

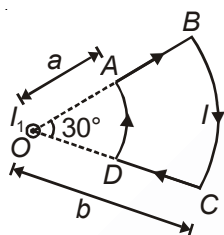
Chapter 17

Moving Charges and Magnetism

Directions : Question numbers 1 and 2 are based on the following paragraph.

A current loop $ABCD$ is held fixed on the plane of the paper as shown in the figure. The arcs BC (radius = b) and DA (radius = a) of the loop are joined by two straight wires AB and CD . A steady current I is flowing in the loop. Angle made by AB and CD at the origin O is 30° . Another straight thin wire with steady current I_1 flowing out of the plane of the paper is kept at the origin.

[AIEEE-2009]



1. The magnitude of the magnetic field (B) due to the loop $ABCD$ at the origin (O) is

(1) $\frac{\mu_0 I(b-a)}{24ab}$

(2) $\frac{\mu_0 I}{4\pi} \left[\frac{b-a}{ab} \right]$

(3) $\frac{\mu_0 I}{4\pi} \left[2(b-a) + \frac{\pi}{3}(a+b) \right]$

(4) Zero

2. Due to the presence of the current I_1 at the origin

(1) The forces on AD and BC are zero

(2) The magnitude of the net force on the loop is

given by $\frac{I_1 I}{4\pi} \mu_0 \left[2(b-a) + \frac{\pi}{3}(a+b) \right]$

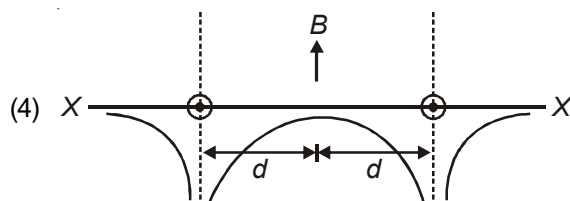
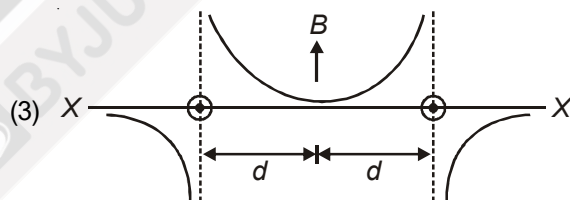
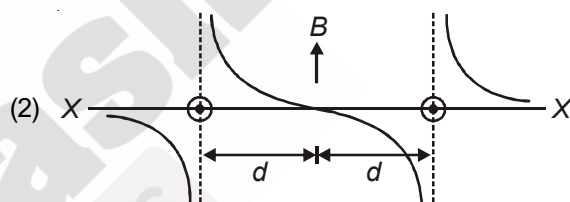
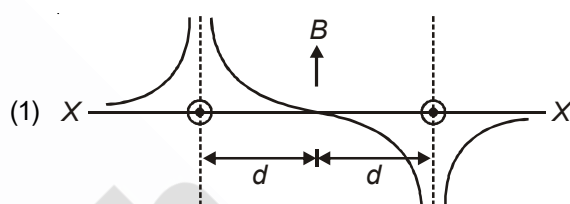
(3) The magnitude of the net force on the loop is

given by $\frac{\mu_0 I I_1}{24ab} (b-a)$

(4) The forces on AB and DC are zero

3. Two long parallel wires are at a distance $2d$ apart. They carry steady equal currents flowing out of the plane of the paper as shown. The variation of the magnetic field B along the line XX' is given by

[AIEEE-2010]



4. A thin circular disk of radius R is uniformly charged with density $\sigma > 0$ per unit area. The disk rotates about its axis with a uniform angular speed ω . The magnetic moment of the disk is

[AIEEE-2011]

(1) $\frac{\pi R^4}{4} \sigma \omega$

(2) $2\pi R^4 \sigma \omega$

(3) $\pi R^4 \sigma \omega$

(4) $\frac{\pi R^4}{2} \sigma \omega$

5. An electric charge $+q$ moves with velocity $\vec{V} = 3\hat{i} + 4\hat{j} + \hat{k}$, in an electromagnetic field given by $\vec{E} = 3\hat{i} + \hat{j} + 2\hat{k}$ and $\vec{B} = \hat{i} + \hat{j} - 3\hat{k}$. The y -component of the force experienced by $+q$ is

[AIEEE-2011]

- (1) $3q$ (2) $2q$
(3) $11q$ (4) $5q$

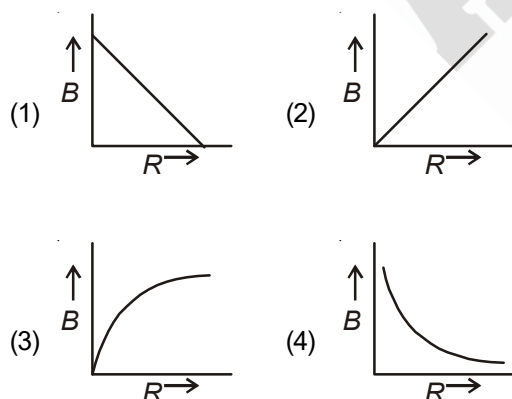
6. Proton, deuteron and alpha particle of the same kinetic energy are moving in circular trajectories in a constant magnetic field. The radii of proton, deuteron and alpha particle are respectively r_p , r_d and r_α . Which one of the following relations is correct?

[AIEEE-2012]

- (1) $r_\alpha = r_p < r_d$
(2) $r_\alpha > r_d > r_p$
(3) $r_\alpha = r_d > r_p$
(4) $r_\alpha = r_p = r_d$

7. A charge Q is uniformly distributed over the surface of non-conducting disc of radius R . The disc rotates about an axis perpendicular to its plane and passing through its centre with an angular velocity ω . As a result of this rotation a magnetic field of induction B is obtained at the centre of the disc. If we keep both the amount of charge placed on the disc and its angular velocity to be constant and vary the radius of the disc then the variation of the magnetic induction at the centre of the disc will be represented by the figure

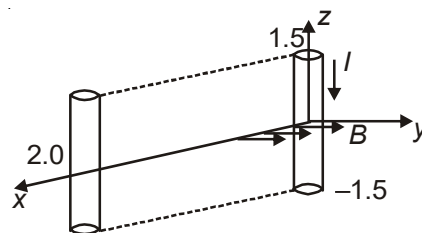
[AIEEE-2012]



8. A conductor lies along the z -axis at $-1.5 \leq z < 1.5$ m and carries a fixed current of 10.0 A in $-\hat{a}_z$ direction (see figure). For a field $\vec{B} = 3.0 \times 10^{-4} e^{-0.2x} \hat{a}_y$ T, find the power required

to move the conductor at constant speed to $x = 2.0$ m, $y = 0$ m in 5×10^{-3} s. Assume parallel motion along the x -axis

[JEE (Main)-2014]



- (1) 1.57 W (2) 2.97 W
(3) 14.85 W (4) 29.7 W

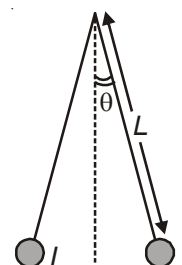
9. Two coaxial solenoids of different radii carry current I in the same direction. Let $\vec{F}_1$ be the magnetic force on the inner solenoid due to the outer one and $\vec{F}_2$ be the magnetic force on the outer solenoid due to the inner one. Then

[JEE (Main)-2015]

- (1) $\vec{F}_1 = \vec{F}_2 = 0$
(2) $\vec{F}_1$ is radially inwards and $\vec{F}_2$ is radially outwards
(3) $\vec{F}_1$ is radially inwards and $\vec{F}_2 = 0$
(4) $\vec{F}_1$ is radially outwards and $\vec{F}_2 = 0$

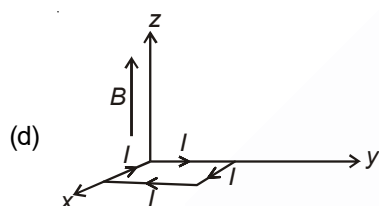
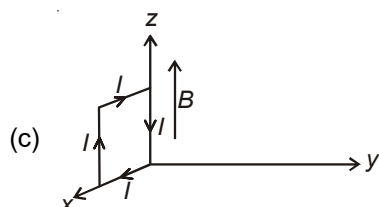
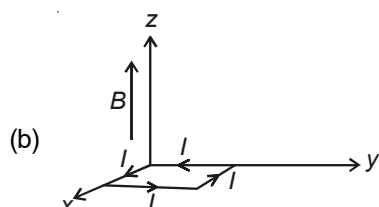
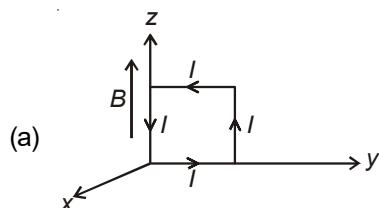
10. Two long current carrying thin wires, both with current I , are held by insulating threads of length L and are in equilibrium as shown in the figure, with threads making an angle θ with the vertical. If wires have mass λ per unit length then the value of I is

(g = gravitational acceleration) [JEE (Main)-2015]



- (1) $\sin \theta \sqrt{\frac{\pi \lambda g L}{\mu_0 \cos \theta}}$ (2) $2 \sin \theta \sqrt{\frac{\pi \lambda g L}{\mu_0 \cos \theta}}$
(3) $2 \sqrt{\frac{\pi g L}{\mu_0}} \tan \theta$ (4) $\sqrt{\frac{\pi \lambda g L}{\mu_0}} \tan \theta$

11. A rectangular loop of sides 10 cm and 5 cm carrying a current I of 12 A is placed in different orientations as shown in the figures below:



If there is a uniform magnetic field of 0.3 T in the positive z direction, in which orientations the loop would be in (i) stable equilibrium and (ii) unstable equilibrium? **[JEE (Main)-2015]**

- (1) (a) and (b), respectively
 (2) (a) and (c), respectively
 (3) (b) and (d), respectively
 (4) (b) and (c), respectively
12. Two identical wires A and B , each of length ' l ' carry the same current I . Wire A 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]

- (1) $\frac{\pi^2}{16\sqrt{2}}$ (2) $\frac{\pi^2}{16}$
 (3) $\frac{\pi^2}{8\sqrt{2}}$ (4) $\frac{\pi^2}{8}$

13. 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]**

- (1) $r_e > r_p = r_\alpha$ (2) $r_e < r_p = r_\alpha$
 (3) $r_e < r_p < r_\alpha$ (4) $r_e < r_\alpha < r_p$

14. 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

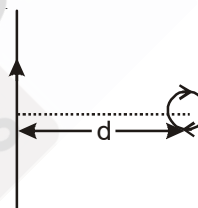
ratio $\frac{B_1}{B_2}$ is

[JEE (Main)-2018]

- (1) 2 (2) $\sqrt{3}$
 (3) $\sqrt{2}$ (4) $\frac{1}{\sqrt{2}}$

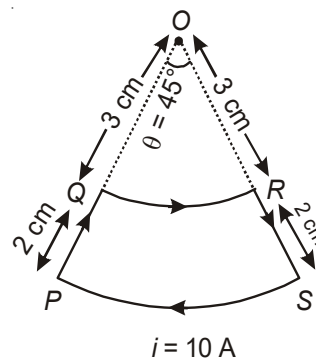
15. An infinitely long current carrying wire and a small current carrying loop are in the plane of the paper as shown. The radius of the loop is a and distance of its centre from the wire is d ($d \gg a$). If the loop applies a force F on the wire then

[JEE (Main)-2019]



- (1) $F = 0$ (2) $F \propto \left(\frac{a}{d}\right)^2$
 (3) $F \propto \left(\frac{a}{d}\right)$ (4) $F \propto \left(\frac{a^2}{d^3}\right)$

16. A current loop, having two circular arcs joined by two radial lines is shown in the figure. It carries a current of 10 A. The magnetic field at point O will be close to **[JEE (Main)-2019]**



- (1) 1.5×10^{-7} T (2) 1.0×10^{-5} T
 (3) 1.5×10^{-5} T (4) 1.0×10^{-7} T

17. 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 central 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]

- (1) $\frac{1}{N}$ (2) N^2
(3) N (4) $\frac{1}{N^2}$

18. 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]

- (1) 9.1×10^{-31} kg (2) 1.6×10^{-27} kg
(3) 1.6×10^{-19} kg (4) 2.0×10^{-24} kg

19. An insulating, thin rod of length l has a linear charge density $\rho(x) = \rho_0 \frac{x}{l}$ 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]

- (1) $\pi n \rho l^3$ (2) $n \rho l^3$
(3) $\frac{\pi}{4} n \rho l^3$ (4) $\frac{\pi}{3} n \rho l^3$

20. 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 the electron = 1.6×10^{-19} C, Mass of the electron = 9.1×10^{-31} kg]

[JEE (Main)-2019]

- (1) 7.5×10^{-3} m
(2) 7.5 m
(3) 7.5×10^{-2} m
(4) 7.5×10^{-4} m

21. 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 velocity $\vec{v} = v\hat{i}$.

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]

- (1) $\frac{qvB}{m} \left(\frac{1}{2}\hat{i} - \frac{\sqrt{3}}{2}\hat{j} \right)$ (2) $-\frac{qvB}{m} \left(\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j} \right)$
(3) $\frac{qvB}{m} \left(\frac{\hat{i} + \hat{j}}{\sqrt{2}} \right)$ (4) $\frac{qvB}{m} \left(\frac{-\hat{j} + \hat{i}}{\sqrt{2}} \right)$

22. A particle of mass m and charge q is in an electric and magnetic field given by

$$\vec{E} = 2\hat{i} + 3\hat{j}; \quad \vec{B} = 4\hat{j} + 6\hat{k}$$

The charged particle is shifted from the origin to the point $P(x = 1; y = 1)$ along a straight path. The magnitude of the total work done is

[JEE (Main)-2019]

- (1) $(0.15)q$ (2) $5q$
(3) $(0.35)q$ (4) $(2.5)q$

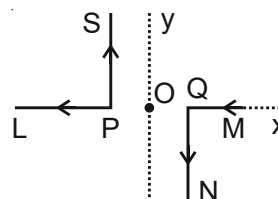
23. A proton and an α -particle (with their masses in the ratio of 1 : 4 and charges in the ratio of 1 : 2) are accelerated from rest through a potential difference V . If a uniform magnetic field (B) is set up perpendicular to their velocities, the ratio of the radii $r_p : r_\alpha$ of the circular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

[JEE (Main)-2019]

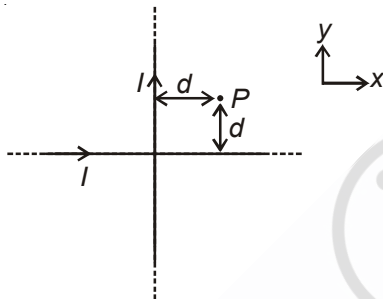
- (1) 1 : 3 (2) 1 : 2
(3) 1 : $\sqrt{3}$ (4) 1 : $\sqrt{2}$

24. 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 currents (see figure), the magnitude of the currents 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]



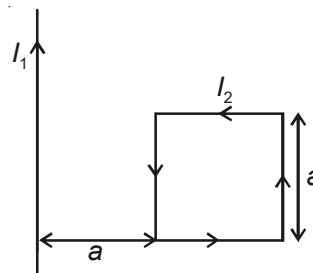
- (1) 40 A, perpendicular into the page
 (2) 20 A, perpendicular into the page
 (3) 40 A, perpendicular out of the page
 (4) 20 A, perpendicular out of the page
25. A circular coil having N turns and radius r carries a current I . It is held in the XZ plane in a magnetic field $B\hat{i}$. The torque on the coil due to the magnetic field is [JEE (Main)-2019]
- (1) $\frac{B\pi r^2 I}{N}$ (2) $\frac{Br^2 I}{\pi N}$
 (3) $B\pi r^2 I N$ (4) Zero
26. Two very long, straight, and insulated wires are kept at 90° angle from each other in xy -plane as shown in the figure. [JEE (Main)-2019]



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]

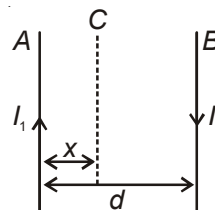
- (1) Zero (2) $\frac{\mu_0 I}{\pi d} (\hat{z})$
 (3) $-\frac{\mu_0 I}{2\pi d} (\hat{x} + \hat{y})$ (4) $\frac{\mu_0 I}{2\pi d} (\hat{x} + \hat{y})$
27. A rectangular coil (Dimension $5\text{ cm} \times 2.5\text{ cm}$) with 100 turns, carrying a current of 3 A in the clockwise direction, is kept centered 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]
- (1) 0.55 Nm
 (2) 0.27 Nm
 (3) 0.42 Nm
 (4) 0.38 Nm
28. A rigid square loop of side a and carrying current I_2 is lying on a 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 the wire will be [JEE (Main)-2019]



- (1) Repulsive and equal to $\frac{\mu_0 I_1 I_2}{4\pi}$
 (2) Repulsive and equal to $\frac{\mu_0 I_1 I_2}{2\pi}$
 (3) Zero
 (4) Attractive and equal to $\frac{\mu_0 I_1 I_2}{3\pi}$

29. 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]
- (1) 10^{-4} (2) 10^{-2}
 (3) 10^{-1} (4) 10^{-3}
30. Two wires A and B are carrying currents I_1 and 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]



- (1) $x = \pm \frac{I_1 d}{(I_1 - I_2)}$
 (2) $x = \left(\frac{I_1}{I_1 + I_2}\right)d$ and $x = \left(\frac{I_2}{I_1 - I_2}\right)d$
 (3) $x = \left(\frac{I_2}{I_1 + I_2}\right)d$ and $x = \left(\frac{I_2}{I_1 - I_2}\right)d$
 (4) $x = \left(\frac{I_1}{I_1 - I_2}\right)d$ and $x = \left(\frac{I_2}{I_1 + I_2}\right)d$

31. The magnitude of the magnetic field at the center of an equilateral triangular loop of side 1 m which is carrying a current of 10 A is [JEE (Main)-2019]

[Take, $\mu_0 = 4\pi \times 10^{-7} \text{ NA}^{-2}$]

- (1) $18 \mu\text{T}$
- (2) $1 \mu\text{T}$
- (3) $3 \mu\text{T}$
- (4) $9 \mu\text{T}$

32. 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]

- (1) $\frac{2m}{\pi}$
- (2) $\frac{4m}{\pi}$
- (3) $\frac{m}{\pi}$
- (4) $\frac{3m}{\pi}$

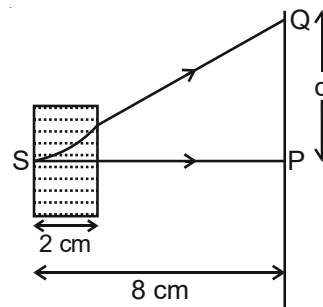
33. A thin ring of 10 cm radius carries a uniformly distributed charge. The ring rotates at a constant angular speed of $40\pi \text{ rad s}^{-1}$ about its axis, perpendicular to its plane. If the magnetic field at its centre is $3.8 \times 10^{-9} \text{ T}$, then the charge carried by the ring is close to ($\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$).

[JEE (Main)-2019]

- (1) $4 \times 10^{-5} \text{ C}$
- (2) $3 \times 10^{-5} \text{ C}$
- (3) $7 \times 10^{-6} \text{ C}$
- (4) $2 \times 10^{-6} \text{ C}$

34. An electron, moving along the x-axis with an initial energy of 100 eV, enters a region of magnetic field $\vec{B} = (1.5 \times 10^{-3} \text{ T}) \hat{k}$ at S (See figure). The field extends between $x = 0$ and $x = 2 \text{ cm}$. 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

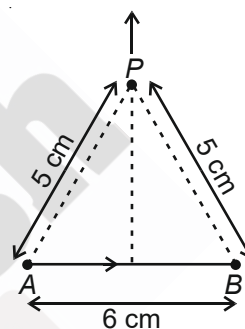
(electron's charge = $1.6 \times 10^{-19} \text{ C}$, mass of electron = $9.1 \times 10^{-31} \text{ kg}$) [JEE (Main)-2019]



- (1) 11.65 cm
- (2) 12.87 cm
- (3) 2.25 cm
- (4) 1.22 cm

35. Find the magnetic field at point P due to a straight line segment AB of length 6 cm carrying a current of 5 A. (See figure) [JEE (Main)-2019]

($\mu_0 = 4\pi \times 10^{-7} \text{ N-A}^{-2}$)



- (1) $2.5 \times 10^{-5} \text{ T}$
- (2) $1.5 \times 10^{-5} \text{ T}$
- (3) $3.0 \times 10^{-5} \text{ T}$
- (4) $2.0 \times 10^{-5} \text{ T}$

36. 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 $\vec{B} = B_0 \hat{j}$ act on the particle, its speed will double after a time [JEE (Main)-2020]

- (1) $\frac{3mv_0}{qE_0}$
- (2) $\frac{\sqrt{3}mv_0}{qE_0}$
- (3) $\frac{2mv_0}{qE_0}$
- (4) $\frac{\sqrt{2}mv_0}{qE_0}$

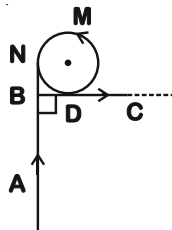
37. Proton with kinetic energy of 1 MeV moves from south to north. It gets an acceleration of 10^{12} m/s^2 by an applied magnetic field (west to east). The value of magnetic field

(Rest mass of proton is $1.6 \times 10^{-27} \text{ kg}$)

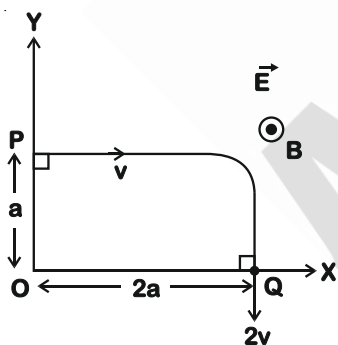
[JEE (Main)-2020]

- (1) 0.071 mT
- (2) 0.71 mT
- (3) 71 mT
- (4) 7.1 mT

38. 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]



- (1) $\frac{\mu_0 I}{2\pi R} (\pi + 1)$ (2) $\frac{\mu_0 I}{2R}$
 (3) $\frac{\mu_0 I}{2\pi R} \left(\pi + \frac{1}{\sqrt{2}} \right)$ (4) $\frac{\mu_0 I}{2\pi R} \left(\pi - \frac{1}{\sqrt{2}} \right)$
39. A charged particle of mass ' m ' and charge ' q ' moving under the influence of uniform electric field $\vec{E}\hat{i}$ and a uniform magnetic field $\vec{B}\hat{k}$ follows a trajectory from point P to Q as shown in figure. The velocities at P and Q are respectively, $\vec{v}\hat{i}$ and $-2\vec{v}\hat{j}$. Then which of the following statements (A, B, C, D) are the correct? (Trajectory shown is schematic and not to scale) [JEE (Main)-2020]



- 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 $2mav$.
- (1) A, B, C (2) A, C, D
 (3) A, B, C, D (4) B, C, D

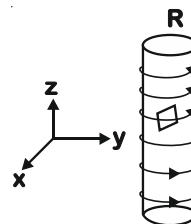
40. A long straight wire of radius a carries a current distributed uniformly over its cross-section. The ratio of the magnetic fields due to the wire at distance $\frac{a}{3}$ and $2a$, respectively from the axis of the wire is [JEE (Main)-2020]

- (1) $\frac{1}{2}$ (2) $\frac{3}{2}$
 (3) 2 (4) $\frac{2}{3}$

41. 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]

- (1) $T = \sqrt{\frac{2\pi m}{IB}}$ (2) $T = \sqrt{\frac{\pi m}{IB}}$
 (3) $T = \sqrt{\frac{2m}{IB}}$ (4) $T = \sqrt{\frac{\pi m}{2IB}}$

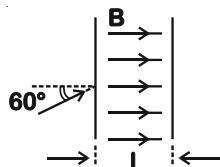
42. An electron gun is placed inside a long solenoid of radius R on its axis. The solenoid has n turns/length and carries a current I . The electron gun shoots an electron along the radius of the solenoid with speed v . If the electron does not hit the surface of the solenoid, maximum possible value of v is (all symbols have their standard meaning) [JEE (Main)-2020]



- (1) $\frac{2e\mu_0 nIR}{m}$ (2) $\frac{e\mu_0 nIR}{m}$
 (3) $\frac{e\mu_0 nIR}{2m}$ (4) $\frac{e\mu_0 nIR}{4m}$
43. A beam of protons with speed $4 \times 10^5 \text{ ms}^{-1}$ 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 = $1.67 \times 10^{-27} \text{ kg}$, charge of the proton = $1.69 \times 10^{-19} \text{ C}$) [JEE (Main)-2020]
- (1) 2 cm (2) 12 cm
 (3) 5 cm (4) 4 cm

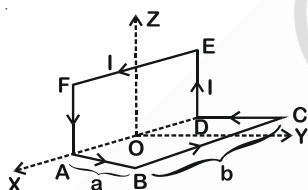
44. The figure shows a region of length ' l ' with a uniform magnetic field of 0.3 T in it and a proton entering the region with velocity $4 \times 10^5 \text{ ms}^{-1}$ making an angle 60° with the field. If the proton completes 10 revolution by the time it cross the region shown, ' l ' is close to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

[JEE (Main)-2020]



- (1) 0.22 m (2) 0.11 m
(3) 0.88 m (4) 0.44 m
45. 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]



- (1) abl , along $\left(\frac{\hat{j}}{\sqrt{5}} + \frac{2\hat{k}}{\sqrt{5}}\right)$
(2) $\sqrt{2} abl$, along $\left(\frac{\hat{j}}{\sqrt{2}} + \frac{\hat{k}}{\sqrt{2}}\right)$
(3) abl , along $\left(\frac{\hat{j}}{\sqrt{2}} + \frac{\hat{k}}{\sqrt{2}}\right)$
(4) $\sqrt{2} abl$, along $\left(\frac{\hat{j}}{\sqrt{5}} + \frac{2\hat{k}}{\sqrt{5}}\right)$
46. A charged particle carrying charge $1 \mu\text{C}$ is moving with velocity $(2\hat{i} + 3\hat{j} + 4\hat{k}) \text{ ms}^{-1}$. If an external magnetic field of $(5\hat{i} + 3\hat{j} - 6\hat{k}) \times 10^{-3} \text{ T}$ exists in the region where the particle is moving then the force on the particle is $\vec{F} \times 10^{-9} \text{ N}$. The vector $\vec{F}$ is

[JEE (Main)-2020]

- (1) $-3.0\hat{i} + 3.2\hat{j} - 0.9\hat{k}$
(2) $-300\hat{i} + 320\hat{j} - 90\hat{k}$
(3) $-0.30\hat{i} + 0.32\hat{j} - 0.09\hat{k}$
(4) $-30\hat{i} + 32\hat{j} - 9\hat{k}$

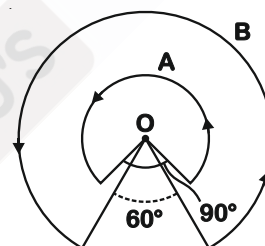
47. Magnitude of magnetic field (in SI units) at the centre of a hexagonal shape coil of side 10 cm, 50 turns and carrying current I (Ampere) in units of

$\frac{\mu_0 I}{\pi}$ is [JEE (Main)-2020]

- (1) $500\sqrt{3}$ (2) $250\sqrt{3}$
(3) $50\sqrt{3}$ (4) $5\sqrt{3}$

48. 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]



- (1) 2 : 5 (2) 6 : 5
(3) 4 : 6 (4) 6 : 4
49. 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

$$\vec{E} = 30\hat{j} \sin(1.5 \times 10^7 t - 5 \times 10^{-2} x) \text{ V/m}.$$

The maximum magnetic force experienced by the electron will be

(given $c = 3 \times 10^8 \text{ ms}^{-1}$ and electron charge = $1.6 \times 10^{-19} \text{ C}$) [JEE (Main)-2020]

- (1) $4.8 \times 10^{-19} \text{ N}$
(2) $2.4 \times 10^{-18} \text{ N}$
(3) $3.2 \times 10^{-18} \text{ N}$
(4) $1.6 \times 10^{-19} \text{ N}$

50. 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 $(0, b, 0)$, ($b \gg a$). The magnitude of the torque on the loop about z -axis is given by **[JEE (Main)-2020]**
- (1) $\frac{2\mu_0 I^2 a^2}{\pi b}$ (2) $\frac{\mu_0 I^2 a^2}{2\pi b}$
 (3) $\frac{\mu_0 I^2 a^3}{2\pi b^2}$ (4) $\frac{2\mu_0 I^2 a^3}{\pi b^2}$
51. A ring is hung on a nail. It can oscillate, without slipping or sliding (I) in its plane with a time period T_1 and, (ii) back and forth in a direction perpendicular to its plane, with a period T_2 . The ratio $\frac{T_1}{T_2}$ will be **[JEE (Main)-2020]**
- (1) $\frac{\sqrt{2}}{3}$ (2) $\frac{2}{\sqrt{3}}$
 (3) $\frac{2}{3}$ (4) $\frac{3}{\sqrt{2}}$
52. A particle of charge q and mass m is moving with a velocity $-v\hat{i}$ ($v \neq 0$) 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]**
- (1) $\frac{2qdB_0}{m}$ (2) $\frac{qdB_0}{3m}$
 (3) $\frac{qdB_0}{2m}$ (4) $\frac{qdB_0}{m}$
53. An electron is moving along $+x$ direction with a velocity of $6 \times 10^6 \text{ ms}^{-1}$. 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]**
- (1) $5 \times 10^{-3} \text{ T}$, along $+z$ direction
 (2) $5 \times 10^{-3} \text{ T}$, along $-z$ direction
 (3) $3 \times 10^{-4} \text{ T}$, along $+z$ direction
 (4) $3 \times 10^{-4} \text{ T}$, along $-z$ direction
54. 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 $(0, b, 0)$, ($b \gg a$). The magnitude of torque on the loop about z -axis will be **[JEE (Main)-2020]**
- (1) $\frac{\mu_0 I^2 a^2}{2\pi b}$ (2) $\frac{2\mu_0 I^2 a^2 b}{\pi(a^2 + b^2)}$
 (3) $\frac{\mu_0 I^2 a^2 b}{2\pi(a^2 + b^2)}$ (4) $\frac{2\mu_0 I^2 a^2}{\pi b}$
55. 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]**
- (1) $-\frac{mv^2\vec{B}}{2B^2}$
 (2) $\frac{mv^2\vec{B}}{2B^2}$
 (3) $-\frac{mv^2\vec{B}}{2\pi B^2}$
 (4) $-\frac{mv^2\vec{B}}{B^2}$
56. A loop $ABCDEF$ of straight edges has six corner points $A(0, 0, 0)$, $B(5, 0, 0)$, $C(5, 5, 0)$, $D(0, 5, 0)$, $E(0, 5, 5)$ and $F(0, 0, 5)$. The magnetic field in this region is $\vec{B} = (3\hat{i} + 4\hat{k}) \text{ T}$. The quantity of flux through the loop $ABCDEF$ (in Wb) is **[JEE (Main)-2020]**
57. A galvanometer coil has 500 turns and each turn has an average area of $3 \times 10^{-4} \text{ m}^2$. 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]**
58. Magnetic fields at two points on the axis of a circular coil at a distance of 0.05 m and 0.2 m from the centre are in the ratio $8 : 1$. The radius of coil is **[JEE (Main)-2021]**
- (1) 0.15 m
 (2) 0.1 m
 (3) 0.2 m
 (4) 1.0 m

59. A proton, a deuteron and an α particle are moving with same momentum in a uniform magnetic field. The ratio of magnetic forces acting on them is _____ and their speed is _____ in the ratio

[JEE (Main)-2021]

- (1) 1 : 2 : 4 and 1 : 1 : 2
 (2) 1 : 2 : 4 and 2 : 1 : 1
 (3) 4 : 2 : 1 and 2 : 1 : 1
 (4) 2 : 1 : 1 and 4 : 2 : 1

60. A charge Q is moving $d\vec{l}$ distance in the magnetic field $\vec{B}$. Find the value of work done by $\vec{B}$.

[JEE (Main)-2021]

- (1) -1 (2) Zero
 (3) 1 (4) Infinite

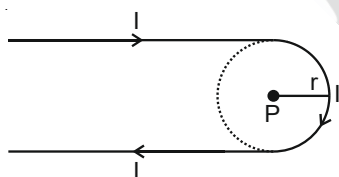
61. A solenoid of 1000 turns per metre has a core with relative permeability 500. Insulated windings of the solenoid carry an electric current of 5 A. The magnetic flux density produced by the solenoid is: (permeability of free space = $4\pi \times 10^{-7}$ H/m)

[JEE (Main)-2021]

- (1) $2 \times 10^{-3}\pi$ T (2) $10^{-4}\pi$ T
 (3) π T (4) $\frac{\pi}{5}$ T

62. A hairpin-like shape as shown in figure is made by bending a long current carrying wire. What is the magnitude of a magnetic field at point P which lies on the centre of the semicircle?

[JEE (Main)-2021]



- (1) $\frac{\mu_0 I}{4\pi r}(2 + \pi)$
 (2) $\frac{\mu_0 I}{4\pi r}(2 - \pi)$
 (3) $\frac{\mu_0 I}{2\pi r}(2 - \pi)$
 (4) $\frac{\mu_0 I}{2\pi r}(2 + \pi)$

63. 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]

- (1) Wire gets stretched to become straight
 (2) Loop assumes circular shape with its plane normal to the field
 (3) Loop assumes circular shape with its plane parallel to the field
 (4) Shape of the loop remains unchanged

64. A proton and an α -particle, having kinetic energies K_p and K_α respectively, enter into a magnetic field at right angles.

The ratio of the radii of trajectory of proton to that of α -particle is 2 : 1. The ratio of $K_p : K_\alpha$ is :

[JEE (Main)-2021]

- (1) 1 : 8
 (2) 8 : 1
 (3) 1 : 4
 (4) 4 : 1

65. Which of the following statements are correct?

[JEE (Main)-2021]

- (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) $x = -1$ is the condition for a perfect diamagnetic material, where x is its magnetic susceptibility.

Choose the correct answer from the options given below:

- (1) (C) and (E) only
 (2) (B) and (C) only
 (3) (B) and (D) only
 (4) (A) and (B) only

66. A deuteron and an alpha particle having equal kinetic energy enter perpendicularly into a magnetic field. Let r_d and r_α be their respective radii

of circular path. The value of $\frac{r_d}{r_\alpha}$ is

[JEE (Main)-2021]

- (1) $\frac{1}{\sqrt{2}}$ (2) 1
(3) 2 (4) $\sqrt{2}$

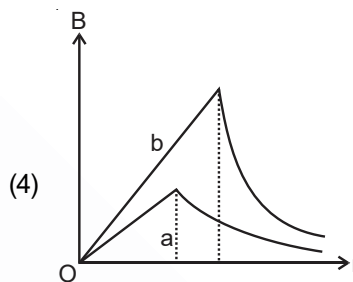
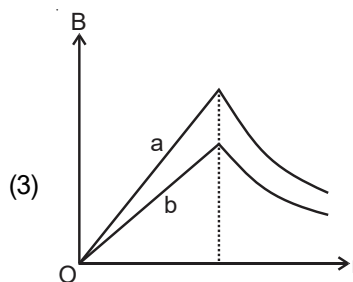
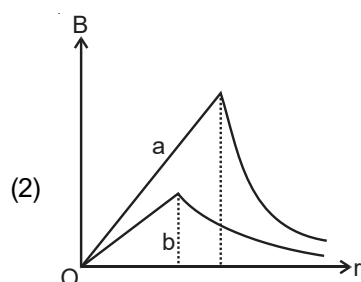
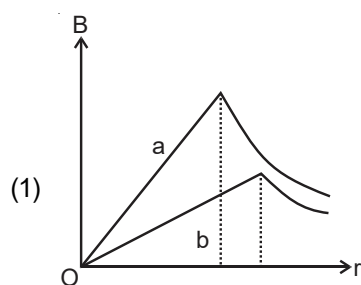
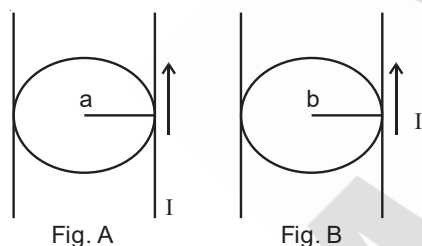
67. Two ions having same mass have charges in the ratio 1 : 2. They are projected normally in a uniform magnetic field with their speeds in the ratio 2 : 3. The ratio of the radii of their circular trajectories is

[JEE (Main)-2021]

- (1) 2 : 3 (2) 3 : 1
(3) 1 : 4 (4) 4 : 3

68. Figure A and B show two long straight wires of circular cross-section (a and b with $a < b$), carrying current I which is uniformly distributed across the cross-section. The magnitude of magnetic field B varies with radius r and can be represented as:

[JEE (Main)-2021]



69. The fractional change in the magnetic field intensity at a distance ' r ' from centre on the axis of current carrying coil of radius ' a ' to the magnetic field intensity at the centre of the same coil is:

(Take $r \ll a$).

[JEE (Main)-2021]

- (1) $\frac{3r^2}{2a^2}$ (2) $\frac{2a^2}{3r^2}$
(3) $\frac{2r^2}{3a^2}$ (4) $\frac{3a^2}{2r^2}$

70. If the maximum value of accelerating potential provided by a radio frequency oscillator is 12 kV. The number of revolution made by a proton in a cyclotron to achieve one sixth of the speed of light is _____.

[$m_p = 1.67 \times 10^{-27}$ kg, $e = 1.6 \times 10^{-19}$ C, Speed of light = 3×10^8 m/s]

[JEE (Main)-2021]

71. A coil in the shape of an equilateral triangle of side 10 cm lies in a vertical plane between the pole pieces of permanent magnet producing a horizontal magnetic field 20 mT. The torque acting on the coil when a current of 0.2 A is passed through it and its plane becomes parallel to the magnetic field will be $\sqrt{x} \times 10^{-5}$ Nm. The value of x is _____.

[JEE (Main)-2021]

72. Two ions of masses 4 amu and 16 amu have charges $+2e$ and $+3e$ respectively. These ions pass through the region of constant perpendicular magnetic field. The kinetic energy of both ions is same. Then: **[JEE (Main)-2021]**

- (1) No ion will be deflected
- (2) Both ions will be deflected equally
- (3) Lighter ion will be deflected more than heavier ion
- (4) Lighter ion will be deflected less than heavier ion

73. A uniform conducting wire of length is $24a$, and resistance R is wound up as a current carrying coil in the shape of an equilateral triangle of side 'a' and then in the form of a square of side 'a'. The coil is connected to a voltage source V_0 . The ratio of magnetic moment of the coils in case of equilateral triangle to that for square is $1:\sqrt{y}$, where y is _____. **[JEE (Main)-2021]**

74. A coil having N turns is wound tightly in the form of a spiral with inner and outer radii 'a' and 'b' respectively. Find the magnetic field at centre, when a current I passes through coil:

[JEE (Main)-2021]

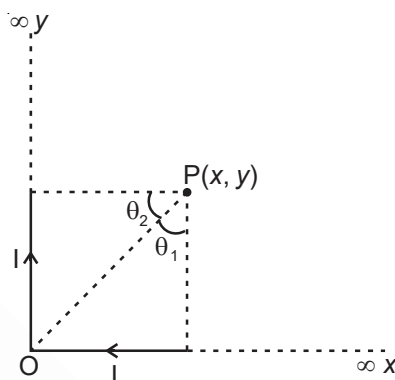
- (1) $\frac{\mu_0 I}{8} \left[\frac{a+b}{a-b} \right]$
- (2) $\frac{\mu_0 I}{4(a-b)} \left[\frac{1}{a} - \frac{1}{b} \right]$
- (3) $\frac{\mu_0 I}{8} \left(\frac{a-b}{a+b} \right)$
- (4) $\frac{\mu_0 I N}{2(b-a)} \log_e \left(\frac{b}{a} \right)$

75. A current of 1.5 A is flowing through a triangle, of side 9 cm each. The magnetic field at the centroid of the triangle is :

(Assume that the current is flowing in the clockwise direction.) **[JEE (Main)-2021]**

- (1) $2\sqrt{3} \times 10^{-7}$ T, outside the plane of triangle
- (2) 3×10^{-7} T, outside the plane of triangle
- (3) $2\sqrt{3} \times 10^{-5}$ T, inside the plane of triangle
- (4) 3×10^{-5} T, inside the plane of triangle

76. There are two infinitely long straight current carrying conductors and they are held at right angles to each other so that their common ends meet at the origin as shown in the figure given below. The ratio of current in both conductors is 1 : 1. The magnetic field at point P is _____. **[JEE (Main)-2021]**



- (1) $\frac{\mu_0 I x y}{4\pi} \left[\sqrt{x^2 + y^2} + (x + y) \right]$
- (2) $\frac{\mu_0 I}{4\pi x y} \left[\sqrt{x^2 + y^2} + (x + y) \right]$
- (3) $\frac{\mu_0 I x y}{4\pi} \left[\sqrt{x^2 + y^2} - (x + y) \right]$
- (4) $\frac{\mu_0 I}{4\pi x y} \left[\sqrt{x^2 + y^2} - (x + y) \right]$

77. Given below are two statements: One is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

Assertion (A): In a uniform magnetic field, speed and energy remains the same for a moving charged particle.

Reason (R): Moving charged particle experiences magnetic force perpendicular to its direction of motion.

[JEE (Main)-2022]

- (1) Both **(A)** and **(R)** true and **(R)** is the correct explanation of **(A)**.
- (2) Both **(A)** and **(R)** are true but **(R)** is NOT the correct explanation of **(A)**.
- (3) **(A)** is true but **(R)** is false.
- (4) **(A)** is false but **(R)** is true.

78. The magnetic field at the centre of a circular coil of radius r , due to current I flowing through it, is B . The magnetic field at a point along the axis at a distance

$\frac{r}{2}$ from the centre is : [JEE (Main)-2022]

- (1) $\frac{B}{2}$ (2) $2B$
 (3) $\left(\frac{2}{\sqrt{5}}\right)^3 B$ (4) $\left(\frac{2}{\sqrt{3}}\right)^3 B$

79. A proton, a deuteron and an α -particle with same kinetic energy enter into a uniform magnetic field at right angle to magnetic field. The ratio of the radii of their respective circular paths is :

[JEE (Main)-2022]

(1) $1 : \sqrt{2} : \sqrt{2}$

(2) $1 : 1 : \sqrt{2}$

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

(4) $1 : \sqrt{2} : 1$

$R = \sqrt{\frac{2m(kE)}{qB}}$
 $R_p : R_d : R_\alpha :: \frac{\sqrt{m}}{e} : \frac{\sqrt{2m}}{e} : \frac{\sqrt{4m}}{2e}$
 $= 1 : \sqrt{2} : 1$

80. A long straight wire with a circular cross-section having radius R , is carrying a steady current I . The current I is uniformly distributed across this cross-section. Then the variation of magnetic field due to current I with distance r ($r < R$) from its centre will be [JEE (Main)-2022]

(1) $B \propto r^2$

(2) $B \propto r$

(3) $B \propto \frac{1}{r^2}$

(4) $B \propto \frac{1}{r}$

81. Along solenoid carrying a current produces a magnetic field B along its axis. If the current is doubled and the number of turns per cm is halved, the new value of magnetic field will be equal to [JEE (Main)-2022]

(1) B (2) $2B$

(3) $4B$ (4) $\frac{B}{2}$

82. A proton and an alpha particle of the same velocity enter in a uniform magnetic field which is acting perpendicular to their direction of motion. The ratio of the radii of the circular paths described by the alpha particle and proton is : [JEE (Main)-2022]

(1) 1:4 (2) 4:1

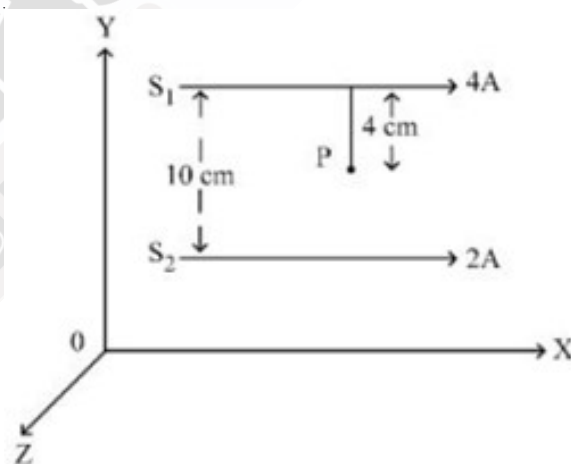
(3) 2:1 (4) 1:2

83. Two long parallel conductors S_1 and S_2 are separated by a distance 10 cm and carrying currents of 4 A and 2 A respectively. The conductors are placed along x-axis in X-Y plane. There is a point P located between the conductors (as shown in figure).

A charge particle of 3π coulomb is passing through the point P with velocity $\vec{v} = (2\hat{i} + 3\hat{j})$ m/s; where $\hat{i}$ and $\hat{j}$ represents unit vector along x & y axis respectively. The force acting on the charge particle

is $4\pi \times 10^{-5} (-x\hat{i} + 2\hat{j})$ N. The value of x is:

[JEE (Main)-2022]



(1) 2 (2) 1

(3) 3 (4) -3

84. A deuteron and a proton moving with equal kinetic energy enter into a uniform magnetic field at right angle to the field. If r_d and r_p are the radii of their

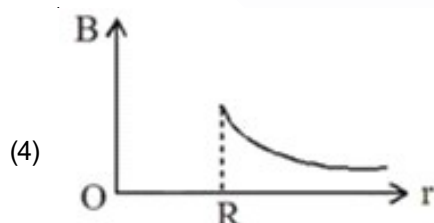
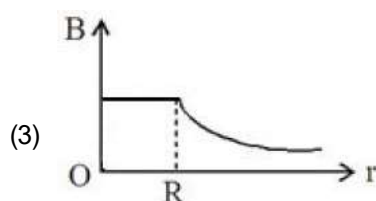
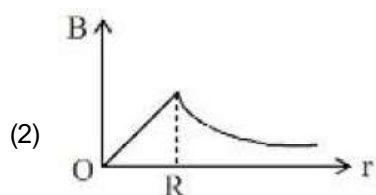
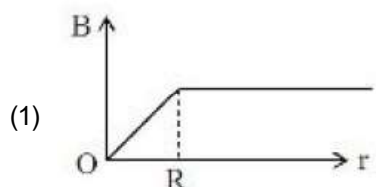
circular paths respectively, then the ratio $\frac{r_d}{r_p}$ will be

$\sqrt{x} : 1$ where x is _____. [JEE (Main)-2022]

85. An infinitely long hollow conducting cylinder with radius R carries a uniform current along its surface.

Choose the correct representation of magnetic field (B) as a function of radial distance (r) from the axis of cylinder.

[JEE (Main)-2022]



86. A singly ionized magnesium atom ($A = 24$) ion is accelerated to kinetic energy 5 keV , and is projected perpendicularly into a magnetic field B of the magnitude 0.5 T . The radius of path formed will be _____ cm.

[JEE (Main)-2022]

87. Two parallel, long wires are kept 0.20 m apart in vacuum, each carrying current of $x \text{ A}$ in the same direction. If the force of attraction per meter of each wire is $2 \times 10^{-6} \text{ N}$, then the value of x is approximately:

[JEE (Main)-2022]

- (1) 1 (2) 2.4
(3) 1.4 (4) 2

88. A charge particle moves along circular path in a uniform magnetic field in a cyclotron. The kinetic energy of the charge particle increases to 4 times its initial value. What will be the ratio of new radius to the original radius of circular path of the charge particle

[JEE (Main)-2022]

- (1) 1 : 1
(2) 1 : 2
(3) 2 : 1
(4) 1 : 4

89. Two long current carrying conductors are placed parallel to each other at a distance of 8 cm between them. The magnitude of magnetic field produced at mid-point between the two conductors due to current flowing in them is 30 mT . The equal current flowing in the two conductors is:

[JEE (Main)-2022]

- (1) 30 A in the same direction
(2) 30 A in the opposite direction
(3) 60 A in the opposite direction
(4) 300 A in the opposite direction

90. Given below are two statements:

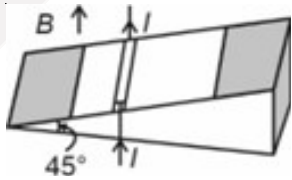
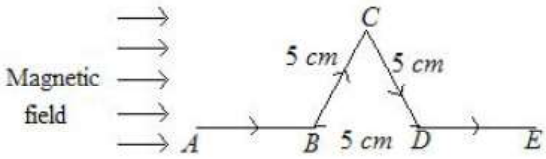
Statement I: The electric force changes the speed of the charged particle and hence changes its kinetic energy; whereas the magnetic force does not change the kinetic energy of the charged particle.

Statement II: The electric force accelerates the positively charged particle perpendicular to the direction of electric field. The magnetic force accelerates the moving charged particle along the direction of magnetic field.

In the light of the above statements, choose the most appropriate answer from the options given below:

[JEE (Main)-2022]

- (1) Both statement I and statement II are correct
(2) Both statement I and statement II are incorrect
(3) Statement I is correct but statement II is incorrect
(4) Statement I is incorrect but statement II is correct

91. Two charged particles, having same kinetic energy, are allowed to pass through a uniform magnetic field perpendicular to the direction of motion. If the ratio of radii of their circular path is 6 : 5 and their respective masses ratio is 9 : 4. Then, the ratio of their charges will be : **[JEE (Main)-2022]**
- (1) 8 : 5 (2) 5 : 4
(3) 5 : 3 (4) 8 : 7
92. The electric current in a circular coil of 2 turns produces a magnetic induction B_1 at its centre. The coil is unwound and is rewound into a circular coil of 5 turns and the same current produces a magnetic induction B_2 at its centre. The ratio of $\frac{B_2}{B_1}$ is **[JEE (Main)-2022]**
- (1) $\frac{5}{2}$ (2) $\frac{25}{4}$
(3) $\frac{5}{4}$ (4) $\frac{25}{2}$
93. An electron with energy 0.1 keV moves at right angle to the earth's magnetic field of $1 \times 10^{-4} \text{ Wbm}^{-2}$. The frequency of revolution of the electron will be (Take mass of electron = $9.0 \times 10^{-31} \text{ kg}$) **[JEE (Main)-2022]**
- (1) $1.6 \times 10^5 \text{ Hz}$ (2) $5.6 \times 10^5 \text{ Hz}$
(3) $2.8 \times 10^6 \text{ Hz}$ (4) $1.8 \times 10^6 \text{ Hz}$
94. A charge particle is moving in a uniform field $(2\hat{i} + 3\hat{j}) \text{ T}$. If it has an acceleration of $(\alpha\hat{i} - 4\hat{j}) \text{ m/s}^2$, then the value of α will be **[JEE (Main)-2022]**
- (1) 3
(2) 6
(3) 12
(4) 2
95. B_x and B_y are the magnetic field at the centre of two coils X and Y respectively each carrying equal current. If coil X has 200 turns and 20 cm radius and coil Y has 400 turns and 20 cm radius, the ratio of B_x and B_y is **[JEE (Main)-2022]**
- (1) 1 : 1 (2) 1 : 2
(3) 2 : 1 (4) 4 : 1
96. A cyclotron is used to accelerate protons. If the operating magnetic field is 1.0 T and the radius of the cyclotron 'dees' is 60 cm, the kinetic energy of the accelerated protons in MeV will be **[JEE (Main)-2022]**
- [Use $m_p = 1.6 \times 10^{-27} \text{ kg}$, $e = 1.6 \times 10^{-19} \text{ C}$]
- (1) 12 (2) 18
(3) 16 (4) 32
97. As shown in the figure, a metallic rod of linear density 0.45 kg m^{-1} is lying horizontally on a smooth inclined plane which makes an angle of 45° with the horizontal. The minimum current flowing in the rod required to keep it stationary, when 0.15 T magnetic field is acting on it in the vertical upward direction, will be : **[JEE (Main)-2022]**
- 
- (1) 30 A (2) 15 A
(3) 10 A (4) 3 A
98. A triangular shaped wire carrying 10 A current is placed in a uniform magnetic field of 0.5 T, as shown in figure. The magnetic force on segment CD is (Given $BC = CD = BD = 5 \text{ cm}$). **[JEE (Main)-2022]**
- 
- (1) 0.126 N (2) 0.312 N
(3) 0.216 N (4) 0.245 N

99. The magnetic field at the center of current carrying circular loop is B_1 . The magnetic field at a distance of $\sqrt{3}$ times radius of the given circular loop from the center on its axis is B_2 . The value of B_1/B_2 will be [JEE (Main)-2022]

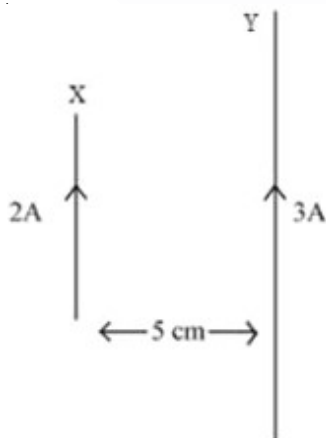
- (1) 9 : 4 (2) 12 : $\sqrt{5}$
(3) 8 : 1 (4) 5 : $\sqrt{3}$

100. A closely wound circular coil of radius 5 cm produces a magnetic field of 37.68×10^{-4} T at its center. The current through the coil is _____ A.

[Given, number of turns in the coil is 100 and $\pi = 3.14$] [JEE (Main)-2022]

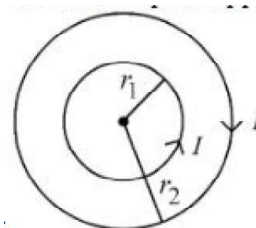
101. A wire of length 314 cm carrying current of 14 A is bent to form a circle. The magnetic moment of the coil is _____ A-m². [Given $\pi = 3.14$] [JEE (Main)-2022]

102. A wire X of length 50 cm carrying a current of 2 A is placed parallel to a long wire Y of length 5 m. The wire Y carries a current of 3 A. The distance between two wires is 5 cm and currents flow in the same direction. The force acting on the wire Y is



- (1) 1.2×10^{-5} N directed towards wire X
(2) 1.2×10^{-4} N directed away from wire X
(3) 1.2×10^{-4} N directed towards wire X
(4) 2.4×10^{-5} N directed towards wire X

103. Two concentric circular loops of radii $r_1 = 30$ cm and $r_2 = 50$ cm are placed in X-Y plane as shown in the figure. A current $I = 7$ A is flowing through them in the direction as shown in figure. The net magnetic moment of this system of two circular loops is approximately [JEE (Main)-2022]



- (1) $\frac{7}{2} \hat{k}$ Am²
(2) $-\frac{7}{2} \hat{k}$ Am²
(3) $7 \hat{k}$ Am²
(4) $-7 \hat{k}$ Am²

104. A velocity selector consists of electric field $\vec{E} = E\hat{k}$ and magnetic field $\vec{B} = B\hat{j}$ with $B = 12$ mT. The value of E required for an electron of energy 728 eV moving along the positive x-axis to pass undeflected is

(Given, mass of electron = 9.1×10^{-31} kg)

[JEE (Main)-2022]

- (1) 192 kVm⁻¹
(2) 192 mVm⁻¹
(3) 9600 kVm⁻¹
(4) 16 kVm⁻¹

105. Two 10 cm long, straight wires, each carrying a current of 5 A are kept parallel to each other. If each wire experienced a force of 10^{-5} N, then separation between the wires is _____ cm.

[JEE (Main)-2022]



Chapter 17

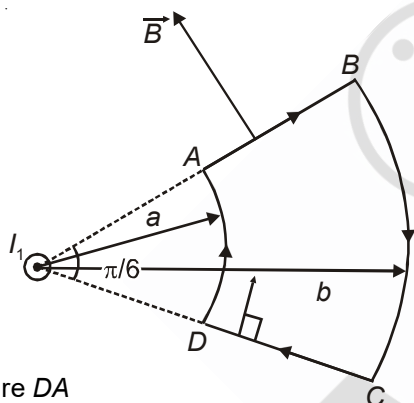
Moving Charges and Magnetism

1. Answer (1)

Magnetic field due to AB and CD is zero

$$\begin{aligned}\therefore \vec{B}_{\text{net}} &= \frac{\mu_0}{4\pi} \times \frac{I}{a} \times \frac{\pi}{6} \hat{k} + \frac{\mu_0}{4\pi} \times \frac{I}{b} \times \frac{\pi}{6} (-\hat{k}) \\ &= \frac{\mu_0}{24} \times I \left\{ \frac{1}{a} - \frac{1}{b} \right\} \hat{k} \\ &= \frac{\mu_0 I (b-a)}{24ab} \hat{k}\end{aligned}$$

2. Answer (1)



In wire DA

$$\vec{B} \uparrow \uparrow d\vec{\ell}$$

$$\therefore F_{DA} = 0$$

In wire AB, $d\vec{\ell} \times \vec{B}$ is upwards

In wire BC, $\vec{B} \uparrow \downarrow d\vec{\ell} \therefore F_{BC} = 0$

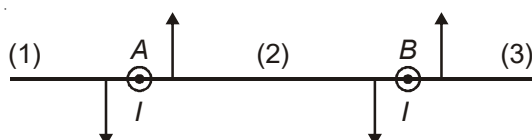
In wire CD, $d\vec{\ell} \times \vec{B}$ is downwards.

Since, AB and CD are symmetrical to I_1

So, $\vec{F}_{AB} + \vec{F}_{CD} = 0$.

3. Answer (2)

Taking up as positive, in region 1, field will remain negative, and as one moves from $-\infty$ to A, field increases in magnitude from zero to large value.



As one moves from A to B, field changes sign from positive to negative, becoming zero at mid point. As one moves in region 3, from B to $+\infty$, field decreases from a large value to zero.

4. Answer (1)

$$M = \frac{\sigma \pi R^2}{2m} \times \frac{m R^2}{2} \omega = \frac{\sigma \pi R^4 \omega}{4}$$

5. Answer (3)

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

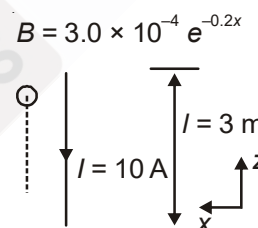
$$\vec{F} = q[(3\hat{i} + \hat{j} + 2\hat{k}) + \vec{v} \times \vec{B}]$$

y-component = $11q$

6. Answer (1)

7. Answer (2)

8. Answer (2)



$$\text{Average Power} = \frac{\text{work}}{\text{time}}$$

$$W = \int_0^2 F dx$$

$$= \int_0^2 3.0 \times 10^{-4} e^{-0.2x} \times 10 \times 3 dx$$

$$= 9 \times 10^{-3} \int_0^2 e^{-0.2x} dx$$

$$= \frac{9 \times 10^{-3}}{0.2} [-e^{-0.2 \times 2} + 1]$$

$$= \frac{9 \times 10^{-3}}{0.2} \times [1 - e^{-0.4}]$$

$$= 9 \times 10^{-3} \times (0.33)$$

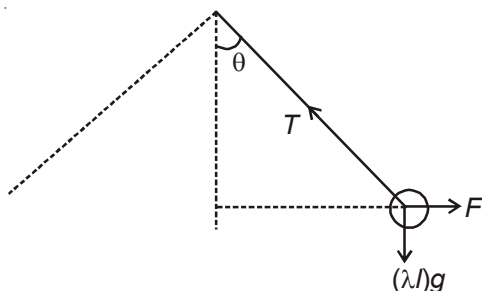
$$= 2.97 \times 10^{-3} \text{ J}$$

$$P = \frac{2.97 \times 10^{-3}}{(0.2) \times 5 \times 10^{-3}} = 2.97 \text{ W}$$

9. Answer (1)

Net force on each of them would be zero.

10. Answer (2)

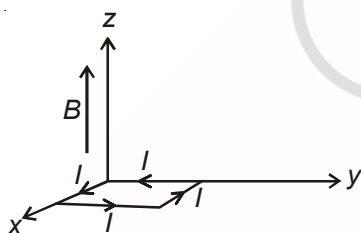
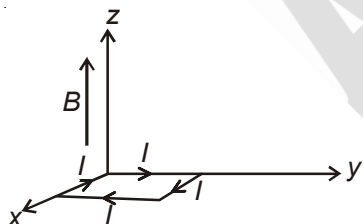


$$T \cos \theta = \lambda g l \quad \dots(i)$$

$$T \sin \theta = \frac{\mu_0}{2\pi} \cdot \frac{I \times I}{(2L \sin \theta)} \quad \dots(ii)$$

$$\Rightarrow I = 2 \sin \theta \sqrt{\frac{\pi \lambda g L}{\mu_0 \cos \theta}}$$

11. Answer (3)

 Stable equilibrium $\vec{M} \parallel \vec{B}$

 Unstable equilibrium $\vec{M} \parallel (-\vec{B})$


12. Answer (3)

For A

$$2\pi R = L$$

$$\Rightarrow R = \frac{L}{2\pi}$$

For B

$$4a = L$$

$$\Rightarrow a = \frac{L}{4}$$

$$B_A = \frac{\mu_0 I}{2R} \quad B_B = 4 \left[\frac{\mu_0 I}{4\pi a/2} \left(\sin \frac{\pi}{4} + \sin \frac{\pi}{4} \right) \right]$$

$$\text{Now } \frac{B_A}{B_B} = \frac{\pi^2}{8\sqrt{2}}$$

13. Answer (2)

$$r = \frac{\sqrt{2mk}}{qB}$$

$$\frac{r_\alpha}{r_p} = \frac{\sqrt{2m_\alpha}}{q_\alpha} \times \frac{q_p}{\sqrt{2m_p}} \quad \left[\begin{matrix} m_\alpha = 4m_p \\ q_\alpha = 2q_p \end{matrix} \right]$$

$$= 1$$

 Mass of electron is least and charge $q_e = e$

$$\text{So, } r_e < r_p = r_\alpha$$

14. Answer (3)

$$m = I(\pi R^2), \quad m' = 2m = I \times (\pi \sqrt{2} R)^2$$

$$\therefore R' = \sqrt{2} R$$

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

$$B_2 = \frac{\mu_0 I}{2 \times (\sqrt{2} R)}$$

$$\therefore \frac{B_1}{B_2} = \sqrt{2}$$

15. Answer (2)

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

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

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

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

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

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

16. Answer (4)

$$B = \frac{\mu_0 I}{2R} \left(\frac{\theta}{360^\circ} \right)$$

So,

$$B_{\text{eff}} = B_{\odot\odot} - B_{\otimes\otimes} = \frac{\mu_0 I}{2 \times 3 \times 10^{-2}} \times \frac{45}{360} - \frac{\mu_0 I}{2 \times 5 \times 10^{-2}} \times \frac{45}{360}$$

$$B = \frac{\mu_0 I}{120} = 1.047 \times 10^{-5} \approx 1.0 \times 10^{-5} \text{ T}$$

17. Answer (4)

$$r_1 = \frac{L}{2\pi}$$

$$B_L = \frac{\mu_0 I}{2r_1}$$

$$r_2 = \frac{L}{2N\pi}$$

$$B_C = \frac{N\mu_0 I}{2r_2}$$

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

18. Answer (4)

$$eE = eVB$$

$$R = \frac{mV}{eB} \Rightarrow V = \frac{ReB}{m}$$

$$\Rightarrow E = \frac{ReB}{m} \cdot B \Rightarrow m = \frac{eB^2 R}{E}$$

$$m = \frac{1.6 \times 10^{-19} \times (0.5)^2 \times 0.5 \times 10^{-2}}{100}$$

$$= 2.0 \times 10^{-24} \text{ kg}$$

19. Answer (3)

$$dm = \rho dx n \pi x^2$$

$$\int dm = \int_0^{\ell} \frac{\rho_0 n \pi x^3 dx}{\ell}$$

$$m = \frac{\pi \rho_0 n}{\ell} \cdot \frac{\ell^4}{4} = \frac{\pi \rho_0 n \ell^3}{4}$$

20. Answer (4)

$$r = \frac{mv}{Bq} = \frac{\sqrt{2mqV}}{Bq}$$

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

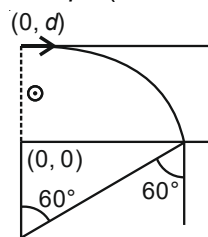
$$= \frac{1}{100 \times 10^{-3}} \frac{\sqrt{2 \times 9.1 \times 500 \times 10^{-12}}}{1.6}$$

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

21. Answer (2)

Assuming particle enters from $(0, d)$

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



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

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

22. Answer (2)

The straight path from origin to $P(x = 1, y = 1)$ is $y = x$

Work is done by electric force only

$$W = q \int \vec{E} \cdot d\vec{r} = q \int_0^1 2dx + q3 \int_0^1 dy$$

$$= 2q + 3q = 5q$$

23. Answer (4)

$$r = \frac{mv}{qB} = \frac{\sqrt{2m \times (qV)}}{qB}$$

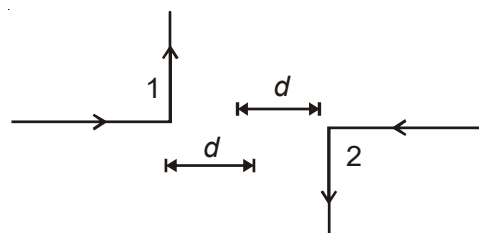
$$\Rightarrow r \propto \sqrt{\frac{m}{q}}$$

$$\therefore \frac{r_p}{r_\alpha} = \sqrt{\frac{m_p}{m_\alpha} \times \frac{q_\alpha}{q_p}}$$

$$\Rightarrow \frac{r_p}{r_\alpha} = \sqrt{\frac{1}{4} \times \frac{2}{1}} = \frac{1}{\sqrt{2}}$$

24. Answer (2)

$$\vec{B} = \vec{B}_1 + \vec{B}_2$$



$$\vec{B}_1 = \vec{B}_2 = \frac{\mu_0 i}{4\pi d}$$

$$B = \frac{\mu_0 i}{2\pi d} = 10^{-4}$$

$$\Rightarrow \frac{2 \times 10^{-7} \times i}{4 \times 10^{-2}} = 10^{-4}$$

$$\Rightarrow i = \frac{2}{10^{-1}} = 20 \text{ A}$$

25. Answer (3)

$$|\vec{\tau}| = |\vec{\mu} \times \vec{B}|$$

$$= NIA \times B \quad [A = \pi r^2]$$

$$\Rightarrow \tau = N\pi r^2 B$$

26. Answer (1)

$$\vec{B} = \vec{B}_1 + \vec{B}_2 = \frac{\mu_0 I}{2\pi d} [\hat{k} - \hat{k}] = 0$$

27. Answer (2)

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

$$\tau = 100 \times 3 \times 5 \times 2.5 \times 10^{-4} \times 1 \times \frac{1}{\sqrt{2}} = 0.27 \text{ Nm}$$

28. Answer (1)

$$F = I_2 a (B_1 - B_2)$$

$$B_1 = \frac{\mu_0 I_1}{2\pi a}$$

$$B_2 = \frac{\mu_0 I_1}{4\pi a}$$

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

29. Answer (4)

$$NIAB = KQ$$

$$175 \times 1 \times 10^{-3} \times 1 \times 10^{-4} \times B = \frac{10^{-6} \times \pi}{180}$$

$$\Rightarrow B = \frac{\pi}{180} \times \frac{10}{175} \approx 9.97 \times 10^{-4} \text{ T}$$

$$\Rightarrow B = 10^{-3} \text{ T}$$

30. Answer (1)

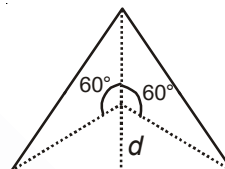
$$\Sigma \vec{F} = 0$$

$$\frac{\mu_0 I_1}{2\pi x} = \frac{\mu_0 I_2}{2\pi(x-d)} \quad \text{since } (x > d)$$

$$I_1 x - I_1 d = I_2 x$$

$$x = \frac{I_1 d}{I_1 - I_2}$$

31. Answer (1)



$$d = \left(\frac{1}{3}\right)(a \sin 60)$$

$$d = \frac{a}{3} \times \frac{\sqrt{3}}{2} = \left(\frac{a}{2\sqrt{3}}\right)$$

$$B_0 = 3 \left[\frac{\mu_0 I}{4\pi d} (\sin 60 + \sin 60) \right]$$

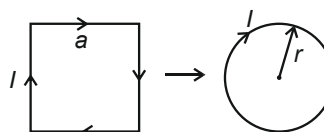
$$= \frac{3\mu_0 I}{4\pi \left(\frac{a}{2\sqrt{3}}\right)} = (2) \left(\frac{\sqrt{3}}{2}\right)$$

$$= \frac{9 \left(\frac{\mu_0 I}{\pi a}\right)}{1}$$

$$= \frac{9 \times 2 \times 10^{-7} \times 10}{1}$$

$$= 18 \mu\text{T}$$

32. Answer (2)



$$2\pi r = 4a \Rightarrow r = \left(\frac{2a}{\pi}\right)$$

$$m = (I) a^2$$

$$m_1 = (I) \pi r^2$$

$$m_1 = (I)(\pi) \left(\frac{4a^2}{\pi^2}\right)$$

$$m_1 = \frac{4Ia^2}{\pi}$$

$$m_1 = \frac{4m}{\pi}$$

33. Answer (2)

$$B = \frac{\mu_0 i}{2a} \text{ and } \frac{\omega q}{2\pi} = i$$

$$\therefore B = \frac{\mu_0}{2a} \cdot \frac{\omega q}{2\pi}$$

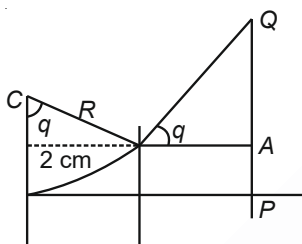
$$B = \frac{10^{-7} \times 40}{0.1} \times q \times \pi \Rightarrow q = 3 \times 10^{-5} \text{ C}$$

34. Answer (2)

$$\text{Radius of path, } R = \frac{mv}{eB} = \frac{\sqrt{2m KE}}{eB}$$

$$= \frac{\sqrt{2 \times 9.1 \times 10^{-31} \times 100e}}{e \times 1.5 \times 10^{-3}}$$

$$= \frac{\sqrt{2 \times 9.1 \times 10^{-29}}}{\sqrt{1.6 \times 10^{-19} \times 1.5 \times 10^{-3}}} \text{ m}$$



$$= \frac{3.37 \times 10^{-5}}{1.5 \times 10^{-3}} \times 100 \text{ cm} = 2.25 \text{ cm}$$

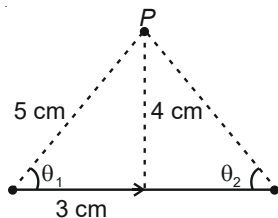
$$\sin \theta = \frac{2}{2.25} = \frac{8}{9}$$

$$PQ = PA + AQ$$

$$= 2.25 [1 - \cos \theta] + 11.64$$

$$= 1.22 + 11.64 = 12.86 \text{ cm}$$

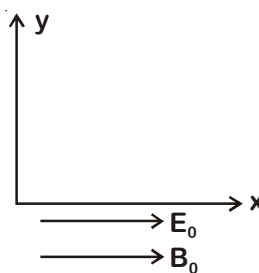
35. Answer (2)



$$B_P = \frac{\mu_0 I}{4\pi d} (\cos \theta_1 + \cos \theta_2)$$

$$= \frac{10^{-7} \times 5}{0.04} \times \left(2 \times \frac{3}{5}\right) = 1.5 \times 10^{-5} \text{ T}$$

36. Answer (2)



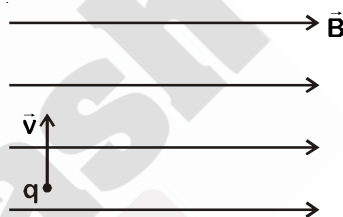
$$a_x = \frac{E_0 q}{m}$$

$$V_0^2 + V_x^2 = (2V_0)^2$$

$$\Rightarrow V_x = \sqrt{3} V_0 = a_x t$$

$$\Rightarrow t = \frac{\sqrt{3} V_0 m}{E_0 q}$$

37. Answer (2)



$$\text{Magnetic Force } F = qvB$$

$$\therefore \vec{a} = \left(\frac{qvB}{m} \right) \text{ perpendicular to velocity.}$$

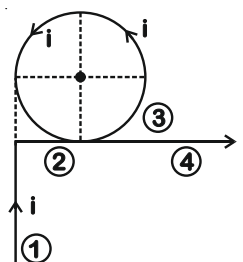
$$\therefore \text{Also } v = \sqrt{\frac{2K}{m}} = \sqrt{\frac{2 \times e \times 10^6}{m}}$$

$$\therefore a = \frac{qvB}{m} = \frac{eB}{m} \sqrt{\frac{2 \times e \times 10^6}{m}}$$

$$\therefore 10^{12} = \left(\frac{1.6 \times 10^{-19}}{1.67 \times 10^{-27}} \right)^{\frac{3}{2}} \cdot \sqrt{2} \times 10^3 B$$

$$\therefore B = \frac{1}{\sqrt{2}} \times 10^{-3} \text{ T} = 0.71 \text{ mT (approx)}$$

38. Answer (3)



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

$$= -\frac{\mu_0 I}{4\pi R} \left(1 - \frac{1}{\sqrt{2}}\right) + \frac{\mu_0 I}{2R} + \frac{\mu_0 I}{4\pi R} \left(1 + \frac{1}{\sqrt{2}}\right)$$

$$\vec{B}_0^{\odot} = \frac{\mu_0 I}{2\pi R} \left(\pi + \frac{1}{\sqrt{2}}\right)^{\odot}$$

39. Answer (1)

$$W_T = \Delta KE$$

$$W_m + W_E = \frac{1}{2} m (2v)^2 - \frac{1}{2} mv^2$$

$$0 + qE(2a) = \frac{3}{2} mv^2$$

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

$$\vec{L}_i^{\odot} = mva(-\hat{k})$$

$$\vec{L}_f^{\odot} = 4mva(-\hat{k})$$

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

40. Answer (4)

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

$$B_1 \left(\text{at } \frac{a}{3} \right) = \frac{\mu_0 J a}{6}$$

$$B_2 \left(\text{at } 2a \right) = \frac{(\mu_0) (J) \pi a^2}{2\pi (2a)} = \frac{\mu_0 J a}{4}$$

$$\Rightarrow \frac{B_1}{B_2} = \frac{2}{3}$$

41. Answer (1)

$$\tau = MB \sin \theta = I \alpha$$

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

$$\omega = \sqrt{\frac{2\pi I B}{m}}$$

$$T = \sqrt{\frac{2\pi m}{I B}}$$

42. Answer (3)

$$B = \mu_0 n i$$

$$\frac{m V_{\max}}{qB} = \frac{R}{2}$$

$$V_{\max} = \frac{qBR}{2m}$$

$$= \frac{qR\mu_0 n i}{2m}$$

43. Answer (4)

$$\text{Pitch} = v \cos \theta \times \frac{2\pi m}{qB}$$

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

$$= 4 \text{ cm}$$

44. Answer (4)

$$(v_0 \cos \theta) \times \Delta T = l$$

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

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

$$\Rightarrow l = 0.44 \text{ m}$$

45. Answer (2)

$$\vec{M} = \vec{M}_1 + \vec{M}_2$$

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

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

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

46. Answer (4)

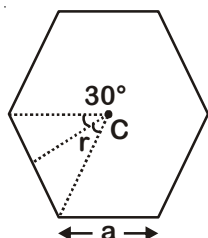
$$\vec{F} = q(\vec{V} \times \vec{B})$$

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

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

47. Answer (1)

$$B_C = N \cdot \left(6 \cdot \frac{\mu_0 i}{4\pi r} (\sin 30^\circ + \sin 30^\circ) \right)$$



$$r = \frac{\sqrt{3}}{2} a$$

$$= \frac{300}{4r} \frac{\mu_0 i}{\pi}$$

$$= 500\sqrt{3} \frac{\mu_0 i}{\pi}$$

48. Answer (2)

$$B_A = \frac{(\mu_0)(2)}{(2)(2)} \frac{3(\pi/2)}{2\pi} \dots (1)$$

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

From (1) and (2)

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

49. Answer (1)

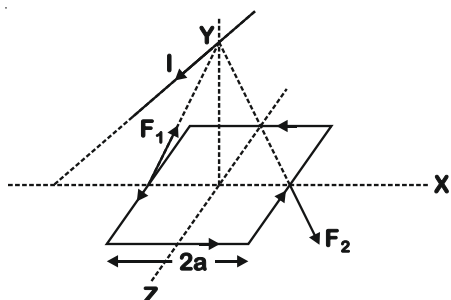
$$F_m^{\max} = (q)VB_0$$

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

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

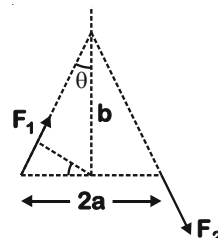
$$\approx 4.8 \times 10^{-19} \text{ N}$$

50. Answer (1)



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

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



Torque about z-axis

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

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

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

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

51. Answer (2)

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

$$\frac{T_1}{T_2} = \sqrt{\frac{I_1}{I_2}}$$

$$I_1 = 2MR^2, I_2 = \frac{MR^2}{2} + MR^2 = \frac{3}{2}MR^2$$

$$\Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{4}{3}} = \frac{2}{\sqrt{3}}$$

52. Answer (4)

$$r = \frac{mv}{qB_0}$$

To not collide, $r < d$

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

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

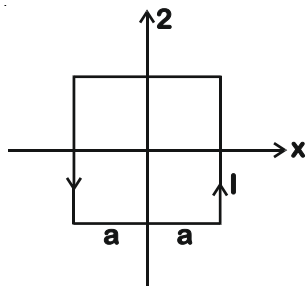
Note : It should be maximum instead of minimum.

53. Answer (1)

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

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

54. Answer (2)



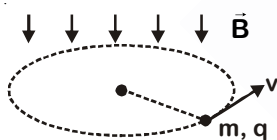
$$\tau = (f_{\perp})r$$

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

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

55. Answer (1)

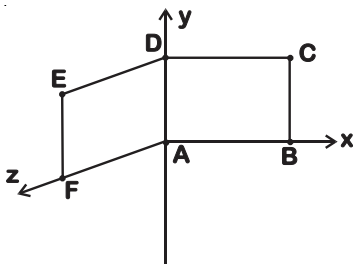
$$\vec{M} = \frac{1}{2} qvR (-\hat{B})$$



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

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

56. Answer (175.00)



$$\vec{B} = 3\hat{i} + 4\hat{k} \text{ T}$$

$$\phi = 3 \times 25 + 25 \times 4 = 175 \text{ Wb}$$

57. Answer (20)

$$\vec{\mu} = NiA = 500 \times 3 \times 10^{-4} \times \frac{5}{10}$$

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

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

$$B = 20 \text{ T}$$

58. Answer (2)

$$B \propto \frac{1}{(R^2 + x^2)^{3/2}}$$

$$\frac{B_1}{B_2} = \frac{[R^2 + (0.2)^2]^{3/2}}{[R^2 + (0.05)^2]^{3/2}} = \frac{8}{1}$$

$$\frac{R^2 + 0.04}{R^2 + 0.0025} = \frac{4}{1}$$

$$R^2 + 0.04 = 4R^2 + 0.01$$

$$R = 0.1 \text{ m}$$

59. Answer (4)

$$V = \frac{p}{m}$$

$$V_p : V_d : V_{\alpha} = 4 : 2 : 1$$

$$f_p : f_d : f_{\alpha} = q_p V_p : q_d V_d : q_{\alpha} V_{\alpha}$$

$$= 4 : 2 : 2$$

$$= 2 : 1 : 1$$

60. Answer (2)

$$\vec{F}_m = q\vec{V} \times \vec{B}$$

$$\because \vec{B} \perp \vec{V} \Rightarrow \text{Work done is zero}$$

$$\therefore W = 0$$

61. Answer (3)

$$B = (\mu_0 ni) \mu_r$$

$$= 4\pi \times 10^{-7} \times 10^3 \times 5 \times 500$$

$$= \pi \text{ T}$$

62. Answer (1)

$$\text{Field due to straight section} = \frac{\mu_0 I}{4\pi r}$$

$$\text{Field due to circular section} = \frac{\mu_0 I}{4r}$$

$$\text{Net field} = \frac{\mu_0 I}{2\pi r} + \frac{\mu_0 I}{4r}$$

63. Answer (2)

For aligning magnetic moment with external magnetic field, loop will align its plane normal to the field. This position of loop in magnetic field will cause the wire to stretch out and the loop will assume a circular shape.

64. Answer (4)

$$R = \frac{mV}{qB} = \frac{\sqrt{2mK}}{qB}$$

$$\frac{R_p}{R_\alpha} = \sqrt{\frac{m_p K_p}{m_\alpha K_\alpha} \frac{q_\alpha}{q_p}}$$

$$\Rightarrow \frac{K_p}{K_\alpha} = 4:1$$

65. Answer (3)

Theory based.

66. Answer (4)

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

$$r = \frac{\sqrt{2mk}}{qB}$$

$$\frac{r_d}{r_\alpha} = \frac{\sqrt{m_d}}{q_d} \times \frac{q_\alpha}{\sqrt{m_\alpha}} = \frac{2}{\sqrt{2}} = \sqrt{2}$$

67. Answer (4)

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

$$\frac{q_1}{q_2} = \frac{1}{2}, \frac{v_1}{v_2} = \frac{2}{3}$$

$$\frac{R_1}{R_2} = \frac{v_1}{q_1} \times \frac{q_2}{v_2} = \frac{v_1}{v_2} \times \frac{q_2}{q_1} = \frac{2}{3} \times 2 = \frac{4}{3}$$

68. Answer (1)

For inside point

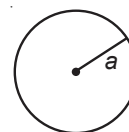
$$B \cdot 2\pi r = \frac{\mu_0 I \cdot \pi r^2}{\pi a^2}$$

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

For outside point

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

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

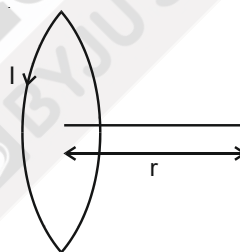


$$\text{For fig. A- } B \text{ (at } r = a) = \frac{\mu_0 I}{2\pi a}$$

$$\text{For fig. B- } B \text{ (at } r = b) = \frac{\mu_0 I}{2\pi b}$$

So option (1) is correct.

69. Answer (1)



$$B(r) = \frac{\mu_0 I a^2}{2(r^2 + a^2)^{3/2}}$$

$$B(r=0) = \frac{\mu_0 I}{2a}$$

$$\frac{\Delta B}{B} = \left[\frac{\frac{\mu_0 I}{2a} - \frac{\mu_0 I a^2}{2(r^2 + a^2)^{3/2}}}{\frac{\mu_0 I}{2a}} \right]$$

$$\frac{\Delta B}{B} = 1 - \frac{a^3}{(r^2 + a^2)^{3/2}}$$

$$\frac{\Delta B}{B} = 1 - \left[1 + \frac{r^2}{a^2} \right]^{-\frac{3}{2}}$$

$$= \frac{3r^2}{2a^2}$$

70. Answer (543)

$$\frac{1}{2}m\left(\frac{c}{6}\right)^2 = n \times 2 \times 12 \text{ keV}$$

$$n = \frac{1.67 \times 10^{-27} \times 9 \times 10^{16}}{4 \times 36 \times 1.6 \times 10^{-19} \times 12 \times 10^3}$$

$$= 543.6197$$

71. Answer (3)

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

$$\vec{\tau} = (0.2) \left(\frac{\sqrt{3}}{4} a^2 \right) \times 20 \times 10^{-3} \times \sin 90^\circ$$

$$= \sqrt{3} \times 10^{-5} \text{ Nm}$$

72. Answer (3)

$$\text{Radius} = \frac{mV}{qB} = \frac{\sqrt{2Km}}{qB}$$

$$\frac{R_1}{R_2} = \frac{\sqrt{m_1}}{q_1} \times \frac{q_2}{\sqrt{m_2}}$$

$\Rightarrow R_1 < R_2$ so deviation of lighter ion is more

73. Answer (3)

Magnetic moment of triangular coil

$$= \frac{V_0}{R} \times \left(\frac{\sqrt{3}}{4} a^2 \right) 8 = M_1$$

$$\text{Magnetic moment of square coil} = \frac{V_0}{R} (a^2) 6 = M_2$$

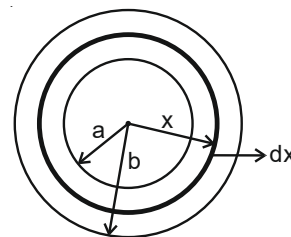
$$\frac{M_1}{M_2} = \frac{2\sqrt{3}}{6} = \frac{1}{\sqrt{3}}$$

74. Answer (4)

$$dN = \frac{N}{(b-a)} dx$$

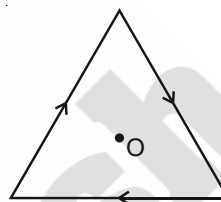
$$\therefore B = \int_a^b \frac{\mu_0 N \times I dx}{(b-a) \times 2x}$$

$$= \frac{\mu_0 NI}{2(b-a)} \ln \left(\frac{b}{a} \right)$$

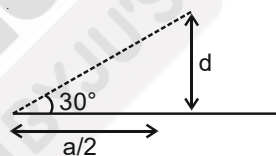


75. Answer (4)

Field due to each wire will add up.



$$B_{\text{net}} = 3B_0 [B_0: \text{Field due to single wire}]$$



$$B_0 = \frac{\mu_0 I_0}{4\pi d} \times 2 \sin 60^\circ$$

$$B_0 = \frac{\sqrt{3}\mu_0 I_0}{4\pi d}$$

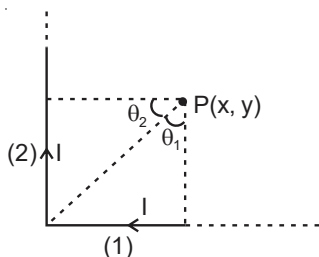
$$d = \frac{a}{2\sqrt{3}}$$

$$B_0 = \frac{3\mu_0 I_0}{2\pi a}$$

$$B_{\text{net}} = \frac{9\mu_0 I_0}{2\pi a} = \frac{18 \times 10^{-7} \times 1.5}{9 \times 10^{-2}}$$

$$= 3 \times 10^{-5} \text{ T}$$

76. Answer (2)



$$\vec{B}_1 = \frac{\mu_0 I}{4\pi y} (\sin \theta_1 + 1)(-\hat{k})$$

$$\vec{B}_2 = \frac{\mu_0 I}{4\pi x} (\sin \theta_2 + 1)(-\hat{k})$$

$$\text{So, } B_{\text{Net}} = \vec{B}_1 + \vec{B}_2$$

$$= \frac{\mu_0 I}{4\pi} \left(\frac{x}{y\sqrt{x^2+y^2}} + \frac{1}{y} \right) + \frac{\mu_0 I}{4\pi} \left(\frac{1}{x} \frac{y}{\sqrt{x^2+y^2}} + \frac{1}{x} \right)$$

$$= \frac{\mu_0 I}{4\pi xy} (\sqrt{x^2+y^2} + x + y)$$

77. Answer (1)

Magnetic force $\vec{F} \perp \vec{v}$

$$\Rightarrow W_b = 0$$

$$\Rightarrow \Delta KE = 0 \text{ and speed remains constant.}$$

78. Answer (3)

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

$$B_a = \frac{\mu_0 I r^2}{2 \left(r^2 + \frac{r^2}{4} \right)}$$

$$\Rightarrow \frac{B_a}{B} = \left(\frac{2}{\sqrt{5}} \right)^3$$

$$\Rightarrow B_a = \left(\frac{2}{\sqrt{5}} \right)^3 B$$

79. Answer (4)

$$\therefore r = \frac{mv}{qB} = \frac{\sqrt{2m(KE)}}{qB}$$

$$\Rightarrow r_1 : r_2 : r_3 = \frac{\sqrt{m_1}}{q_1} : \frac{\sqrt{m_2}}{q_2} : \frac{\sqrt{m_3}}{q_3}$$

$$= \frac{\sqrt{1}}{1} : \frac{\sqrt{2}}{1} : \frac{\sqrt{4}}{2}$$

$$= 1 : \sqrt{2} : 1$$

80. Answer (2)

$$\int \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{in}}$$

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

$$\Rightarrow B \propto r$$

 $\Rightarrow$ option (2) is correct

81. Answer (1)

$$B = \mu_0 ni$$

$$\text{Now } i \rightarrow 2i$$

$$\text{And } n \rightarrow \frac{n}{2}$$

$$B' = \mu_0 \frac{n}{2} \times 2i = \mu_0 ni = B$$

82. Answer (3)

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

$$\frac{R_\alpha}{R_p} = \frac{m_\alpha / q_\alpha}{m_p / q_p} = 2$$

83. Answer (3)

$$\text{Field at } P \text{ is } = \left(\frac{\mu_0 \times i_1}{2\pi r_1} - \frac{\mu_0 i_2}{2\pi r_2} \right) (-\hat{k})$$

$$= - \left(\frac{\mu_0 4}{2\pi \times 0.04} - \frac{\mu_0 \times 2}{2\pi \times 0.06} \right) \hat{k} = - \frac{\mu_0 \times 200}{6\pi} \hat{k}$$

So, force $\vec{F} = q\vec{v} \times \vec{B}$

$$\begin{aligned}
 &= 3\pi(2\hat{i} + 3\hat{j}) \times \left(-\left(\frac{\mu_0 \times 200}{6\pi} \hat{k} \right) \right) \\
 &= 3\pi \left(\frac{200\mu_0}{3\pi} \hat{j} - \frac{100\mu_0}{\pi} \hat{i} \right) \\
 &= 200\mu_0 \hat{j} - 300\mu_0 \hat{i} \\
 &= 4\pi \times 10^{-5} (2\hat{j} - 3\hat{i})
 \end{aligned}$$

So, $x = 3$

84. Answer (2)

$$R = \frac{\sqrt{2mK}}{qB}$$

$$\begin{aligned}
 \text{So } \frac{r_d}{r_p} &= \frac{\sqrt{m_d} / q_d}{\sqrt{m_p} / q_p} \\
 &= \sqrt{2}
 \end{aligned}$$

So $x = 2$

85. Answer (D)

Inside a hollow cylindrical conductor with uniform current distribution net magnetic field is zero in hollow space.

But outside the cylindrical conductor $B \propto \frac{1}{r}$

$\Rightarrow$ Graph in option D would be a correct one

86. Answer (10)

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

$$R = \frac{\sqrt{2mKE}}{qB}$$

$$= \frac{\sqrt{2 \times 24 \times 1.67 \times 10^{-27} \times 5 \times 1.6 \times 10^{-16}}}{1.6 \times 10^{-19} \times 0.5}$$

$$= 10.009 \text{ cm} = 10 \text{ cm}$$

87. Answer (3)

$$\frac{dF}{dl} = 2 \times 10^{-6} \text{ N/m} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

$$2 \times 10^{-6} = \frac{2 \times 10^{-7} \times x^2}{0.2}$$

$$x = \sqrt{2} \approx 1.4$$

88. Answer (3)

$$R = \frac{mv}{Bq} = \frac{\sqrt{2mK}}{Bq}$$

$$\Rightarrow R \propto \sqrt{K}$$

$$\Rightarrow \text{ratio} = 2 : 1$$

89. Answer (2)

As $B_{\text{net}} \neq 0$ that is the wires are carrying current in opposite direction.

$$\frac{\mu_0 I \times 2}{2\pi(4 \times 10^{-2})} = 30 \times 10^{-6} \text{ T}$$

$$\Rightarrow I = \frac{30 \times 10^{-6}}{10^{-6}} \text{ A} = 30 \text{ A in opposite direction.}$$

90. Answer (3)

Electric field accelerates the particle in the direction of field ($\vec{F} = q\vec{E} = m\vec{a}$) and magnetic field accelerates the particle perpendicular to the field ($\vec{F} = q\vec{v} \times \vec{B} = m\vec{a}$).

91. Answer (2)

$$\text{We know that } R = \frac{mv}{Bq} = \sqrt{\frac{2mK}{Bq}}$$

$$\Rightarrow \text{Ratio of radii} = \frac{R_1}{R_2} = \sqrt{\frac{m_1}{m_2} \frac{q_2}{q_1}}$$

$$\Rightarrow \frac{6}{5} = \sqrt{\frac{9}{4} \frac{q_2}{q_1}}$$

$$\Rightarrow \frac{q_1}{q_2} = \frac{3}{2} \times \frac{5}{6} = \frac{5}{4}$$

92. Answer (2)

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

$$B_1 = \frac{2\mu_0 I}{2R_1}$$

$$B_2 = \frac{5\mu_0 I}{2R_2}$$

$$R_2 = \frac{2R_1}{5}$$

$$\Rightarrow \frac{B_2}{B_1} = \frac{5}{2} \times \frac{R_1}{R_2} = \frac{25}{4}$$

93. Answer (3)

$$T = \frac{2\pi m}{Bq}$$

$$\Rightarrow \text{Frequency } f = \frac{Bq}{2\pi m}$$

$$= \frac{10^{-4} \times 1.6 \times 10^{-19}}{2\pi \times 9 \times 10^{-31}}$$

$$\approx 2.8 \times 10^6 \text{ Hz}$$

94. Answer (2)

As magnetic force is perpendicular to magnetic field So, $\vec{F} \cdot \vec{B}$ must be 0

$$\text{So, } 2\alpha - 12 = 0$$

$$\alpha = 6$$

95. Answer (2)

$$B = \frac{\mu_0 NI}{2R}$$

$$\frac{B_x}{B_y} = \frac{N_x R_y}{N_y R_x}$$

$$= \frac{200 \times 20}{400 \times 20} = \frac{1}{2}$$

96. Answer (2)

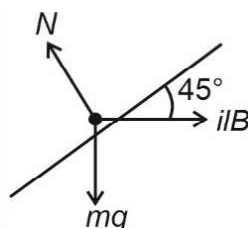
$$R = \frac{mv}{Bq} = \frac{\sqrt{2mK}}{Bq}$$

$$\Rightarrow K = \frac{B^2 q^2 R^2}{2m}$$

$$= \frac{(1.6 \times 10^{-19})^2 \times 0.6^2}{2 \times 1.6 \times 10^{-27}} \text{ J}$$

$$= 18 \text{ MeV}$$

97. Answer (1)



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

$$\Rightarrow i = \frac{mg}{Bl}$$

$$= \frac{0.45 \times 10}{0.15} = 30 \text{ A}$$

98. Answer (3)

$$\vec{F} = i\vec{l} \times \vec{B}$$

$$= ilB \sin 60^\circ$$

$$= 10 \times \frac{5}{100} \times 0.5 \times \frac{\sqrt{3}}{2}$$

$$= 0.2165 \text{ N}$$

99. Answer (3)

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

$$B_2 = \frac{\mu_0 i R^2}{2(R^2 + x^2)^{\frac{3}{2}}}$$

$$\Rightarrow \frac{B_1}{B_2} = \frac{1}{R^3} (R^2 + x^2)^{\frac{3}{2}}$$

$$= \frac{1}{R^3} (8R^3)$$

$$= 8$$

100. Answer (3)

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

$$37.68 \times 10^{-4} = \frac{4\pi \times 10^{-7} 100 I}{2 \times 5 \times 10^{-2}}$$

$$I = \frac{300A}{100}$$

$$= 3A$$

101. Answer (11)

$$R = \frac{l}{2\pi} = \frac{314}{2 \times 3.14} = 50 \text{ cm}$$

$$\mu = \pi R^2 i$$

$$= 14 \times 3.14 \times (0.5)^2$$

$$= 11 \text{ A-m}^2$$

102. Answer (1)

$$F_{xy} = F_{yx} = F$$

$$F = \frac{\mu_0 I_2}{2\pi r} I_1 (l)$$

$$= \frac{4\pi \times 10^{-7} \times 3 \times 2 \times [50 \times 10^{-2}]}{2\pi (5 \times 10^{-2})}$$

$$= 1.2 \times 10^{-5} \text{ N}$$

103. Answer (2)

$$\mu_1 = \pi r_1^2 \times I_1$$

$$\mu_2 = \pi r_2^2 \times I_2$$

$$\therefore \mu_{\text{net}} = (\mu_2 - \mu_1)(-\hat{k})$$

$$= \pi(r_2^2 - r_1^2)I(-\hat{k})$$

$$= 3.142 \times (0.5^2 - 0.3^2) \times 7(-\hat{k})$$

$$= -\frac{7}{2} \hat{k} \text{ Am}^2$$

104. Answer (1)

$$v = \frac{E}{B} \text{ and } K = \frac{1}{2}mv^2$$

$$\Rightarrow \sqrt{\frac{2K}{m}} \times B = E$$

$$\Rightarrow E = \sqrt{\frac{2 \times 728 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}} \times 12 \times 10^{-3}$$

$$= 192000 \text{ V/m}$$

105. Answer (5)

$$\frac{dF}{dl} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

$$\text{So } \frac{2 \times 10^{-7} \times 5 \times 5}{d} = \frac{10^{-5}}{10 \times 10^{-2}}$$

$$d = \frac{2 \times 10^{-7} \times 5 \times 5}{10^{-4}}$$

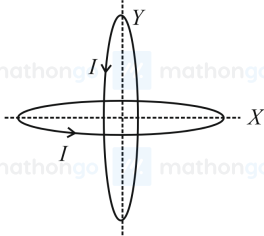
$$= 50 \text{ mm}$$

$$= 5 \text{ cm}$$



- A long straight wire of circular cross-section (radius a) is carrying steady current I . The current I is uniformly distributed across this cross-section. The magnetic field is
[2023 (06 Apr Shift 1)]
(1) inversely proportional to r in the region $r < a$ and uniform throughout in the region $r > a$
(2) directly proportional to r in the region $r < a$ and inversely proportional to r in the region $r > a$
(3) Zero in the region $r < a$ and inversely proportional to r in the region $r > a$
(4) uniform in the region $r < a$ and inversely proportional to distance r from the axis, in the region $r > a$

- Two identical circular wires of radius 20 cm and carrying current $\sqrt{2}$ A are placed in perpendicular planes as shown in figure. The net magnetic field at the centre of the circular wires is $\times 10^{-8}$ T.



(Take $\pi = 3.14$)

[2023 (06 Apr Shift 1)]

- A proton with a kinetic energy of 2.0 eV moves into a region of uniform magnetic field of magnitude $\frac{\pi}{2} \times 10^{-3}$ T. The angle between the direction of magnetic field and velocity of proton is 60° . The pitch of the helical path taken by the proton is ____ cm. (Take, mass of proton = 1.6×10^{-27} kg and charge on proton = 1.6×10^{-19} C).

[2023 (06 Apr Shift 2)]

- A charge particle moving in magnetic field B , has the components of velocity along B as well as perpendicular to B . The path of the charge particle will be
[2023 (08 Apr Shift 1)]

- (1) helical path with the axis perpendicular to the direction of magnetic field B
- (2) helical path with the axis along magnetic field B
- (3) circular path
- (4) straight along the direction of magnetic field B

- The magnetic intensity at the centre of a long current carrying solenoid is found to be 1.6×10^3 A m^{-1} . If the number of turns is 8 per cm, then the current flowing through the solenoid is ____ A.

[2023 (08 Apr Shift 1)]

- The ratio of magnetic field at the centre of a current carrying coil of radius r to the magnetic field at distance r from the centre of coil on its axis is $\sqrt{x} : 1$. The value of x is ____.

[2023 (08 Apr Shift 2)]

- Given below are two statements:

Statement I: If the number of turns in the coil of a moving coil galvanometer is doubled then the current sensitivity becomes double.

Statement II: Increasing current sensitivity of a moving coil galvanometer by only increasing the number of turns in the coil will also increase its voltage sensitivity in the same ratio

In the light of the above statements, choose the correct answer from the options given below:

[2023 (10 Apr Shift 1)]

- (1) Statement I is true but Statement II is false
- (2) Statement I is false but Statement II is true
- (3) Both Statement I and Statement II are false
- (4) Both Statement I and Statement II are true

- A straight wire carrying a current of 14 A is bent into a semicircular arc of radius 2.2 cm as shown in the figure. The magnetic field produced by the current at the centre O of the arc is $\times 10^{-4}$ T



[2023 (10 Apr Shift 2)]

9. An electron is allowed to move with constant velocity along the axis of current carrying straight solenoid.

- (A) The electron will experience magnetic force along the axis of the solenoid.
- (B) The electron will not experience magnetic force.
- (C) The electron will continue to move along the axis of the solenoid.
- (D) The electron will be accelerated along the axis of the solenoid.
- (E) The electron will follow parabolic path-inside the solenoid.

Choose the correct answer from the option given below:

[2023 (11 Apr Shift 2)]

- (1) B, C and D only
- (2) A and D only
- (3) B and C only
- (4) B and E only

10. An electron is moving along the positive x-axis. If uniform magnetic field is applied parallel to the negative z-axis, then

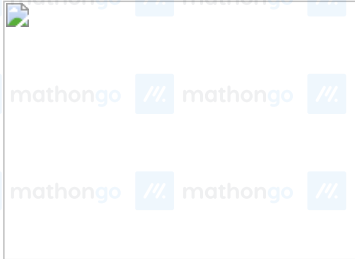
- A. The electron will experience magnetic force along positive y-axis
- B. The electron will experience magnetic force along negative y-axis
- C. The electron will not experience any force in magnetic field
- D. The electron will continue to move along the positive x-axis
- E. The electron will move along circular path in magnetic field

Choose the correct answer from the option given below:

[2023 (13 Apr Shift 2)]

- (1) A and E only
- (2) C and D only
- (3) B and E only
- (4) B and D only

11. A straight wire AB of mass 40 g and length 50 cm is suspended by a pair of flexible leads in uniform magnetic field of magnitude 0.40 T as shown in the figure. The magnitude of the current required in the wire to remove the tension in the supporting leads is _____ A. (Take $g = 10 \text{ m s}^{-2}$).



[2023 (13 Apr Shift 2)]

12. An electron in a hydrogen atom revolves around its nucleus with a speed of $6.76 \times 10^6 \text{ m s}^{-1}$ in an orbit of radius $0.52 \text{ \AA}$. The magnetic field produced at the nucleus of the hydrogen atom is _____ T.

[2023 (15 Apr Shift 1)]

ANSWER KEYS

1. (2) 2. (628) 3. (40) 4. (2) 5. (2) 6. (8) 7. (1) 8. (2)
9. (3) 10. (3) 11. (2) 12. (40)

1. (2)

The formula to calculate the magnetic field inside the conducting wire is given by

$$B_{\text{in}} = \frac{\mu_0 J r}{2} \dots (1)$$

The formula to calculate the magnetic field outside the conducting wire is given by

$$B_{\text{out}} = \frac{\mu_0 J a^2}{2r} \dots (2)$$

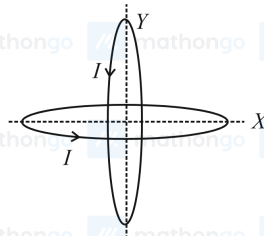
From equation (1), it can be concluded that the magnetic field is directly proportional to the radial distance inside the wire, whereas from equation (2), it can be concluded that the magnetic field is inversely proportional to the radial distance outside the wire.

2. (628)

The formula to calculate the magnetic field (B) at the centre of a current carrying circular loop is given by

$$B = \frac{\mu_0 i}{2R} \dots (1)$$

where, μ_0 is the permeability of free space, i is the current and R is the radius of the loop.



B_V , B_H are the magnetic field due to the vertical and the horizontal loop, which by magnitude are equal.

The resultant magnetic field (B_{net}) at the centre is, then, given by

$$\begin{aligned} B_{\text{net}} &= \sqrt{B^2 + B^2} = \sqrt{2}B \\ &= \frac{\sqrt{2} \times 4\pi \times 10^{-7} \times \sqrt{2}}{2 \times 0.2} \\ &= 628 \times 10^{-8} \text{ T} \end{aligned}$$

3. (40)

The given data is

$$K.E = 2 \text{ eV}$$

$$B = \frac{\pi}{2} \times 10^{-3} \text{ T}$$

$$\theta = 60^\circ$$

The pitch of the proton is given by

$$P = \frac{2\pi m}{qB} \times v \cos \theta \dots (i)$$

By using

$$\begin{aligned} K &= \frac{mv^2}{2} \\ \Rightarrow v &= \sqrt{\frac{2K}{m}} \end{aligned}$$

Substituting the values in equation (i)

$$\begin{aligned} &= \frac{2\pi \times \sqrt{2mKE} \times \frac{1}{2} \times 2}{1.6 \times 10^{-19} \times \pi \times 10^{-3}} \\ &= \frac{2 \times \sqrt{2 \times 1.6 \times 10^{-27} \times 2 \times 1.6 \times 10^{-19}} \times 10^3}{1.6 \times 10^{-19}} \\ &= 2 \times 2 \times 10^{-1} = 0.4 \text{ m} \end{aligned}$$

4. (2)

The formula to calculate the radius of the path followed by the charged particle under an external magnetic field can be written as

$$r = \frac{mv}{Bq} \dots (1)$$

The perpendicular component of velocity results in circular motion, while the parallel component results in linear motion. Hence, the path of the charged particle is helical in nature, the axis of which lies along the direction of the magnetic field.

5. (2)

The magnetic intensity H is defined as the product of the number of turns per unit length in a coil n and the current that it carries I .

The magnetic field of a solenoid is given by $B = \mu_0 ni$

$$H = \frac{B}{\mu_0} = \frac{\mu_0 ni}{\mu_0}$$

$$\Rightarrow H = ni \dots (i)$$

The given data is

$$H = 1.6 \times 10^3 \text{ A m}^{-1}$$

$$n = 8 \text{ per cm}$$

Substituting the values in equation (i)

$$\Rightarrow 1.6 \times 1000 = \frac{8}{100} \times i$$

$$\Rightarrow i = 2 \text{ A}$$

6. (8)

The formula to calculate the magnetic field at any axial point situated at a distance x from the centre of a circular current carrying conductor of radius r can be written as

$$B = \frac{\mu_0 I r^2}{2(r^2 + x^2)^{3/2}} \dots (1)$$

Substitute 0 for x in equation (1) to calculate the magnetic field (B_c) at the centre of the conductor.

$$B_c = \frac{\mu_0 I r^2}{2(r^2 + 0^2)^{3/2}}$$

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

$$= \frac{\mu_0 I}{2r} \dots (2)$$

Substitute r for x in equation (1) to calculate the magnetic field (B_r) at the given distance from the centre of the conductor.

$$B_r = \frac{\mu_0 I r^2}{2(r^2 + r^2)^{3/2}}$$

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

$$= \frac{\mu_0 I}{4\sqrt{2}r} \dots (3)$$

Divide equation (2) by equation (3) to calculate the required ratio of the magnetic fields.

$$\frac{B_c}{B_r} = \frac{\frac{\mu_0 I}{2r}}{\frac{\mu_0 I}{4\sqrt{2}r}}$$

$$= 2\sqrt{2}$$

$$= \sqrt{8}$$

7. (1)

For a moving coil galvanometer,

$$(NiAB) = k\theta$$

The current sensitivity is given by

$$S_i = \frac{NAB}{k}$$

So, if N is doubled then, the current sensitivity is also doubled.

The voltage is given by

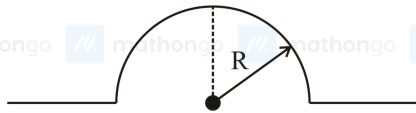
$$V = \left(\frac{BNA}{Rk} \right) \theta$$

The voltage sensitivity is given by

$$S_v = \left(\frac{NAB}{kR} \right)$$

As, N is increased, R also increases. So, the voltage sensitivity does not change as $\frac{N}{R}$ remains constant.

8. (2)



It is given that

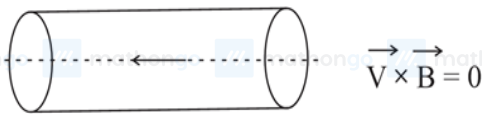
$$i = 14 \text{ A}$$

$$R = 2.2 \times 10^{-2} \text{ m}$$

The magnetic field at the centre O is

$$\begin{aligned} B &= \frac{\mu_0 i}{4R} \\ &= \frac{4\pi \times 10^{-7} \times 14}{4 \times 2.2 \times 10^{-2}} \\ &= 2 \times 10^{-4} \text{ T} \end{aligned}$$

9. (3)



$$\vec{F} = 0$$

The Lorentz force is given by $\vec{F} = q(\vec{v} \times \vec{B}) = qvB \sin \theta \hat{n}$. The angle $\theta = 0^\circ$. Hence the force experienced is zero.

Thus, the electron will not experience any magnetic force and the electron will continue to move along the axis.

10. (3)

The Lorentz force is given by

$$\begin{aligned} \vec{F} &= q\vec{v} \times \vec{B} \\ &= -e\vec{v} \times \vec{B} \end{aligned}$$

$$\text{So, } \hat{F} = \hat{i} \times \hat{k} = -\hat{j}.$$

$\vec{F}$ is along $-y$ axis

As the magnetic field is perpendicular to the velocity, motion would be circular.

11. (2)

The formula to calculate the magnetic force on the conductor is given by

$$F_B = ILB \dots (1)$$

The formula to calculate the gravitational force on the conductor is given by

$$F_G = mg \dots (2)$$

Equate both the equations and simplify to obtain the required current through the conductor.

$$ILB = mg$$

$$\Rightarrow I = \frac{mg}{LB} \dots (3)$$

Substitute the values of the known parameters into equation (3) to calculate the required current through the conductor.

$$\begin{aligned} I &= \frac{\frac{40}{1000} \text{ kg} \times 10 \text{ m s}^{-2}}{0.5 \text{ m} \times 0.40 \text{ T}} \\ &= 2 \text{ A} \end{aligned}$$

12. (40)

The magnetic field due to the electron is given by

$$B = \frac{\mu_0 q v \sin 90^\circ}{4\pi r^2}$$

The given data is

$$v = 6.76 \times 10^6 \text{ m s}^{-1}$$

$$r = 0.52 \times 10^{-10} \text{ m}$$

Thus, the magnetic field is

$$B = \frac{10^{-7} \times (1.6 \times 10^{-19}) \times (6.76 \times 10^6)}{0.52 \times 0.52 \times 10^{-20}} = 40 \text{ T}$$

Q1 - 24 January - Shift 1

Two long straight wires P and Q carrying equal current 10A each were kept parallel to each other at 5 cm distance. Magnitude of magnetic force experienced by 10 cm length of wire P is F_1 . If distance between wires is halved and currents on them are doubled, force F_2 on 10 cm length of wire P will be :

- (1) $8 F_1$ (2) $10 F_1$
(3) $F_1/8$ (4) $F_1/10$

Space for your notes:

Q2 - 24 January - Shift 1

A circular loop of radius r is carrying current I A. The ratio of magnetic field at the centre of circular loop and at a distance r from the center of the loop on its axis is :

- (1) $1:3\sqrt{2}$ (2) $3\sqrt{2}:2$
(3) $2\sqrt{2}:1$ (4) $1:\sqrt{2}$

Space for your notes:

Q3 - 24 January - Shift 2

A long solenoid is formed by winding 70 turns cm^{-1} . If 2.0 A current flows, then the magnetic field produced inside the solenoid is _____
($\mu_0 = 4\pi \times 10^{-7} \text{ TmA}^{-1}$)

- (1) $1232 \times 10^{-4} \text{ T}$
(2) $176 \times 10^{-4} \text{ T}$
(3) $352 \times 10^{-4} \text{ T}$
(4) $88 \times 10^{-4} \text{ T}$

Space for your notes:

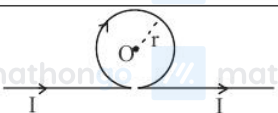
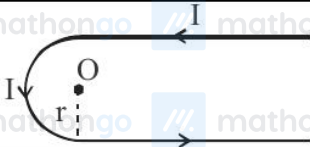
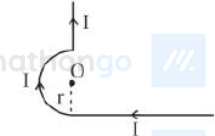
Q4 - 24 January - Shift 2

A single turn current loop in the shape of a right angle triangle with sides 5 cm, 12 cm, 13 cm is carrying a current of 2A. The loop is in a uniform magnetic field of magnitude 0.75 T whose direction is parallel to the current in the 13 cm side of the loop. The magnitude of the magnetic force on the 5 cm side will be $\frac{x}{130}$ N. The value of x is

Space for your notes:

Q5 - 25 January - Shift 1

Math List I with List II

List – I (Current configuration)		List – II (Magnetic field at point O)	
A		I.	$B_0 = \frac{\mu_0 I}{4\pi r} [\pi + 2]$
B		II.	$B_0 = \frac{\mu_0 I}{4 r}$
C		III.	$B_0 = \frac{\mu_0 I}{2\pi r} [\pi - 1]$
D		IV.	$B_0 = \frac{\mu_0 I}{4\pi r} [\pi + 1]$

Space for your notes:

Choose the correct answer from the option given below:

- (1) A-III, B-IV, C-I, D-II
- (2) A-I, B-III, C-IV, D-II
- (3) A-III, B-I, C-IV, D-II
- (4) A-II, B-I, C-IV, D-III

Q6 - 25 January - Shift 1

A solenoid of 1200 turns is wound uniformly in a single layer on a glass tube 2 m long and 0.2 m in diameter. The magnetic intensity at the center of the solenoid when a current of 2 A flows through it is:

- (1) $2.4 \times 10^3 \text{ A m}^{-1}$
- (2) $1.2 \times 10^3 \text{ A m}^{-1}$
- (3) 1 A m^{-1}
- (4) $2.4 \times 10^{-3} \text{ A m}^{-1}$

Space for your notes:

Q7 - 25 January - Shift 2

For a moving coil galvanometer, the deflection in the coil is 0.05 rad when a current of 10 mA is passed through it. If the torsional constant of suspension wire is $4.0 \times 10^{-5} \text{ Nm rad}^{-1}$, the magnetic field is 0.01 T and the number of turns in the coil is 200, the area of each turn (in cm^2) is :

- (1) 2.0
- (2) 1.0
- (3) 1.5
- (4) 0.5

Space for your notes:

Q8 - 25 January - Shift 2

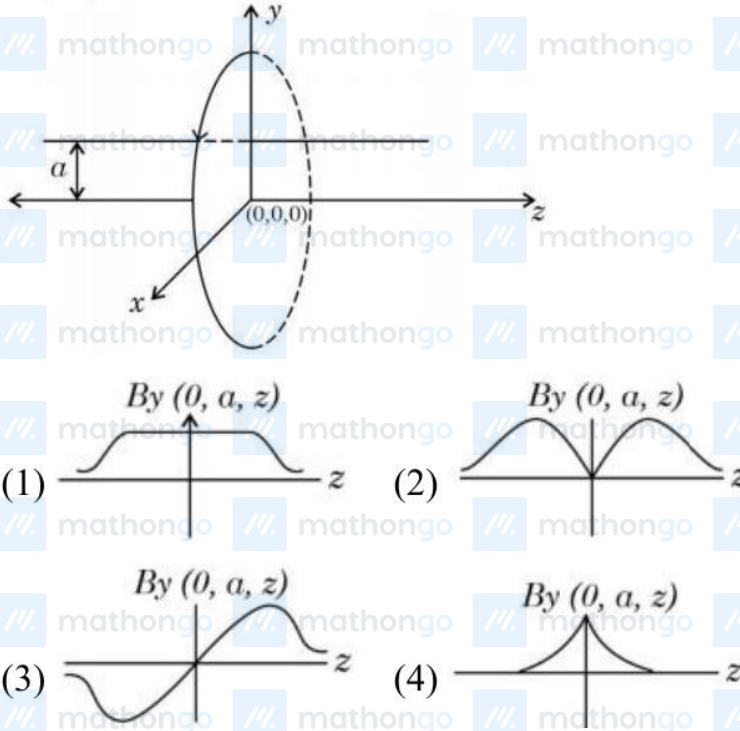
Two long parallel wires carrying currents 8A and 15 A in opposite directions are placed at a distance of 7 cm from each other. A point P is at equidistant from both the wires such that the lines joining the point P to the wires are perpendicular to each other. The magnitude of magnetic field at P is $\times 10^{-6} \text{ T}$. (Given : $\sqrt{2} = 1.4$)

Space for your notes:

Q9 - 29 January - Shift 1

A single current carrying loop or wire carrying current I flowing in anticlockwise direction seen from +ve z direction and lying in xy plane is shown in figure. The plot of $\hat{j}$ component of magnetic field (B_y) at a distance ' a ' (less than radius of the coil) and on yz plane vs z coordinate look like

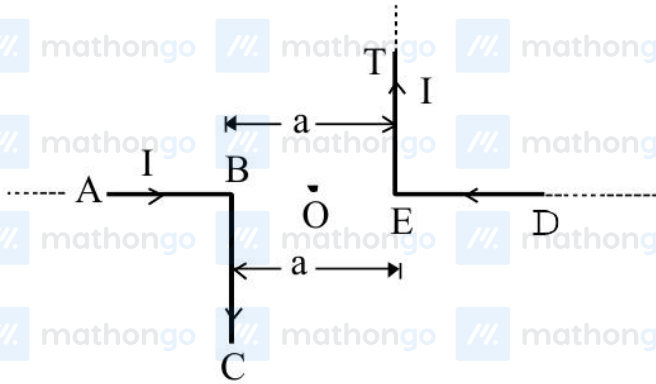
Space for your notes:



Q10 - 29 January - Shift 1

The magnitude of magnetic induction at mid-point O due to current arrangement as shown in Fig will be :

Space for your notes:



- (1) $\frac{\mu_0 I}{2\pi a}$ (2) 0
 (3) $\frac{\mu_0 I}{4\pi a}$ (4) $\frac{\mu_0 I}{\pi a}$

Q11 - 29 January - Shift 2

A square loop of area 25cm^2 has a resistance of 10Ω . The loop is placed in uniform magnetic field of magnitude 40.0 T . The plane of loop is perpendicular to the magnetic field. The work done in pulling the loop out of the magnetic field slowly and uniformly in 1.0 sec , will be

Space for your notes:

- (1) $2.5 \times 10^{-3}\text{ J}$ (2) $1.0 \times 10^{-3}\text{ J}$
 (3) $1.0 \times 10^{-4}\text{ J}$ (4) $5 \times 10^{-3}\text{ J}$

Q12 - 29 January - Shift 2

The electric current in a circular coil of four turns produces a magnetic induction 32 T at its centre. The coil is unwound and is rewound into a circular coil of single turn, the magnetic induction at the centre of the coil by the same current will be :

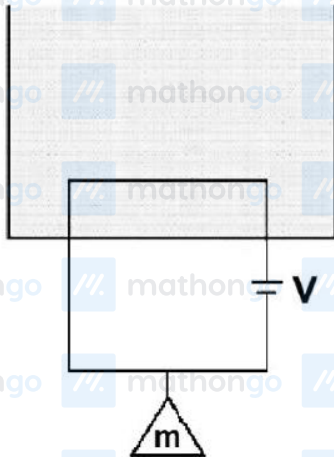
- (1) 8T (2) 4T
(3) 2T (4) 16T

Space for your notes:

Q13 - 30 January - Shift 1

A massless square loop, of wire of resistance 10Ω , supporting a mass of 1 g, hangs vertically with one of its sides in a uniform magnetic field of 10^3 G, directed outwards in the shaded region. A dc voltage V is applied to the loop. For what value of V , the magnetic force will exactly balance the weight of the supporting mass of 1g?

(If sides of the loop = 10 cm, $g = 10 \text{ ms}^{-2}$)



- (1) $\frac{1}{10}$ V (2) 100 V
(3) 1 V (4) 10 V

Space for your notes:

Q14 - 30 January - Shift 1

The magnetic moments associated with two closely wound circular coils A and B of radius $r_A = 10$ cm and $r_B = 20$ cm respectively are equal if: (Where N_A , I_A and N_B , I_B are number of turn and current of A and B respectively)

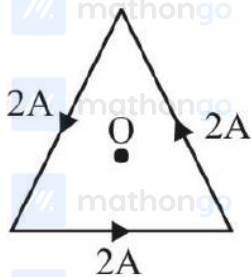
- (1) $2N_A I_A = N_B I_B$ (2) $N_A = 2N_B$
(3) $N_A I_A = 4N_B I_B$ (4) $4N_A I_A = N_B I_B$

Space for your notes:

Q15 - 30 January - Shift 2

As shown in the figure, a current of 2A flowing in an equilateral triangle of side $4\sqrt{3}$ cm. The magnetic field at the centroid O of the triangle is :

Space for your notes:



(Neglect the effect of earth's magnetic field.)

- (1) $4\sqrt{3} \times 10^{-4}$ T (2) $4\sqrt{3} \times 10^{-5}$ T
(3) $\sqrt{3} \times 10^{-4}$ T (4) $3\sqrt{3} \times 10^{-5}$ T

Q16 - 30 January - Shift 2

A current carrying rectangular loop PQRS is made of uniform wire. The length $PR = QS = 5\text{ cm}$ and $PQ = RS = 100\text{ cm}$. If ammeter current reading changes from I to $2I$, the ratio of magnetic forces per unit length on the wire PQ due to wire RS in the two cases respectively $f_{PQ}^I : f_{PQ}^{2I}$ is :



- (1) 1 : 2 (2) 1 : 4
(3) 1 : 5 (4) 1 : 3

Q17 - 31 January - Shift 1

A rod with circular cross-section area 2 cm^2 and length 40 cm is wound uniformly with 400 turns of an insulated wire. If a current of 0.4 A flows in the wire windings, the total magnetic flux produced inside windings is $4\pi \times 10^{-6}\text{ Wb}$. The relative permeability of the rod is (Given : Permeability of vacuum $\mu_0 = 4\pi \times 10^{-7}\text{ NA}^{-2}$)

- (1) 12.5
(2) $\frac{32}{5}$
(3) 125
(4) $\frac{5}{16}$

Q18 - 31 January - Shift 1

A bar magnet with a magnetic moment 5.0 Am^2 is placed in parallel position relative to a magnetic field of 0.4 T . The amount of required work done in turning the magnet from parallel to antiparallel position relative to the field direction is _____.

- (1) 4 J (2) 1 J
(3) 2 J (4) Zero

Space for your notes:

Q19 - 31 January - Shift 2

A long conducting wire having a current I flowing through it, is bent into a circular coil of N turns. Then it is bent into a circular coil of n turns. The magnetic field is calculated at the centre of coils in both the cases. The ratio of the magnetic field in first case to that of second case is:

- (1) $N : n$ (2) $n^2 : N^2$
(3) $N^2 : n^2$ (4) $n : N$

Space for your notes:

Q20 - 01 February - Shift 1

Find the magnetic field at the point P in figure. The curved portion is a semicircle connected to two long straight wires.



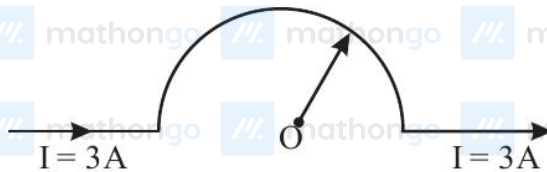
Space for your notes:

- (1) $\frac{\mu_0 i}{2r} \left(1 + \frac{2}{\pi}\right)$ (2) $\frac{\mu_0 i}{2r} \left(1 + \frac{1}{\pi}\right)$
 (3) $\frac{\mu_0 i}{2r} \left(\frac{1}{2} + \frac{1}{2\pi}\right)$ (4) $\frac{\mu_0 i}{2r} \left(\frac{1}{2} + \frac{1}{\pi}\right)$

Q21 - 01 February - Shift 2

As shown in the figure, a long straight conductor with semicircular arc of radius $\frac{\pi}{10}$ m is carrying current $I = 3$ A. The magnitude of the magnetic field, at the center O of the arc is:
 (The permeability of the vacuum $= 4\pi \times 10^{-7} \text{ NA}^{-2}$)

Space for your notes:



- (1) $6\mu\text{T}$ (2) $1\mu\text{T}$
 (3) $4\mu\text{T}$ (4) $3\mu\text{T}$

Q22 - 01 February - Shift 2

A coil is placed in magnetic field such that plane of coil is perpendicular to the direction of magnetic field. The magnetic flux through a coil can be changed:

A. By changing the magnitude of the magnetic field within the coil.

B. By changing the area of coil within the magnetic field.

C. By changing the angle between the direction of magnetic field and the plane of the coil.

D. By reversing the magnetic field direction abruptly without changing its magnitude.

Choose the most appropriate answer from the options given below:

(1) **A** and **B** only (2) **A**, **B** and **C** only

(3) **A**, **B** and **D** only (4) **A** and **C** only

Q23 - 01 February - Shift 2

A square shaped coil of area 70 cm^2 having 600 turns rotates in a magnetic field of 0.4 wb m^{-2} , about an axis which is parallel to one of the side of the coil and perpendicular to the direction of field. If the coil completes 500 revolution in a minute, the instantaneous emf when the plane of the coil is inclined at 60° with the field, will be ____ V.

(Take $\pi = \frac{22}{7}$)

Space for your notes:

Space for your notes:

Answer Key

(As per Official NTA Key released on 2 Feb)

Q1 (1)

Q2 (3)

Q3 (2)

Q4 (9)

Q5 (3)

Q6 (2)

Q7 (2)

Q8 (68)

Q9 (3)

Q10 (4)

Q11 (2)

Q12 (3)

Q13 (4)

Q14 (3)

Q15 (4)

Q16 (2)

Q17 (3)

Q18 (1)

Q19 (3)

Q20 (3)

Q21 (4)

Q22 (2)

Q23 (44)

#MathBoleTohMathonGo

Q1 (1)

Force per unit length between two parallel straight

$$\text{wires} = \frac{\mu_0 i_1 i_2}{2\pi d}$$

$$\frac{F_1}{F_2} = \frac{\mu_0 (10)^2}{2\pi (5\text{cm})} = \frac{1}{8}$$

$$\frac{\mu_0 (20)^2}{2\pi \left(\frac{5\text{cm}}{2}\right)}$$

$$\Rightarrow F_2 = 8F_1$$

Q2 (3)

Magnetic field due to current carrying circular loop

on its axis is given as

$$\frac{\mu_0 i r^2}{2(r^2 + x^2)^{3/2}}$$

$$\text{At centre, } x = 0, B_1 = \frac{\mu_0 i}{2r}$$

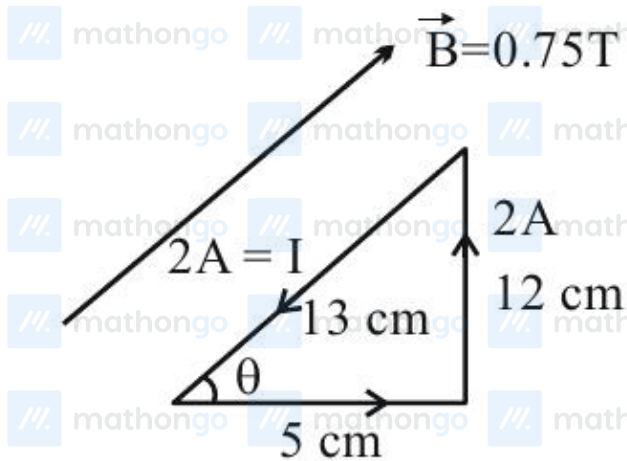
$$\text{At } x = r, B_2 = \frac{\mu_0 i}{2 \times 2\sqrt{2}r}$$

$$\frac{B_1}{B_2} = 2\sqrt{2}$$

Q3 (2)

$$\begin{aligned}
 B &= \mu_0 n I \\
 &= 4\pi \times 10^{-7} \times 70 \times 10^2 \times 2 \\
 &= 56\pi \times 10^{-4} \text{ T} \\
 &= 176 \times 10^{-4} \text{ T}
 \end{aligned}$$

Q4 (9)



Force on 5 cm side is

$$\begin{aligned}
 |\vec{F}| &= ILB \sin \theta \\
 &= (2)(5 \times 10^{-2}) \times \frac{3}{4} \times \frac{12}{13} = \frac{9}{130} \text{ N}
 \end{aligned}$$

So, $x = 9$

Q5 (3)

Math List I with List II

List – I (Current configuration)		List – II (Magnetic field at point O)	
A		I.	$B_0 = \frac{\mu_0 I}{4\pi r} [\pi + 2]$
B		II.	$B_0 = \frac{\mu_0 I}{4 r}$
C		III.	$B_0 = \frac{\mu_0 I}{2\pi r} [\pi - 1]$
D		IV.	$B_0 = \frac{\mu_0 I}{4\pi r} [\pi + 1]$

Choose the correct answer from the option given below:

- (1) A-III, B-IV, C-I, D-II
- (2) A-I, B-III, C-IV, D-II
- (3) A-III, B-I, C-IV, D-II
- (4) A-II, B-I, C-IV, D-III

Q6 (2)

Magnetic field at centre inside the solenoid is given by

$$B = \mu_0 nI$$

So magnetic intensity at centre

$$H = \frac{B}{\mu_0} = nI = \left(\frac{1200}{2} \right) (2)$$

$$H = 1.2 \times 10^3 \text{ Am}^{-1}$$

Q7 (2)

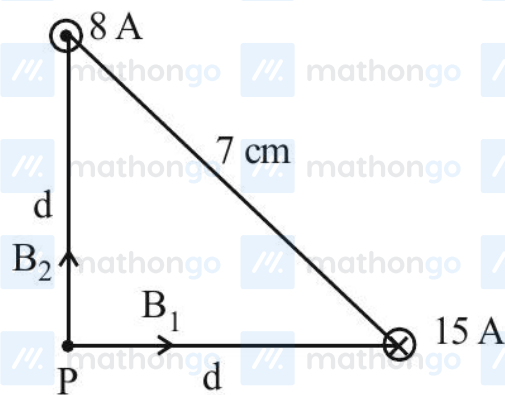
$$\tau = K\theta$$

$$NiAB = K\theta$$

$$A = \frac{K\theta}{NiB} = \frac{4 \times 10^{-5} \times 0.05}{200 \times 10 \times 10^{-3} \times 0.01}$$

$$\text{On solving } A = 10^{-4} \text{ m}^2 = 1 \text{ cm}^2$$

Q8 (68)



Magnetic fields due to both wires will be perpendicular to each other.

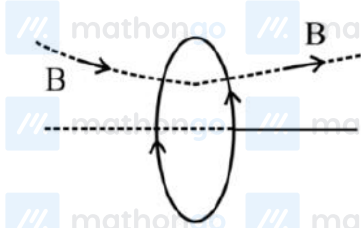
$$B_1 = \frac{\mu_0 i_1}{2\pi d} \quad B_2 = \frac{\mu_0 i_2}{2\pi d}$$

$$B_{\text{net}} = \sqrt{B_1^2 + B_2^2} \Rightarrow \frac{\mu_0}{2\pi d} \sqrt{i_1^2 + i_2^2}$$

$$\Rightarrow \frac{4\pi \times 10^{-7}}{2\pi \times (7/\sqrt{2}) \times 10^{-2}} \times \sqrt{8^2 + 15^2} \quad (d = \frac{7}{\sqrt{2}} \text{ cm})$$

$$\Rightarrow 68 \times 10^{-6} \text{ T}$$

Q9 (3)



$B_y = 0$ in plane of coil

B_y is opposite of each other in $-z$ and $+z$ positions.

Q10 (4)

Magnetic field due to current in BC and ET are outward at point 'O'

$$B_0 = \frac{\mu_0 i}{4\pi r} + \frac{\mu_0 i}{4\pi r} = \frac{\mu_0 i}{2\pi r} = \frac{\mu_0 i}{\pi a}$$

Q11 (2)

$$\ell = 50 \text{ cm}$$

$$t = 1 \text{ sec}$$

$$\therefore V = \frac{0.05}{1} = 0.05 \text{ m/s.}$$

$$i = \frac{40 \times 0.05 \times 0.05}{10} = 0.01 \text{ A}$$

$$F = B_i \ell = 40 \times 0.01 \times 0.05$$

$$F = 0.02 \text{ N}$$

$$\therefore W = 0.02 \times \ell = 0.02 \times .05$$

$$\therefore W = 1 \times 10^{-3} \text{ J}$$

Q12 (3)

$$B = \frac{\mu_0 i}{2R} \times 4$$

$$B' = \frac{\mu_0 i}{2R'}$$

$$R' = 4R$$

$$B' = \frac{\mu_0 i}{8R}$$

$$\frac{B'}{B} = \frac{1}{16}$$

$$B' = 2T$$

Q13 (4)

$$F_m = mg$$

$$\therefore ILB = mg$$

$$\therefore \left(\frac{V}{R}\right)LB = mg$$

$$\therefore V = \frac{mgR}{LB}$$

$$= \frac{(1 \times 10^{-3} \text{ kg})(10 \text{ m/s}^2)(10\Omega)}{(0.1 \text{ m})(10^3 \times 10^{-4} \text{ T})} = 10 \text{ V}$$

Q14 (3)

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$$M = NIA$$

$$M_A = M_B$$

$$\therefore N_A I_A A_A = N_B I_B A_B$$

$$\therefore N_A I_A \pi (0.1)^2 = N_B I_B \pi (0.2)^2$$

$$\therefore N_A I_A = 4 N_B I_B$$

Q15 (4)

$$d \tan 60^\circ = 2\sqrt{3}$$

$$d = 2 \text{ cm}$$

$$B = 3 \times \frac{\mu_0 i}{2\pi d} \sin 60^\circ$$

$$= 3 \times \frac{2 \times 10^{-7} \times 2}{2 \times 10^{-2}} \times \frac{\sqrt{3}}{2}$$

$$= 3\sqrt{3} \times 10^{-5}$$

Q16 (2)

$$F \propto I_1 I_2$$

$$F_1 : F_2 = 1 : 4$$

Q17 (3)

$$\phi = \mu_r \mu_0 \frac{N}{\ell} I \times A$$

$$\mu_r = 125$$

Option 3.

Q18 (1)

$$u = -MB \cos \theta$$

$$W = \Delta u$$

$$W = -MB \cos 180^\circ (-mB \cos 0^\circ)$$

$$W = 2MB = 2 \times 5 \times 0.4 = 4J$$

Option 1

Q19 (3)

No Solution

Q20 (3)

$$B_P = \left(\frac{\mu_0 i}{4r} + \frac{\mu_0 i}{4\pi r} \right) = \frac{\mu_0 i}{2r} \left(\frac{1}{2} + \frac{1}{2\pi} \right)$$

Q21 (4)

$$B_c = \frac{\mu_0 I}{4\pi R} (\pi) \text{ (B at centre of circular arc)}$$

$$= \frac{\mu_0 I}{4R} = \frac{4\pi \times 10^{-7} \times 3}{4 \times \frac{\pi}{10}}$$

$$= 3 \times 10^{-6} \text{ T} = 3 \mu\text{T}$$

Q22 (2)

$$\phi = \vec{B} \cdot \vec{A}$$

$$= BA \cos \theta$$

Most suitable ans is 2 [Otherwise ABCD]

Q23 (44)

$$N = 600, A = 70 \times 10^{-4} \text{ m}^2, B = 0.4 \text{ T}$$

$$\omega = \frac{500 \times 2\pi}{60} = \frac{100\pi}{6} \text{ rad/s}$$

$$E = NAB\omega \sin \omega t \quad \omega t \text{ is angle b/w } \vec{A} \text{ \& \> } \vec{B}$$

$$= 600 \times 70 \times 10^{-4} \times 0.4 \times \frac{100\pi}{6} \times \frac{1}{2}$$

$$= 44 \text{ V}$$

Questions

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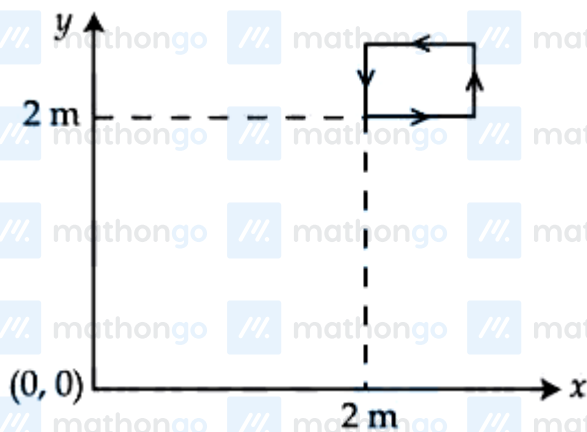
Q1 - 2024 (04 Apr Shift 1)

An electron is projected with uniform velocity along the axis inside a current carrying long solenoid. Then :

- (1) the electron will continue to move with uniform velocity along the axis of the solenoid.
- (2) the electron will be accelerated along the axis.
- (3) the electron path will be circular about the axis.
- (4) the electron will experience a force at 45° to the axis and execute a helical path.

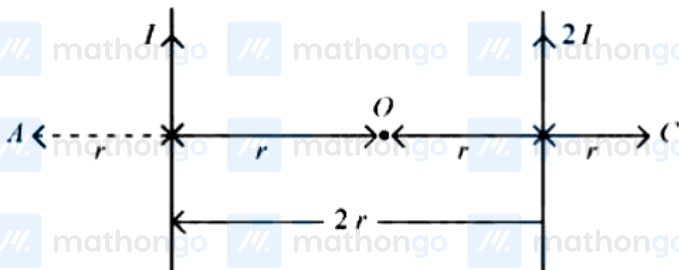
Q2 - 2024 (04 Apr Shift 1)

The magnetic field existing in a region is given by $\vec{B} = 0.2(1 + 2x)\hat{k}$ T. A square loop of edge 50 cm carrying 0.5 A current is placed in $x - y$ plane with its edges parallel to the $x - y$ axes, as shown in figure. The magnitude of the net magnetic force experienced by the loop is _____ mN.



Q3 - 2024 (04 Apr Shift 2)

Two parallel long current carrying wire separated by a distance $2r$ are shown in the figure. The ratio of magnetic field at A to the magnetic field produced at C is $\frac{x}{7}$. The value of x is _____



Questions

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Q4 - 2024 (05 Apr Shift 1)

In a co-axial straight cable, the central conductor and the outer conductor carry equal currents in opposite directions. The magnetic field is zero :

- (1) outside the cable
- (2) inside the outer conductor
- (3) inside the inner conductor
- (4) in between the two conductors

Q5 - 2024 (05 Apr Shift 1)

A 2 A current carrying straight metal wire of resistance 1Ω , resistivity $2 \times 10^{-6}\Omega\text{m}$, area of cross-section 10 mm^2 and mass 500 g is suspended horizontally in mid air by applying a uniform magnetic field $\vec{B}$. The magnitude of B is $\underline{\hspace{2cm}} \times 10^{-1}\text{ T}$ (given, $g = 10\text{ m/s}^2$).

Q6 - 2024 (05 Apr Shift 2)

The electrostatic force $\left(\vec{F}_1\right)$ and magnetic force $\left(\vec{F}_2\right)$ acting on a charge q moving with velocity v can be written :

- (1) $\vec{F}_1 = q\vec{E}, \vec{F}_2 = q(\vec{V} \times \vec{B})$
- (2) $\vec{F}_1 = q\vec{B}, \vec{F}_2 = q(\vec{B} \times \vec{V})$
- (3) $\vec{F}_1 = q\vec{E}, \vec{F}_2 = q(\vec{B} \times \vec{V})$
- (4) $\vec{F}_1 = q\vec{V} \cdot \vec{E}, \vec{F}_2 = q(\vec{B} \cdot \vec{V})$

Q7 - 2024 (05 Apr Shift 2)

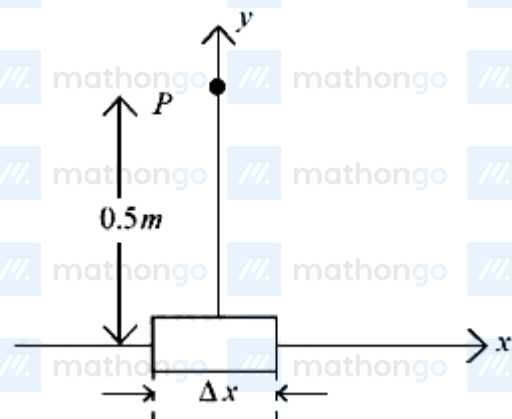
A solenoid of length 0.5 m has a radius of 1 cm and is made up of 'm' number of turns. It carries a current of 5 A. If the magnitude of the magnetic field inside the solenoid is $6.28 \times 10^{-3}\text{ T}$ then the value of m is $\underline{\hspace{2cm}}$.

Q8 - 2024 (06 Apr Shift 1)

Questions

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An element $\Delta l = \Delta x \hat{i}$ is placed at the origin and carries a large current $I = 10$ A. The magnetic field on the y -axis at a distance of 0.5 m from the elements Δx of 1 cm length is:



- (1) 4×10^{-8} T
- (2) 10×10^{-8} T
- (3) 8×10^{-8} T
- (4) 12×10^{-8} T

Q9 - 2024 (06 Apr Shift 1)

A circular coil having 200 turns, $2.5 \times 10^{-4} \text{ m}^2$ area and carrying $100\mu\text{A}$ current is placed in a uniform magnetic field of 1T. Initially the magnetic dipole moment ($\vec{M}$) was directed along $\vec{B}$. Amount of work, required to rotate the coil through 90° from its initial orientation such that $\vec{M}$ becomes perpendicular to $\vec{B}$, is _____ μJ .

Q10 - 2024 (06 Apr Shift 2)

A coil having 100 turns, area of $5 \times 10^{-3} \text{ m}^2$, carrying current of 1 mA is placed in uniform magnetic field of 0.20 T such a way that plane of coil is perpendicular to the magnetic field. The work done in turning the coil through 90° is _____ μJ .

Q11 - 2024 (08 Apr Shift 1)

Questions

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An electron with kinetic energy 5eV enters a region of uniform magnetic field of $3\text{ }\mu\text{T}$ perpendicular to its direction. An electric field E is applied perpendicular to the direction of velocity and magnetic field. The value of E , so that electron moves along the same path, is _____ NC^{-1} .

(Given, mass of electron $= 9 \times 10^{-31}\text{ kg}$, electric charge $= 1.6 \times 10^{-19}\text{ C}$)

Q12 - 2024 (08 Apr Shift 2)

A long straight wire of radius a carries a steady current I . The current is uniformly distributed across its cross section. The ratio of the magnetic field at $\frac{a}{2}$ and $2a$ from axis of the wire is :

(1) $1 : 4$

(2) $1 : 1$

(3) $3 : 4$

(4) $4 : 1$

Q13 - 2024 (09 Apr Shift 1)

Given below are two statements :

Statement (I) : When currents vary with time, Newton's third law is valid only if momentum carried by the electromagnetic field is taken into account.

Statement (II) : Ampere's circuital law does not depend on Biot-Savart's law.

In the light of the above statements, choose the correct answer from the options given below :

(1) Both Statement I and Statement II are true

(2) Statement I is true but Statement II is false

(3) Both Statement I and Statement II are false

(4) Statement I is false but Statement II is true

Q14 - 2024 (09 Apr Shift 1)

A square loop of edge length 2 m carrying current of 2 A is placed with its edges parallel to the x y axis. A

magnetic field is passing through the $x - y$ plane and expressed as $\vec{B} = B_0(1 + 4x)\hat{k}$, where $B_0 = 5\text{ T}$. The

Questions

MathonGo

net magnetic force experienced by the loop is _____ N.

Q15 - 2024 (09 Apr Shift 2)

A proton and a deuteron ($q = +e, m = 2.0u$) having same kinetic energies enter a region of uniform magnetic field $\vec{B}$, moving perpendicular to $\vec{B}$. The ratio of the radius r_d of deuteron path to the radius r_p of the proton path is:

(1) $\sqrt{2} : 1$

(2) $1 : 1$

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

(4) $1 : 2$

Q16 - 2024 (09 Apr Shift 2)

A straight magnetic strip has a magnetic moment of 44Am^2 . If the strip is bent in a semicircular shape, its magnetic moment will be _____ Am^2 .

(given $\pi = \frac{22}{7}$)

Questions

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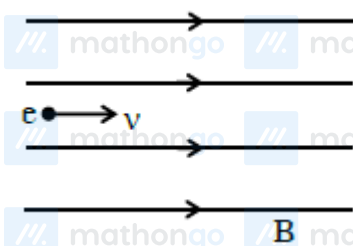
Answer Key

Q1 (1)	Q2 (50)	Q3 (5)	Q4 (1)		
Q5 (5)	Q6 (1)	Q7 (500)	Q8 (1)		
Q9 (5)	Q10 (100)	Q11 (4)	Q12 (2)		
Q13 (2)	Q14 (160)	Q15 (1)	Q16 (28)		

Solutions

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Q1



Since $\vec{v} \parallel \vec{B}$ so force on electron due to magnetic field is zero. So it will move along axis with uniform velocity.

Q2

Force on segment parallel to x-axis will cancel each other. Hence F_{net} will be due to portion parallel to y-axis.

$$F = 0.5 \times 0.5 \times 6 \times 0.2 - 0.5 \times 0.5 \times 0.2 \times 5$$

$$= 0.5 \times 0.5 \times 0.2$$

$$= 0.25 \times 0.2$$

$$= 50 \times 10^{-3} \text{ N}$$

$$= 50 \text{ mN}$$

Q3

$$B_A = \frac{\mu_0 i}{2\pi r} + \frac{\mu_0 (2i)}{2\pi (3r)} = \frac{5\mu_0 i}{6\pi r}$$

$$B_C = \frac{\mu_0 (2i)}{2\pi r} + \frac{\mu_0 i}{2\pi (3r)} = \frac{7\mu_0 i}{6\pi r}$$

$$\therefore \frac{B_A}{B_C} = \frac{5}{7}$$

$$\therefore x = 5$$

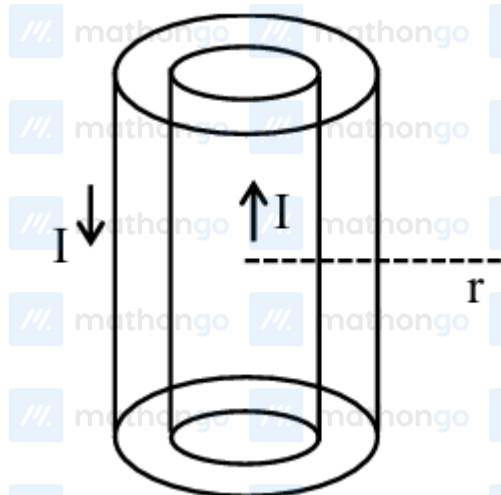
Q4

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Solutions

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$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 i_{\text{enc}} = 0$$

$\therefore B = 0$ outside the cable

Q5

$$R = \frac{\rho \ell}{A} \Rightarrow \frac{2 \times 10^{-6} \times \ell}{10^{-5}} = 1 \Rightarrow \ell = 5$$

$$mg = Bi\ell$$

$$B = \frac{mg}{i\ell} = \frac{5}{2 \times 5} = 0.5 = 5 \times 10^{-1} \text{ Tesla}$$

Q6

$$\vec{F}_1 = q\vec{E}$$

$$\vec{F}_2 = q(\vec{V} \times \vec{B})$$

(Theory)

Q7

$$\mu_0 n i = B \quad n = \text{number of turns per unit length}$$

$$\mu_0 \left(\frac{m}{\ell} \right) i = B$$

$$m = \frac{B \cdot \ell}{\mu_0 i} = \frac{6.28 \times 10^{-3} \times 0.5}{12.56 \times 10^{-7} \times 5}$$

$$m = 500$$

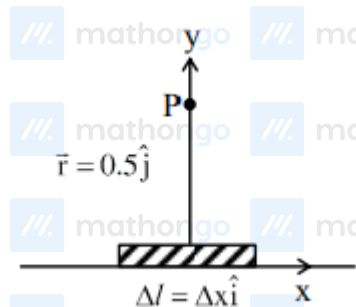
Q8

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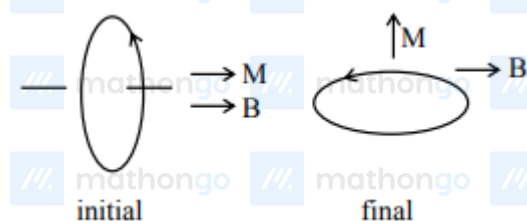
Solutions

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$$\begin{aligned} d\vec{B} &= \frac{\mu_0 I}{4\pi} \frac{(\vec{dl} \times \vec{r})}{r^3} \text{ (Tesla)} \\ &= \frac{10^{-7} \times 10 \times \left(\frac{1}{2} \times \frac{1}{100}\right) (+\hat{k})}{\left(\frac{1}{2}\right)^3} = 4 \times 10^{-8} \text{ T} (+\hat{k}) \end{aligned}$$

Q9



We know

$$\begin{aligned} W_{\text{ext}} &= \Delta U + \Delta KE \quad (\text{P.E.} = -\vec{M} \cdot \vec{B}) \\ &= -\vec{M} \cdot \vec{B}_f + \vec{M} \cdot \vec{B}_i + 0 \\ &= -MB \cos 90^\circ + MB \cos 0^\circ \\ &= MB \\ &= NIAB \\ &= 200 \times 100 \times 10^{-6} \times \frac{5}{2} \times 10^{-4} \times 1 = 5 \mu\text{J} \end{aligned}$$

Q10

$$\begin{aligned} W &= \Delta U = U_f - U_i \\ W &= (-\vec{\mu} \cdot \vec{B})_f - (-\vec{\mu} \cdot \vec{B})_i \\ &= 0 + (\vec{\mu} \cdot \vec{B})_i \\ &= (100 \times 5 \times 10^{-3} \times 1 \times 10^{-3}) \times 0.2 \text{ J} \\ &= 1 \times 10^{-4} \text{ J} = 100 \mu\text{J} \end{aligned}$$

Q11

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Solutions

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For the given condition of moving undeflected, net force should be zero.

$$qE = qVB$$

$$E = VB$$

$$= \sqrt{\frac{2 \times KE}{m}} \times B$$

$$= \sqrt{\frac{2 \times 5 \times 1.6 \times 10^{-19}}{9 \times 10^{-31}}} \times 3 \times 10^{-6}$$

$$= 4 \text{ N/C}$$

Q12

$$B_1 2\pi \frac{a}{2} = \mu_0 \frac{I}{4}$$

$$B_1 = \frac{\mu_0 I}{4\pi a}$$

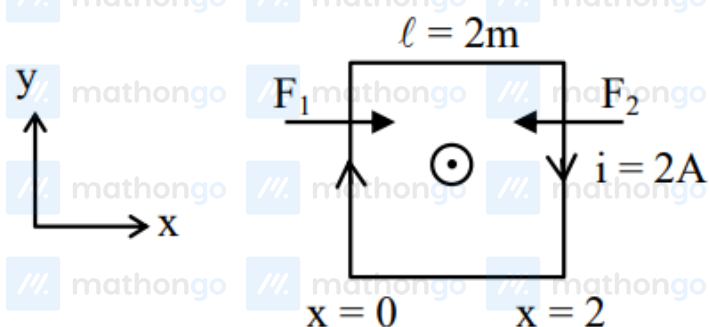
$$B_2 2\pi 2a = \mu_0 I$$

$$B_2 = \frac{\mu_0 I}{4\pi a}$$

Q13

Conceptual.

Q14



$$B(x=0) = B_0,$$

$$B(x=2) = 9 B_0$$

$$\text{Also, } F = i\ell B$$

$$\Rightarrow F_1 = i\ell B_0 \text{ \& } F_2 = 9i\ell B_0$$

$$F = F_2 - F_1 = 8i\ell B_0 = 8 \times 2 \times 2 \times 5$$

$$F = 160 \text{ N}$$

Q15

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Solutions

MathonGo

In uniform magnetic field,

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

Since same K.E

$$R \propto \frac{\sqrt{m}}{q}$$

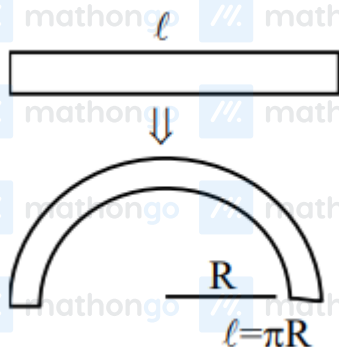
$$\therefore \frac{R_{\text{deuteron}}}{R_{\text{proton}}} = \sqrt{\frac{m_d}{m_p}} \times \frac{q_p}{q_d}$$

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

$$\therefore \gamma_d : \gamma_p = \sqrt{2} : 1$$

Q16

Magnetic moment of straight wire = $mx\ell = 44$



Magnetic moment of arc

$$= m \times 2r$$

$$= m \times \frac{2\ell}{\pi}$$

$$= \frac{44 \times 2}{\pi} = \frac{88}{\pi} = 28$$

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Questions with Answer Keys

MathonGo

Q1 - 2024 (01 Feb Shift 1)

A regular polygon of 6 sides is formed by bending a wire of length 4π meter. If an electric current of $4\pi\sqrt{3}$ A is flowing through the sides of the polygon, the magnetic field at the centre of the polygon would be $x \times 10^{-7}$ T. The value of x is _____

Q2 - 2024 (01 Feb Shift 2)

A moving coil galvanometer has 100 turns and each turn has an area of 2.0 cm^2 . The magnetic field produced by the magnet is 0.01 T and the deflection in the coil is 0.05 radian when a current of 10 mA is passed through it. The torsional constant of the suspension wire is $x \times 10^{-5} \text{ N - m/rad}$. The value of x is _____

Q3 - 2024 (27 Jan Shift 1)

Position of an ant (S in metres) moving in Y – Z plane is given by $S = 2t^2\hat{j} + 5\hat{k}$ (where t is in second). The magnitude and direction of velocity of the ant at $t = 1$ s will be :

- (1) 16 m/s in y-direction
- (2) 4 m/s in x-direction
- (3) 9 m/s in z-direction
- (4) 4 m/s in y-direction

Q4 - 2024 (27 Jan Shift 1)

A proton moving with a constant velocity passes through a region of space without any change in its velocity.

If $\vec{E}$ and $\vec{B}$ represent the electric and magnetic fields respectively, then the region of space may have :

- (A) $E = 0, B = 0$
- (B) $E = 0, B \neq 0$
- (C) $E \neq 0, B = 0$
- (D) $E \neq 0, B \neq 0$

Choose the most appropriate answer from the options given below :

- (1) (A), (B) and (C) only

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Questions with Answer Keys

MathonGo

(2) (A), (C) and (D) only

(3) (A), (B) and (D) only

(4) (B), (C) and (D) only

Q5 - 2024 (27 Jan Shift 1)

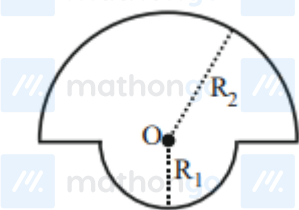
Two long, straight wires carry equal currents in opposite directions as shown in figure. The separation between the wires is 5.0 cm. The magnitude of the magnetic field at a point P midway between the wires is _____ μT

(Given : $\mu_0 = 4\pi \times 10^{-7} \text{TmA}^{-1}$)



Q6 - 2024 (27 Jan Shift 2)

The magnetic field at the centre of a wire loop formed by two semicircular wires of radii $R_1 = 2\pi\text{m}$ and $R_2 = 4\pi\text{m}$ carrying current $I = 4\text{ A}$ as per figure given below is $\alpha \times 10^{-7}\text{ T}$. The value of α is _____ (Centre O is common for all segments)



Q7 - 2024 (29 Jan Shift 1)

The magnetic potential due to a magnetic dipole at a point on its axis situated at a distance of 20 cm from its center is $1.5 \times 10^{-5} \text{Tm}$. The magnetic moment of the dipole is _____ Am^2 . (Given : $\frac{\mu_0}{4\pi} = 10^{-7} \text{TmA}^{-1}$)

Q8 - 2024 (29 Jan Shift 2)

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Questions with Answer Keys

MathonGo

Two particles X and Y having equal charges are being accelerated through the same potential difference.

Thereafter they enter normally in a region of uniform magnetic field and describes circular paths of radii R_1 and R_2 respectively. The mass ratio of X and Y is :

(1) $\left(\frac{R_2}{R_1}\right)^2$

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

(3) $\left(\frac{R_1}{R_2}\right)$

(4) $\left(\frac{R_2}{R_1}\right)$

Q9 - 2024 (29 Jan Shift 2)

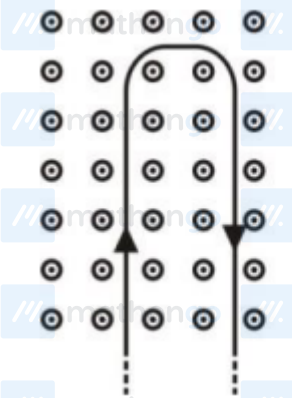
A charge of $4.0\mu\text{C}$ is moving with a velocity of $4.0 \times 10^6 \text{ ms}^{-1}$ along the positive y-axis under a magnetic field $\vec{B}$ of strength $(2\hat{k})$ T. The force acting on the charge is $x\hat{i}$ N. The value of x is _____

Q10 - 2024 (30 Jan Shift 2)

The current of 5 A flows in a square loop of sides 1 m is placed in air. The magnetic field at the centre of the loop is $X\sqrt{2} \times 10^{-7}$ T. The value of X is _____

Q11 - 2024 (31 Jan Shift 1)

A rigid wire consists of a semicircular portion of radius R and two straight sections. The wire is partially immersed in a perpendicular magnetic field $B = B_0\hat{j}$ as shown in figure. The magnetic force on the wire if it has a current i is :



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Questions with Answer Keys

MathonGo

(1) $-iBR\hat{j}$

(2) $2iBR\hat{j}$

(3) $iBR\hat{j}$

(4) $-2iBR\hat{j}$

Q12 - 2024 (31 Jan Shift 1)

A coil is placed perpendicular to a magnetic field of 5000 T. When the field is changed to 3000 T in 2 s, an induced emf of 22 V is produced in the coil. If the diameter of the coil is 0.02 m, then the number of turns in the coil is :

(1) 7

(2) 70

(3) 35

(4) 140

Q13 - 2024 (31 Jan Shift 1)

An electron moves through a uniform magnetic field $\vec{B} = B_0\hat{i} + 2B_0\hat{j}T$. At a particular instant of time, the velocity of electron is $\vec{u} = 3\hat{i} + 5\hat{j}$ m/s. If the magnetic force acting on electron is $\vec{F} = 5ekN$, where e is the charge of electron, then the value of B_0 is _____ T.

Q14 - 2024 (31 Jan Shift 2)

A uniform magnetic field of 2×10^{-3} T acts along positive Y-direction. A rectangular loop of sides 20 cm and 10 cm with current of 5 A is Y – Z plane. The current is in anticlockwise sense with reference to negative X axis. Magnitude and direction of the torque is :

(1) 2×10^{-4} N – m along positive Z-direction

(2) 2×10^{-4} N – m along negative Z-direction

(3) 2×10^{-4} N – m along positive X-direction

(4) 2×10^{-4} N – m along positive Y-direction

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Questions with Answer Keys

MathonGo

Q15 - 2024 (31 Jan Shift 2)

Two circular coils P and Q of 100 turns each have same radius of π cm. The currents in P and R are 1 A and 2 A respectively. P and Q are placed with their planes mutually perpendicular with their centers coincide. The resultant magnetic field induction at the center of the coils is $\sqrt{x}$ mT, where $x = \underline{\hspace{2cm}}$

[Use $\mu_0 = 4\pi \times 10^{-7} \text{ TmA}^{-1}$]

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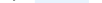
MathonGo

Answer Key

Q1 (72) mathongo **Q2 (4)** mathongo **Q3 (4)** mathongo **Q4 (3)** mathongo

Q5 (160) **Q6** (3) **Q7** (6) **Q8** (2)

Q9 (32) **Q10 (40)** **Q11 (4)** **Q12 (2)**

Q13 (5)  **Q14 (2)**  **Q15 (20)**   

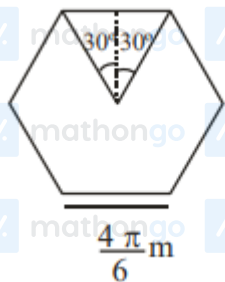
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Solutions

MathonGo

Q1



$$B = 6 \left(\frac{\mu_0 I}{4\pi r} \right) (\sin 30^\circ + \sin 30^\circ)$$

$$= 6 \frac{10^{-7} \times 4\pi \sqrt{3}}{\left(\frac{\sqrt{3} \times 4\pi}{2 \times 6} \right)}$$

$$= 72 \times 10^{-7} \text{ T}$$

Q2

$$\tau = BINA \sin$$

$$C\theta = BINA \sin 90^\circ$$

$$C = \frac{BINA}{\theta} = \frac{0.01 \times 10 \times 10^{-3} \times 100 \times 2 \times 10^{-4}}{0.05}$$

$$= 4 \times 10^{-5} \text{ N-m/rad.}$$

$$x = 4$$

Q3

$$\vec{v} = \frac{d\vec{s}}{dt} = 4t\hat{j}$$

$$\text{At } t = 1 \text{ sec } \vec{v} = 4\hat{j}$$

Q4

Net force on particle must be zero i.e. $q\vec{E} + q\vec{V} \times \vec{B} = 0$

Possible cases are

$$(i) \vec{E} \& \vec{B} = 0$$

$$(ii) \vec{V} \times \vec{B} = 0, \vec{E} = 0$$

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Solutions

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

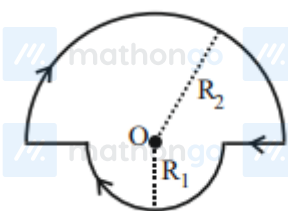
$$\vec{E} \neq 0 \& \vec{B} \neq 0$$

Q5

$$B = \left(\frac{\mu_0 i}{2\pi a} \right) \times 2 = \frac{4\pi \times 10^{-7} \times 10}{\pi \times \left(\frac{5}{2} \times 10^{-2} \right)}$$

$$= 16 \times 10^{-5} = 160 \mu T$$

Q6



$$\frac{\mu_0 i}{2R_2} \left(\frac{\pi}{2\pi} \right) \otimes + \frac{\mu_0 i}{2R_1} \left(\frac{\pi}{2\pi} \right) \otimes$$

$$\left(\frac{\mu_0 i}{4R_2} + \frac{\mu_0 i}{4R_1} \right) \otimes$$

$$\frac{4\pi \times 10^{-7} \times 4}{4 \times 4\pi} + \frac{4\pi \times 10^{-7} \times 4}{4 \times 2\pi}$$

$$= 3 \times 10^{-7} = \alpha \times 10^{-7}$$

$$\alpha = 3$$

Q7

$$V = \frac{\mu_0}{4\pi} \frac{M}{r^2}$$

$$\Rightarrow 1.5 \times 10^{-5} = 10^{-7} \times \frac{M}{(20 \times 10^{-2})^2}$$

$$\Rightarrow M = \frac{1.5 \times 10^{-5} \times 20 \times 20 \times 10^{-4}}{10^{-7}}$$

$$M = 1.5 \times 4 = 6$$

Q8

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Solutions

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$$R = \frac{mv}{qB} = \frac{p}{qB} = \frac{\sqrt{2m(KE)}}{qB} = \frac{\sqrt{2mqV}}{qB}$$

$$R \propto \sqrt{m}$$

$$m \propto R^2$$

$$\frac{m_1}{m_2} = \left(\frac{R_1}{R_2}\right)^2$$

Q9

$$q = 4\mu C, \vec{v} = 4 \times 10^6 \hat{j} \text{ m/s}$$

$$\vec{B} = 2\hat{k} \text{ T}$$

$$\vec{F} = q(\vec{v} \times \vec{B})$$

$$= 4 \times 10^{-6} (4 \times 10^6 \hat{j} \times 2\hat{k})$$

$$= 4 \times 10^{-6} \times 8 \times 10^6 \hat{i}$$

$$\vec{F} = 32\hat{i} \text{ N}$$

$$x = 32$$

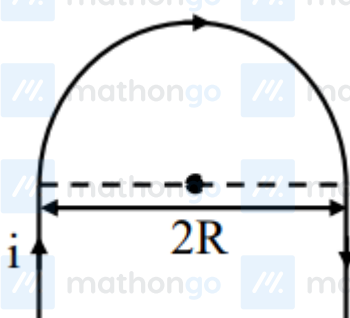
Q10

$$B = 4 \times \frac{\mu_0 i}{4\pi(1/2)} \left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}} \right)$$

$$= 4 \times 10^{-7} \times 5 \times 2 \times \sqrt{2}$$

$$= 40\sqrt{2} \times 10^{-7} \text{ T}$$

Q11



Note : Direction of magnetic field is in $+\hat{k}$

$$\vec{F} = i\vec{\ell} \times \vec{B}$$

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Solutions

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$$\ell = 2R$$

$$\vec{F} = -2iRB\hat{j}$$

Q12

$$\varepsilon = N \left(\frac{\Delta\phi}{t} \right)$$

$$\Delta\phi = (\Delta B)A$$

$$B_i = 5000 \text{ T},$$

$$B_f = 3000 \text{ T}$$

$$d = 0.02 \text{ m}$$

$$r = 0.01 \text{ m}$$

$$\Delta\phi = (\Delta B)A$$

$$= (2000)\pi(0.01)^2 = 0.2\pi$$

$$\varepsilon = N \left(\frac{\Delta\phi}{t} \right) \Rightarrow 22 = N \left(\frac{0.2\pi}{2} \right)$$

$$N = 70$$

Q13

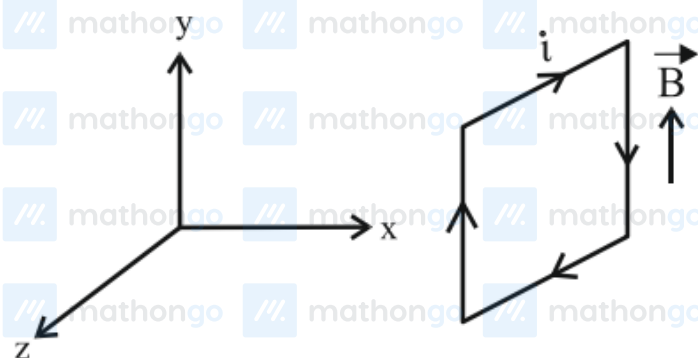
$$\vec{F} = q(\vec{v} \times \vec{B})$$

$$5e\hat{k} = e(3\hat{i} + 5\hat{j}) \times (B_0\hat{i} + 2B_0\hat{j})$$

$$5e\hat{k} = e(6B_0\hat{k} - 5B_0\hat{k})$$

$$\Rightarrow B_0 = 5 \text{ T}$$

Q14



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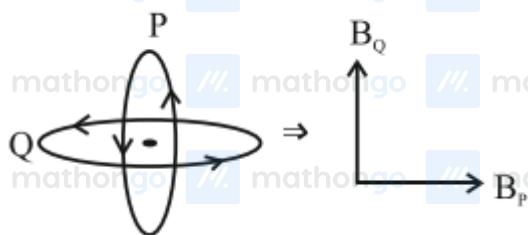
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Solutions

MathonGo

$$\begin{aligned}\vec{M} &= i \vec{A} \\ &= 5 \times (0.2) \times (0.1)(-\hat{i}) \\ &= 0.1(-\hat{i}) \\ \vec{\tau} &= \vec{M} \times \vec{B} = 0.1(-\hat{i}) \times (2 \times 10^{-3})(\hat{j}) \\ &= 2 \times 10^{-4}(-\hat{k}) \text{ N-m}\end{aligned}$$

Q15



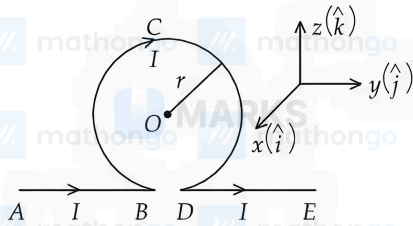
$$\begin{aligned}B_P &= \frac{\mu_0 N i_1}{2r} = \frac{\mu_0 \times 1 \times 100}{2\pi} = 2 \times 10^{-3} \text{ T} \\ B_Q &= \frac{\mu_0 N i_2}{2r} = \frac{\mu_0 \times 2 \times 100}{2\pi} = 4 \times 10^{-3} \text{ T} \\ B_{\text{net}} &= \sqrt{B_P^2 + B_Q^2} \\ &= \sqrt{20} \text{ mT} \\ x &= 20\end{aligned}$$

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Q1. JEE Main 2026 (21 January Shift 2)

An infinitely long straight wire carrying current I is bent in a planer shape as shown in the diagram. The radius of the circular part is r . The magnetic field at the centre O of the circular loop is :



(1) $-\frac{\mu_0}{2\pi} \frac{I}{r} (\pi - 1) \hat{i}$
 (3) $-\frac{\mu_0}{2\pi} \frac{I}{r} (\pi + 1) \hat{i}$

(2) $\frac{\mu_0}{2\pi} \frac{I}{r} (\pi - 1) \hat{i}$
 (4) $\frac{\mu_0}{2\pi} \frac{I}{r} (\pi + 1) \hat{i}$

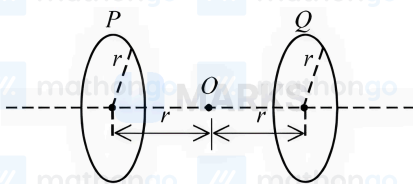
Q2. JEE Main 2026 (28 January Shift 2)

A long cylindrical conductor with large cross section carries an electric current distributed uniformly over its cross-section. Magnetic field due to this current is :

- A. maximum at either ends of the conductor and minimum at the midpoint
- B. maximum at the axis of the conductor
- C. minimum at the surface of the conductor
- D. minimum at the axis of the conductor
- E. same at all points in the cross-section of the conductor

Choose the correct answer from the options given below :

- (1) A, D Only
- (2) D Only
- (3) E Only
- (4) B, C Only

Q3. JEE Main 2026 (24 January Shift 2)

Two identical circular loops P and Q each of radius r are lying in parallel planes such that they have common axis. The current through P and Q are I and $4I$ respectively in clockwise direction as seen from O . The net magnetic field at O is:

- (1) $\frac{3\mu_0 I}{4\sqrt{2}r}$ towards Q
- (2) $\frac{\mu_0 I}{4\sqrt{2}r}$ towards Q
- (3) $\frac{3\mu_0 I}{4\sqrt{2}r}$ towards P
- (4) $\frac{\mu_0 I}{4\sqrt{2}r}$ towards P

Q4. JEE Main 2026 (23 January Shift 2)

The current passing through a conducting loop in the form of equilateral triangle of side $4\sqrt{3}$ cm is 2 A. The magnetic field at its centroid is $\alpha \times 10^{-5}$ T. The value of α is _____.

(Given : $\mu_0 = 4\pi \times 10^{-7}$ SI units)

- (1) $2\sqrt{3}$ (2) $\frac{\sqrt{3}}{2}$ (3) $3\sqrt{3}$ (4) $\sqrt{3}$

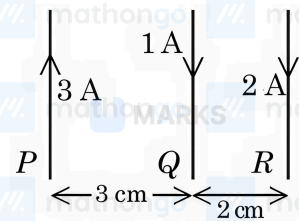
Q5. JEE Main 2026 (21 January Shift 1)

A current carrying solenoid is placed vertically and a particle of mass m with charge Q is released from rest. The particle moves along the axis of solenoid. If g is acceleration due to gravity then the acceleration (a) of the charged particle will satisfy :

- (1) $a > g$ (2) $0 < a < g$
(3) $a = 0$ (4) $a = g$

Q6. JEE Main 2026 (28 January Shift 1)

Three long straight wires carrying current are arranged mutually parallel as shown in the figure. The force experienced by 15 cm length of wire Q is _____.



($\mu_0 = 4\pi \times 10^{-7}$ T.m/A)

- (1) 6×10^{-6} N towards P (2) 6×10^{-7} N towards P
(3) 6×10^{-7} N towards R (4) 6×10^{-6} N towards R

Q7. JEE Main 2026 (28 January Shift 1)

The magnetic field at the centre of a current carrying circular loop of radius R is 16μ T. The magnetic field at a distance $x = \sqrt{3}R$ on its axis from the centre is _____ μ T.

- (1) 4 (2) 2 (3) $2\sqrt{2}$ (4) 8

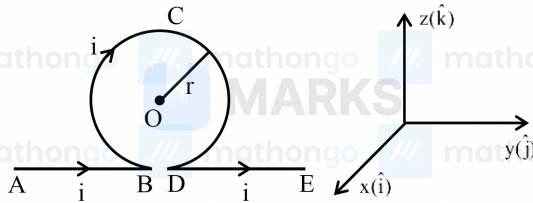
Q8. JEE Main 2026 (24 January Shift 1)

A short bar magnet placed with its axis at 30° with an external field of 800 Gauss, experiences a torque of 0.016 N.m. The work done in moving it from most stable to most unstable position is $\alpha \times 10^{-3}$ J. The value of α is _____.

ANSWERS AND SOLUTIONS

1. (1) 2. (2) 3. (1) 4. (3) 5. (4) 6. (4) 7. (2) 8. 64

1.



(1)

$$\vec{B}_0 = \vec{B}_{AB} + \vec{B}_{DE} + \vec{B}_{BCD}$$

$$= \frac{\mu_0 i}{4\pi} \hat{i} + \frac{\mu_0 i}{4\pi} \hat{i} - \frac{\mu_0 i}{2r} \hat{i}$$

$$= \frac{\mu_0 i}{2\pi} \hat{i} - \frac{\mu_0 i}{2r} \hat{i}$$

$$= \frac{\mu_0 i}{2\pi} (1 - \pi) \hat{i}$$

$$= -\frac{\mu_0 i}{2\pi} (\pi - 1) \hat{i}$$

2. (2) For a long cylindrical conductor with uniform current distribution, apply Ampere's law to find the magnetic field.

At distance r from the axis (inside the conductor, $r < R$): $B(r) = \frac{\mu_0 I r}{2\pi R^2}$ (proportional to r)

At the axis ($r = 0$): $B = 0$ (minimum)

At the surface ($r = R$): $B = \frac{\mu_0 I}{2\pi R}$ (maximum)

Analyzing the statements:

A. Maximum at ends and minimum at midpoint - FALSE. This describes behavior along the axis, but the magnetic field depends on radial distance, not axial position.

B. Maximum at the axis of the conductor - FALSE. The field is zero at the axis.

C. Minimum at the surface of the conductor - FALSE. The field is maximum at the surface.

D. Minimum at the axis of the conductor - TRUE. The field is zero at $r = 0$, making it the minimum.

E. Same at all points in the cross-section - FALSE. The field varies from 0 at the axis to maximum at the surface.

Only D is correct.

3. (1) Two identical circular loops P and Q, each of radius r , are separated by distance r along their common axis.

Current in P is I and in Q is $4I$ (both clockwise as seen from O).

Point O is at the midpoint. The magnetic fields from each loop at O:

$$B_1 = \frac{\mu_0 I R^2}{2(R^2 + R^2)^{3/2}} \text{ (from P, pointing toward Q)}$$

$$B_2 = \frac{4\mu_0 I R^2}{2(R^2 + R^2)^{3/2}} \text{ (from Q, pointing toward P)}$$

$$B_{\text{net}} = B_2 - B_1 = \frac{3\mu_0 I R^2}{2(2R^2)^{3/2}} = \frac{3\mu_0 I}{4\sqrt{2}R}$$

Direction: towards Q.

4. (3) For an equilateral triangle of side a , the distance of the centroid from any side is $r = \frac{a}{2\sqrt{3}}$.

Given side $a = 4\sqrt{3} \text{ cm} = 4\sqrt{3} \times 10^{-2} \text{ m}$.

$$\text{So, } r = \frac{4\sqrt{3} \times 10^{-2}}{2\sqrt{3}} = 2 \times 10^{-2} \text{ m}.$$

The magnetic field at the centroid due to one side of the triangle is $B_1 = \frac{\mu_0 I}{4\pi r} (\sin \theta_1 + \sin \theta_2)$.

For an equilateral triangle, $\theta_1 = \theta_2 = 60^\circ$.

$$B_1 = \frac{10^{-7} \times 2}{2 \times 10^{-2}} (\sin 60^\circ + \sin 60^\circ) = 10^{-5} \times \left(\frac{\sqrt{3}}{2} + \frac{\sqrt{3}}{2} \right) = \sqrt{3} \times 10^{-5} \text{ T}.$$

The total magnetic field at the centroid due to all three sides is $B = 3B_1 = 3\sqrt{3} \times 10^{-5} \text{ T}$.

Comparing with $B = \alpha \times 10^{-5} \text{ T}$, we get $\alpha = 3\sqrt{3}$.

5. (4) Inside a solenoid, magnetic field $\vec{B}$ is uniform and parallel to the axis.

Particle moves along the axis, so velocity $\vec{v}$ is parallel to $\vec{B}$.

Magnetic force $\vec{F} = Q(\vec{v} \times \vec{B}) = 0$ (since $\vec{v} \parallel \vec{B}$)

Only gravity acts on the particle.

Acceleration $a = g$

6. (4) The force per unit length between parallel wires is $F/L = \frac{\mu_0 I_1 I_2}{2\pi d}$.

Force on Q from P (opposite currents, repulsive towards R): $\frac{F_{QP}}{L} = \frac{4\pi \times 10^{-7} \times 3 \times 1}{2\pi \times 0.03} = 2 \times 10^{-5} \text{ N/m}$.

Force on Q from R (same currents, attractive towards R): $\frac{F_{QR}}{L} = \frac{4\pi \times 10^{-7} \times 1 \times 2}{2\pi \times 0.02} = 2 \times 10^{-5} \text{ N/m}$.

Total force per unit length towards R: $4 \times 10^{-5} \text{ N/m}$.

For 0.15 m length: $F = 4 \times 10^{-5} \times 0.15 = 6 \times 10^{-6} \text{ N}$ towards R.

7. (2) The magnetic field at the center of a circular loop is $B_{\text{center}} = \frac{\mu_0 I}{2R} = 16\mu \text{ T}$.

On the axis at distance x from center: $B(x) = \frac{\mu_0 I R^2}{2(R^2 + x^2)^{3/2}}$.

$$\text{At } x = \sqrt{3}R: B(\sqrt{3}R) = \frac{\mu_0 I R^2}{2(R^2 + 3R^2)^{3/2}} = \frac{\mu_0 I R^2}{2(4R^2)^{3/2}} = \frac{\mu_0 I}{16R}.$$

$$\text{The ratio: } \frac{B(\sqrt{3}R)}{B_{\text{center}}} = \frac{1/16R}{1/2R} = \frac{1}{8}.$$

$$\text{Therefore: } B(\sqrt{3}R) = \frac{1}{8} \times 16\mu = 2\mu \text{ T}.$$

8. (64) For a magnetic dipole in an external field, torque is $\tau = mB \sin \theta$

$$\text{At } 30^\circ: 0.016 = m \times 0.08 \times \sin 30^\circ$$

$$0.016 = m \times 0.08 \times 0.5$$

$$m = 0.4 \text{ A} \cdot \text{m}^2$$

Work done from most stable (aligned, 0°) to most unstable (anti-aligned, 180°) position equals the change in potential energy:

$$W = U_{0^\circ} - U_{180^\circ} = -mB \cos 0^\circ - (-mB \cos 180^\circ) = -mB - mB = 2mB$$

$$W = 2 \times 0.4 \times 0.08 = 0.064 \text{ J} = 64 \times 10^{-3} \text{ J}$$

Therefore, $\alpha = 64$