+v_x^2 \quad ; v_x=\sqrt{3}v_0$

∴ $\sqrt{3}v_0 = 0+\frac{eE}{m}t \quad ; t=\frac{mv_0\sqrt{3}}{qE}$

26. (*c*)



∵ K.E. $=1.6\times10^{-13}=\frac{1}{2}\times1.6\times10^{-27}v^2$

$v=\sqrt{2}\times10^7$ m/s

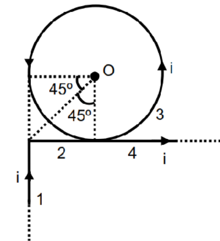
∴ $Bav = ma$

$$B=\frac{1.6\times10^{-27}\times10^{12}}{1.6\times10^{-19}\times\sqrt{2}\times10^7}$$

$=0.71\times10^{-3}$ T

So, 0.71 mT

27. (*a*)



$$\vec{B}_0=(\vec{B}_0)_1+(\vec{B}_0)_2+(\vec{B}_0)_3+(\vec{B}_0)_4$$

$$\frac{\mu_0 i}{4\pi R}[\sin 90^\circ-\sin 45^\circ]\otimes+\frac{\mu_0 i}{2R}\odot+\frac{\mu_0 i}{4\pi R}(\sin 45^\circ+\sin 90^\circ)\odot$$

$$-\frac{-\mu_0 i}{4\pi R}\left[1-\frac{1}{\sqrt{2}}\right]+\frac{\mu_0 i}{2R}+\frac{\mu_0 i}{4\pi R}\left[\frac{1}{\sqrt{2}}+1\right]\odot$$

$$-\frac{\mu_0 i}{4\pi R}\left[-1+\frac{1}{\sqrt{2}}+2\pi+\frac{1}{\sqrt{2}}+1\right]\odot$$

$$=\frac{\mu_0 i}{4\pi R}\left[\sqrt{2}+2\pi\right]\odot$$

$$=\frac{\mu_0 i}{2\pi R}\left[\frac{1}{\sqrt{2}}+\pi\right]\odot$$

28. (*a*)

(*a*) by work energy theorem

$$W_{mag}+W_{ele}=\frac{1}{2}m(2v)^2-\frac{1}{2}m(v)^2$$

$$0+qE2a=\frac{3}{2}mv^2$$

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

(*b*) Rate of work done at A = power of electric force

$= qE_0V$

$=\frac{3}{4}\frac{mv^2}{a}$

(*c*) at Q, $\frac{dW}{dt}=0$ for both forces

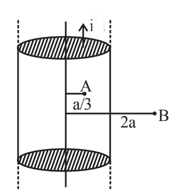
(*d*) $\Delta\vec{L}=(-m2v\,2a\,\hat{k})-(-mva\,\hat{k})$

$|\Delta\vec{L}|=3mva$

29. (*d*) $B_A=\frac{\mu_0 ir}{2\pi a^2}=\frac{\mu_0 i\frac{a}{3}}{2\pi a^2}=\frac{\mu_0 i}{\pi a^2}\frac{a}{6}=\frac{\mu_0 i}{6\pi a}$

$$B_B=\frac{\mu_0 i}{2\pi(2a)}$$

$$\frac{B_A}{B_B}=\frac{4}{6}=\frac{2}{3}$$



30. (*a*) $R_{max} = \frac{R}{2} = \frac{mv_{max}}{e\mu_0 in}$

$V_{max} = \frac{Re\mu_0 in}{2m}$

31. (*d*) $\tau = MB\ \sin\theta = I\alpha$

$\pi R^2 I\ B\theta = \frac{mR^2}{2}\alpha$

$\omega = \sqrt{\frac{2\pi IB}{m}} = \frac{2\pi}{T}; \quad T = \sqrt{\frac{2\pi m}{IB}}$

32. (*b*) $\vec{M} = \vec{M}_1 + \vec{M}_2$

$\vec{M}_1 = abl\,\hat{j}$

$\vec{M}_2 = abl\,\hat{k}$

$\vec{M} = \sqrt{2}\,abl\left(\frac{\hat{j}}{\sqrt{2}} + \frac{\hat{k}}{\sqrt{2}}\right)$

33. (*d*) $(v_0\cos\theta) \times \Delta T = I$

and, $\Delta T = 10 \times \frac{2\pi m}{qB}$

$\therefore\ 4 \times 10^5 \times \frac{1}{2} \times \frac{10 \times 2\pi \times 1.67 \times 10^{-27}}{1.6 \times 10^{-19} \times 0.3} = 1$

$\Rightarrow I = 0.44\,m$

34. (*d*) Pitch $= v\cos\theta \times \frac{2\pi m}{qB}$

$= 4 \times 10^5 \times \frac{1}{2} \times \frac{2\pi \times 1.67 \times 10^{-27}}{1.69 \times 10^{-19} \times 0.3} = 4$ cm

35. (20) $\vec{\mu} = NiA = 500 \times 3 \times 10^{-4} \times \frac{5}{10}$

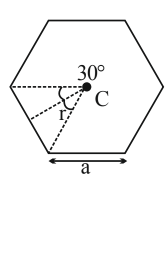
$\tau = \vec{\mu} \times \vec{\beta} = \mu B \sin\theta\ \ (\because \sin\theta = 1)$

$\therefore\ B = \frac{15 \times 10}{10 \times 500 \times 3 \times 5 \times 10^{-4}}$

$B = 20T$

36. (*a*) $B_C = N.\left(6.\frac{\mu_0 i}{4\pi r}(\sin 30° + \sin 30°\right)$

$r = \frac{\sqrt{3}}{2}a = \frac{300}{4r}\frac{\mu_0 i}{\pi}$



$500\sqrt{3}\,\frac{\mu_0 i}{}$

37. (*d*) $F = q(\vec{V} \times \vec{B})$

$= (1 \times 10^{-6})\ [2\hat{i} + 3\hat{j} + 4\hat{k}] \times [5\hat{i} + 3\hat{j} - 6\hat{k}] \times 10^{-3}$

$= (-30\hat{i} + 32\hat{j} - 9\hat{k})10^{-9}$ N

38. (Bonus)

$|U_f - U_i| = \frac{1}{2}I\omega^2$

$20 \times 4 \times \frac{\sqrt{3}}{2} - 0 = \frac{1}{2} \times (0.8)\omega^2$

$\Rightarrow \omega = 13.16$ rad/s

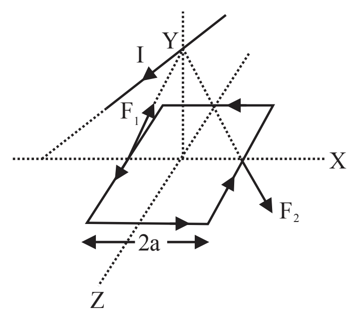
39. (*b*) $B_A = \frac{(\mu_0)(2)}{(2)(2)}\frac{3(\pi/2)}{2\pi}$ ...(1)

$B_B = \frac{(\mu_0)(3)}{(2)(4)}\frac{5\pi/3}{2\pi}$ ...(2)

From (1) and (2)

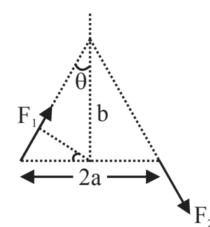
$\frac{B_A}{B_B} = \frac{6}{5}$

40. (*a*)



$F_1 = \frac{\mu_0 I^2}{2\pi r}2a$ toward wire

$F_2 = \frac{\mu_0 I^2}{2\pi r}2a$ away for wire



Torque about z-axis

$= F_1 \cdot a\cos\theta + F_2 \cdot a\cos\theta$

$= 2\left(\frac{\mu_0 I^2 2a}{2\pi r}\right)a \cdot \frac{b}{r}$

$= \frac{2\mu_0 I^2 a^2 b}{\pi(a^2 + b^2)}$

$= \frac{2\mu_0 I^2 a^2}{\pi b}$ for (b >> a)

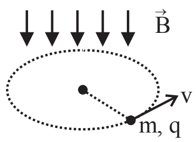
41. (*a*) $F_m^{max} = (q)VB_0$

$$\frac{E_0}{B_0} = c \Rightarrow B_0 = \left(\frac{E_0}{c}\right)$$

$$\Rightarrow F_m^{max} = (1.6 \times 10^{-19})(0.1\,c)\left(\frac{E_0}{c}\right)$$

$$= 4.8 \times 10^{-19}\,N$$

42. (*a*) $\vec{M} = \frac{1}{2}qvR(-\hat{B})$



$$= \frac{qv}{2}\left(\frac{mv}{qb}\right)\left(\frac{-\vec{B}}{\vec{B}}\right)$$

$$= \frac{mv^2}{2B^2}\vec{B}$$

43. (*c*) $\frac{dv_x}{dt} = \frac{k}{m}v_y$

$$\frac{dv_y}{dt} = \frac{k}{m}v_x$$

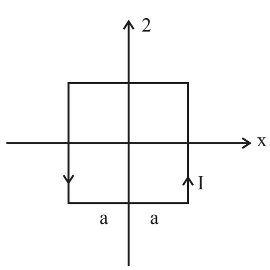
$$\Rightarrow \frac{dv_x}{dv_y} = \frac{v_y}{v_x} \Rightarrow v_x dx = v_y dy$$

$$\Rightarrow v_x^2 = v_y^2 + C$$

$$\vec{v} \times \vec{a}\left(v_x^2 - v_y^2\right)\frac{k}{m}$$

$$\vec{v} \times \vec{a} = \frac{kC}{m}$$

44. (*b*)



$$\tau\,(t_\perp)\,r$$

$$f_\perp = (I)\,\frac{\mu \cdot I}{2\pi\sqrt{a^2+b^2}}\,\frac{(b)2a}{\sqrt{a^2+b^2}}$$

$$\tau_{total} = \frac{2\mu_0 I^2 a^2 b}{\pi(a^2+b^2)}$$

45. (*d*) $r = \frac{mv}{qB_0}$

To not collide, $r < d$

$$\Rightarrow r = \frac{mv}{qB_0} < d$$

$$\therefore v_{max} = \frac{qB_0 d}{m}$$

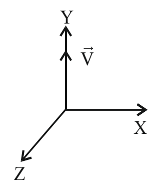
Note: It should be maximum instead of minimum.

46. (*a*) $F = (\vec{E} + \vec{V} \times \vec{B})$

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

47. (*c*)

48. (*a*)



$\because \hat{E} \times \hat{B} = \hat{C}$

$\therefore\ \hat{E} \times \hat{B}$ should point in the direction of propagation of wave ($y-$ direction here)

$\therefore$ possible combinations are $\left(E_x, B_z\right)$ or $\left(E_z, B_x\right)$

49. (*a*) Force on each wire be along radially outward and equal so, it will take the shape of circle and parallel to the field.

50. (*c*) The proportion of the electric to attractive fields in an electromagnetic wave in free space is equivalent all the time to the speed of light. $E = B \times c$. where: B = Magnetic Field. c = speed of light.

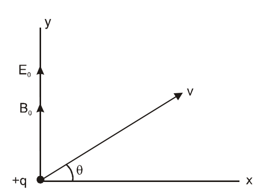
$f = 300\text{MHz}$

$$\vec{B} = 2\times10^{-9}\text{T} \Rightarrow \vec{E} = \vec{B}\times\vec{V} = (2\times10^{8}\hat{k})\times(3\times10^{8}\hat{i})$$

$$= 6(\hat{k}\times\hat{i}) = 6\hat{j}\,\text{V/m} \Rightarrow \vec{E} = 6\hat{j}\,\text{V/m}$$

JEE-ADVANCED PREVIOUS YEAR'S

1. (*c,d*)



If $\theta = 0°$ then due to magnetic force path is circular but due to force $qE_0\,(\uparrow)$ q will have accelerated motion along y–axis. So combined path of q will be a helical path with variable pitch so (A) and (B) are wrong.

If $\theta = 10°$ then due to $v\cos\theta$, path is circular and due to qE_0 and $v\sin\theta$, q has accelerated motion along y-axis so combined path is a helical path with variable pitch (C) is correct.

If $\theta = 90°$ then $F_B = 0$ and due to qE_0 motion is accelerated along y-axis. (D)

2. (5) $B_1 = \dfrac{\mu_o J_a}{2} - \dfrac{\mu_o J_a}{12}$

$$= \left(\frac{\mu_o Ja}{2}\right)\left(1-\frac{1}{6}\right) = \frac{5}{6}\left(\frac{\mu_o Ja}{2}\right) = \frac{5\mu_0 aJ}{12} = \frac{N}{12}\mu_0 aJ$$

N = 5

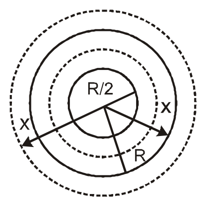
3. (*b*) $\text{Area} = a^2 + 4\times\dfrac{\pi\left(\frac{a}{2}\right)^2}{2} = a^2 + \dfrac{\pi a^2}{2}$

$$A = \left(1+\frac{\pi}{2}\right) a^2\ \hat{k}$$

4. (*d*) **Case-I** $x < \dfrac{R}{2}$

$|B| = 0$

Case-II $\dfrac{R}{2} \le x < R$



$$\int \vec{B}.d\vec{\ell} = \mu_0 I$$

$$|B|\,2\pi x = \mu_0\left[\pi x^2 - \pi\left(\frac{R}{2}\right)^2\right] J$$

$$|B| = \frac{\mu_0 J}{2x}\left(x^2 - \frac{R^2}{4}\right)$$

Case-III $x \ge R$

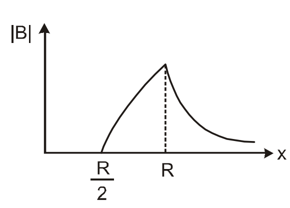
$$\int \vec{B}.\,d\vec{\ell} = \mu_0 I$$

$$|B|\,2\pi x = \mu_0\left[\pi R^2 - \pi\left(\frac{R}{2}\right)^2\right] J$$

$$|B| = \frac{\mu_0 J}{2x}\,\frac{3}{2}R^2$$

$$|B| = \frac{3\mu_0 J R^2}{8x}$$

so



5. (*a,c*)

Component of final velocity of particle is in positive y direction.

Centre of circle is present on positive y axis. so magnetic field is present in negative z-direction

Angle of deviation is 30° because

$$\tan\theta = \frac{v_y}{v_x} = \frac{1}{\sqrt{3}}$$

$$\theta = \frac{\pi}{6}$$

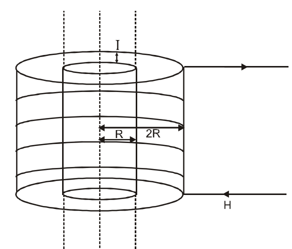
$$\omega t = \theta$$

$$\theta = \frac{QB}{M}t$$

$$B = \frac{M\theta}{Qt}$$

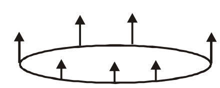
$$B = \left(\frac{50M\pi}{3Q}\right)$$

6. (*a,d*)

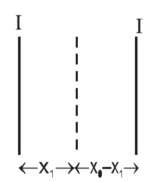


(*a*) For $0 < r < R \Rightarrow B \neq 0$

(*d*) For $r > 2R \Rightarrow B \neq 0$



7. (*c*)



$$B_2 = \frac{\mu_0 I}{2\pi x_1} + \frac{\mu_0 I}{2\pi(x - x_1)} \text{ (opposite)}$$

$$B_1 = \frac{\mu_0 I}{2\pi x_1} - \frac{\mu_0 I}{2\pi(x - x_1)} \text{ (same)}$$

Case - 1 When current is in the same direction

$$B = B_1 = \frac{3\mu_0 I}{2\pi x_0} - \frac{3\mu_0 I}{4\pi x_0} = \frac{3\mu_0 I}{4\pi x_0}$$

$$R_1 = \frac{mv}{qB_1}$$

Case-2 When current is in oposite direction

$$B = B_2 = \frac{9\mu_0 I}{4\pi x_0}$$

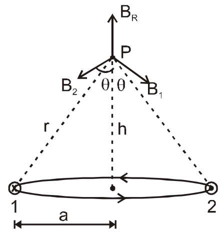
$$R_2 = \frac{mv}{qB_2}$$

$$\frac{R_1}{R_2} = \frac{B_2}{B_1} = \frac{9}{3} = 3$$

8. (*c*) $\vec{B}_R = \vec{B}$ due to ring

$\vec{B}_1 = \vec{B}$ due to wire - 1

$\vec{B}_2 = \vec{B}$ due to wire - 2



In magnitudes $B_1 = B_2 = \frac{\mu_0 I}{2\pi r}$

Resultant of B_1 and $B_2 = 2B_1 \cos\theta = \frac{\mu_0 I a}{\pi r^2}$

$$B_R = \frac{2\mu_0 I\pi a^2}{4\pi r^3}$$

For zero magnetic field at P

$$\frac{\mu_0 I a}{\pi r^2} = \frac{2\mu_0 I \pi a^2}{4\pi r^3}$$

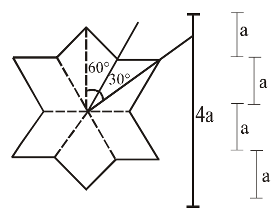
$\Rightarrow$ $h \approx 1.2a$

9. (*b*) Magnetic field at mid point of two wires $= \frac{\mu_0 I}{\pi d} \otimes$

Magnetic moment of loop $= I\pi a^2$

Torque on loop = M B sin 150° $= \frac{\mu_0 I^2 a^2}{2d}$

10. (*a*)



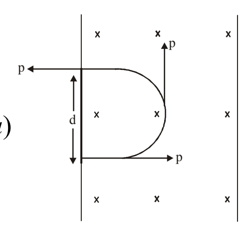
Total Mgnetic Field
at centre = 12 times magnetic field due to one wire

$$B = \frac{12\mu_0 I}{4\pi a}\left[\sin 60° - \sin 30°\right] = \frac{\mu_0 I}{4\pi a} \times 12\left[\frac{\sqrt{3}}{2} - \frac{1}{2}\right]$$

$$\Rightarrow B = \frac{\mu_0 I}{4\pi a} \times 6\left(\sqrt{3} - 1\right)$$

11. (*c,d*)

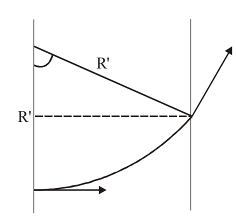
(*a*)



$|\Delta\vec{p}| = \sqrt{2}p$

(*b*) $R' = \frac{mv}{QB}$

$d = 2R' = \frac{2mv}{QB}$ $\quad d \propto m$



(*c*) R' (1 – cosθ) = R

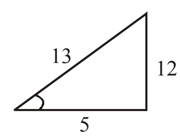
$$R'\sin\theta = \frac{3R}{2}$$

$$\frac{\sin\theta}{1-\cos\theta} = \frac{3}{2}$$

$$\frac{2\sin\frac{\theta}{2}\cos\frac{\theta}{2}}{2\sin^2\frac{\theta}{2}} = \frac{3}{2}$$

$$\cot\frac{\theta}{2} = \frac{3}{2} \Rightarrow \tan\frac{\theta}{2} = \frac{2}{3}$$

$$\Rightarrow \tan\theta = \frac{2\left(\frac{2}{3}\right)}{1-\frac{4}{9}} = \frac{\frac{4}{3}}{\frac{5}{9}} = \frac{4}{3}\times\frac{9}{5} = \frac{12}{5}$$



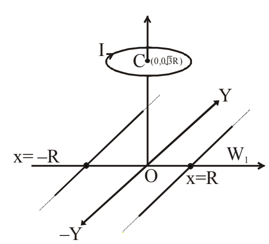
$\sin\theta = \frac{12}{13}$

$$R'\left(\frac{12}{13}\right) = \frac{3R}{2}; R' = \frac{13R}{8} = \frac{P}{QB}; B = \frac{8P}{13QR}$$

(*d*) $\frac{P}{QB} < \frac{3R}{2}$

$$B > \frac{2P}{3QR}$$

12. (*a,b,d*)

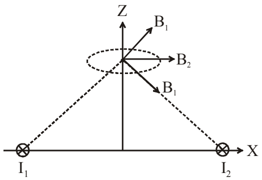


(*a*) at origin, $\vec{B} = 0$ due to two wires if $I_1 = I_2$, hence ($\vec{B}_{net}$) at origin is equal to $\vec{B}$ due to ring, which is non-zero.

(*b*) If $I_1 > 0$ and $I_2 < 0$, $\vec{B}$ at origin due to wires will be along $+\hat{k}$ direction and $\vec{B}$ due to ring is along $-\hat{k}$ direction and hence $\vec{B}$ can be zero at origin.

(*c*) If $I_1 < 0$ and $I_2 > 0$, $\vec{B}$ at origin due to wires will is along $-\hat{k}$ and also along $-\hat{k}$ due to ring, hence $\vec{B}$ cannot be zero.

(*d*)

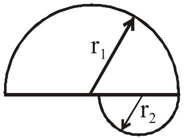


At centre of ring, $\vec{B}$ due two wires is along x-axis, hence z-component is only because of ring which

$$\vec{B} = \frac{\mu_0 i}{2R}(-\hat{k}).$$

13. [2.00]

(*a*) Average speed along x-axis



$$(v_x) = \frac{\int |\vec{v}_x| dt}{\int dt} = \frac{d_1 + d_2}{t_1 + t_2}$$

(*b*) we have

$$r_1 = \frac{mv}{qB_1}, r_2 = \frac{mv}{qB_2}$$

$$\text{Since, } B_1 = \frac{B_2}{4}$$

$$\therefore \ r_1 = 4r_2$$

$$\text{Time in } B_1 \Rightarrow \frac{\pi m}{qB_1} = t_1$$

$$\text{Time in } B_2 \Rightarrow \frac{\pi m}{qB_2} = t_2$$

Total distance along x-axis

$d_1 + d_2 = 2r_1 + 2r_2 = 2(r_1 + r_2) = 2(5r_2)$

Total time $T = t_1 + t_2 = 5t_2$

$$\text{Average speed} = \frac{10r_2}{5t_2} = 2\frac{mv}{qB_2} \times \frac{qB_2}{\pi m} = 2$$

14. (*a,b,d*)