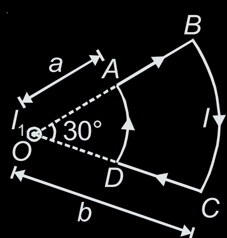
Chapter 17

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

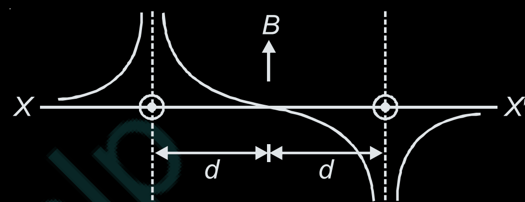
   (1) The forces on *AD* and *BC* are zero

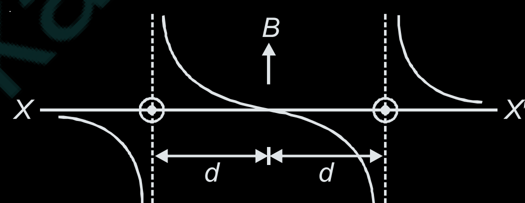
   (2) The magnitude of the net force on the loop is given by $\frac{I_1 I}{4\pi}\mu_0\left[2(b-a)+\frac{\pi}{3}(a+b)\right]$

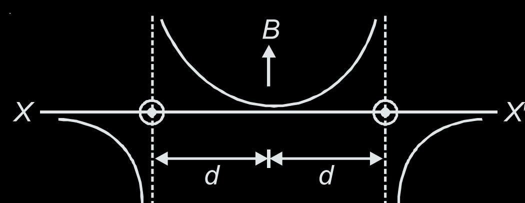
   (3) The magnitude of the net force on the loop is given by $\frac{\mu_0 I I_1}{24ab}(b-a)$

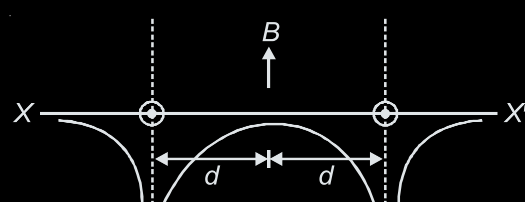
   (4) The forces on *AB* and *DC* are zero

3. Two long parallel wires are at a distance 2*d* 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]**

   (1) 

   (2) 

   (3) 

   (4) 

4. A thin circular disk of radius *R* is uniformly charged with density σ > 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]**

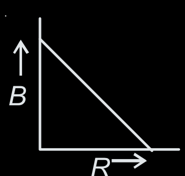
(1) $r_\alpha = r_p < r_d$

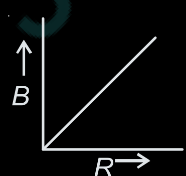
(2) $r_\alpha > r_d > r_p$

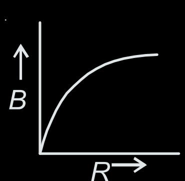
(3) $r_\alpha = r_d > r_p$

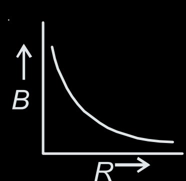
(4) $r_\alpha = r_p = r_d$

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]**

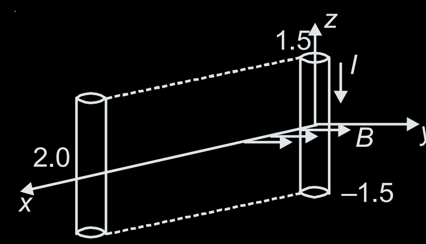
(1) 

(2) 

(3) 

(4) 

8. A conductor lies along the z-axis at $-1.5 \le z < 1.5$ 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) $\vec{F_1} = \vec{F_2} = 0$

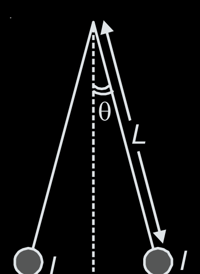
(2) $\vec{F_1}$ is radially inwards and $\vec{F_2}$ is radially outwards

(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

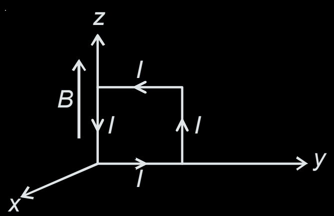
(g = gravitational acceleration) **[JEE (Main)-2015]**

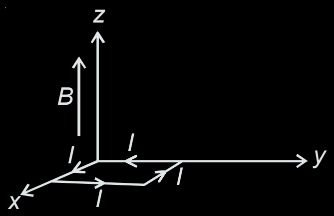


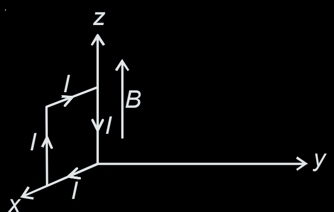
(1) $\sin\theta\sqrt{\dfrac{\pi\lambda gL}{\mu_0\cos\theta}}$ (2) $2\sin\theta\sqrt{\dfrac{\pi\lambda gL}{\mu_0\cos\theta}}$

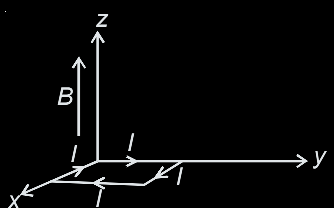
(3) $2\sqrt{\dfrac{\pi gL}{\mu_0}\tan\theta}$ (4) $\sqrt{\dfrac{\pi\lambda gL}{\mu_0}\tan\theta}$

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:

(a)


(b)


(c)


(d)


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) $r_e < r_\alpha < r_p$

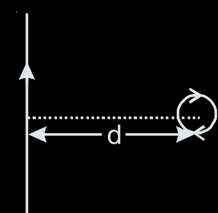
14. The dipole moment of a circular loop carrying a current I, is m and the magnetic field at the centre of the loop is B_1. When the dipole moment is doubled by keeping the current constant, the magnetic field at the centre of the loop is B_2. The ratio $\frac{B_1}{B_2}$ is **[JEE (Main)-2018]**

(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>>a). If the loop applies a force F on the wire then

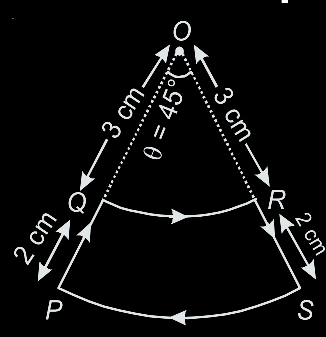
[JEE (Main)-2019]



(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]**



i = 10 A

(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

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

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) $5q$

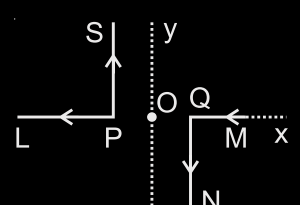
(3) $(0.35)q$ (4) $(2.5)q$

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

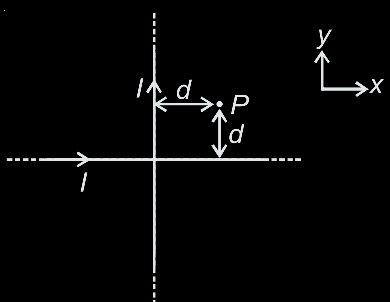
(4) 20 A, perpendicular out of the page

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

[JEE (Main)-2019]

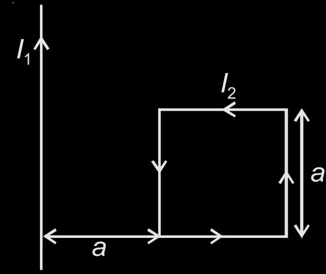
(1) 0.55 Nm

(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 $\frac{\mu_0 I_1 I_2}{3\pi}$

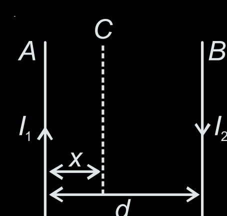
29. A moving coil galvanometer has a coil with 175 turns and area 1 cm^2. It uses a torsion band of torsion constant 10^{-6} N-m/rad. The coil is placed in a magnetic field B parallel to its plane. The coil deflects by 1° for a current of 1 mA. The value of B (in Tesla) is approximately **[JEE (Main)-2019]**

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

(1) 18 μT

(2) 1 μT

(3) 3 μT

(4) 9 μT

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 π rad s^{-1} about its axis, perpendicular to its plane. If the magnetic field at its centre is 3.8×10^{-9} T, then the charge carried by the ring is close to ($\mu_0 = 4\pi \times 10^{-7}$ N/A^2).

[JEE (Main)-2019]

(1) 4×10^{-5} C

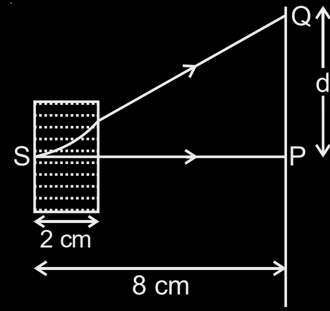
(2) 3×10^{-5} C

(3) 7×10^{-6} C

(4) 2×10^{-6} 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 cm. The electron is detected at the point *Q* on a screen placed 8 cm away from the point *S*. The distance d between *P* and *Q* (on the screen) is

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

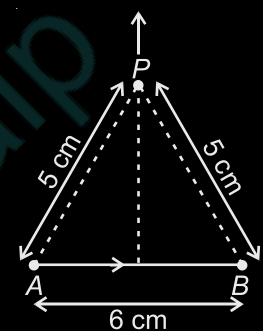


(1) 11.65 cm (2) 12.87 cm

(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]**

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



(1) 2.5×10^{-5} T (2) 1.5×10^{-5} T

(3) 3.0×10^{-5} T (4) 2.0×10^{-5} T

36. A particle of mass *m* and charge *q* has an initial velocity $\vec{\upsilon} = \upsilon_0 \hat{j}$. If an electric field $\vec{E} = E_0 \hat{i}$ and magnetic field $\vec{B} = B_0 \hat{i}$ act on the particle, its speed will double after a time **[JEE (Main)-2020]**

(1) $\frac{3m\upsilon_0}{qE_0}$ (2) $\frac{\sqrt{3}m\upsilon_0}{qE_0}$

(3) $\frac{2m\upsilon_0}{qE_0}$ (4) $\frac{\sqrt{2}m\upsilon_0}{qE_0}$

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

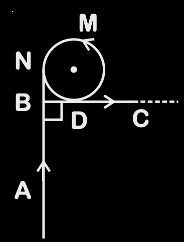
(Rest mass of proton is 1.6×10^{-27} kg)

[JEE (Main)-2020]

(1) 0.071 mT (2) 0.71 mT

(3) 71 mT (4) 7.1 mT

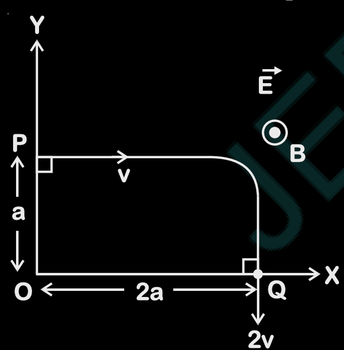
38. A very long wire $ABDMNDC$ is shown in figure carrying current I. AB and BC parts are straight, long and at right angle. At D wire forms a circular turm $DMND$ of radius R. AB, BC parts are tangential to circular turn at N and D. Magnetic field at the centre of circle is **[JEE (Main)-2020]**



(1) $\dfrac{\mu_0 I}{2\pi R}(\pi + 1)$ (2) $\dfrac{\mu_0 I}{2R}$

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

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



A. $E = \dfrac{3}{4}\left(\dfrac{mv^2}{qa}\right)$

B. Rate of work done by the electric field at P is $\dfrac{3}{4}\left(\dfrac{mv^3}{a}\right)$

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 2 mav.

(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 $\dfrac{a}{3}$ and $2a$, respectively from the axis of the wire is **[JEE (Main)-2020]**

(1) $\dfrac{1}{2}$ (2) $\dfrac{3}{2}$

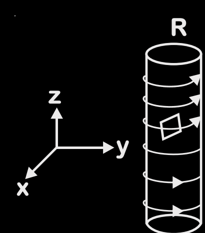
(3) 2 (4) $\dfrac{2}{3}$

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) $T = \sqrt{\dfrac{2\pi m}{IB}}$ (2) $T = \sqrt{\dfrac{\pi m}{IB}}$

(3) $T = \sqrt{\dfrac{2m}{IB}}$ (4) $T = \sqrt{\dfrac{\pi m}{2IB}}$

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, maxium possible value of v is (all symboils have their standard meaning) **[JEE (Main)-2020]**



(1) $\dfrac{2e\mu_0 nIR}{m}$ (2) $\dfrac{e\mu_0 nIR}{m}$

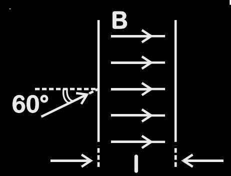
(3) $\dfrac{e\mu_0 nIR}{2m}$ (4) $\dfrac{e\mu_0 nIR}{4m}$

43. A beam of protons with speed $4 \times 10^5\ ms^{-1}$ 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 = 1.67×10^{-27} kg, charge of the proton = 1.69×10^{-19} C) **[JEE (Main)-2020]**

(1) 2 cm (2) 12 cm

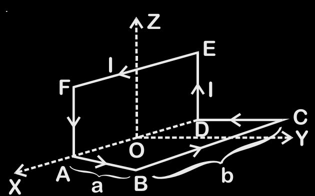
(3) 5 cm (4) 4 cm

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 4×10^5 ms^{-1} making an angle 60° with the field. If the proton completes 10 revolution by the time it cross the region shown, 'l' is close to (mass of proton = 1.67×10^{-27} kg, charge of the proton = 1.6×10^{-19} 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) abI, along $\left(\dfrac{\hat{j}}{\sqrt{5}} + \dfrac{2\hat{k}}{\sqrt{5}}\right)$

(2) $\sqrt{2}\, abI$, along $\left(\dfrac{\hat{j}}{\sqrt{2}} + \dfrac{\hat{k}}{\sqrt{2}}\right)$

(3) abI, along $\left(\dfrac{\hat{j}}{\sqrt{2}} + \dfrac{\hat{k}}{\sqrt{2}}\right)$

(4) $\sqrt{2}\, abI$, along $\left(\dfrac{\hat{j}}{\sqrt{5}} + \dfrac{2\hat{k}}{\sqrt{5}}\right)$

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

(1) $-3.0\hat{i} + 3.2\hat{j} - 0.9\hat{k}$

(2) $-300\hat{i} + 320\hat{j} - 90\hat{k}$

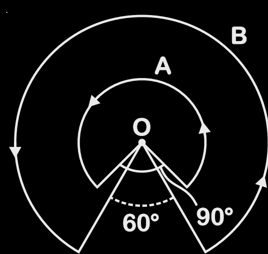
(3) $-0.30\hat{i} + 0.32\hat{j} - 0.09\hat{k}$

(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 $\dfrac{\mu_0 I}{\pi}$ 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 $c = 3 \times 10^8$ ms^{-1} and electron charge = 1.6×10^{-19} C) **[JEE (Main)-2020]**

(1) 4.8×10^{-19} N
(2) 2.4×10^{-18} N
(3) 3.2×10^{-18} N
(4) 1.6×10^{-19} 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), ($b >> a$). 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 6×10^6 ms^{-1}. It enters a region of uniform electric field of 300 V/cm pointing along +y direction. The magnitude and direction of the magnetic field set up in this region such that the electron keeps moving along the x direction will be **[JEE (Main)-2020]**

(1) 5×10^{-3} T, along + z direction

(2) 5×10^{-3} T, along – z direction

(3) 3×10^{-4} T, along + z direction

(4) 3×10^{-4} 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), ($b >> a$). 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 $ABCDEFA$ 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 $\vec{B} = (3\hat{i} + 4\hat{k})$ T. The quantity of flux through the loop $ABCDEFA$ (in Wb) is _________. **[JEE (Main)-2020]**

57. A galvanometer coil has 500 turns and each turn has an average area of 3×10^{-4} m^2. If a torque of 1.5 Nm is required to keep this coil parallel to a magnetic field when a current of 0.5 A is flowing through it, the strength of the field (in T) is __________. **[JEE (Main)-2020]**

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 $\vec{dl}$ 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)

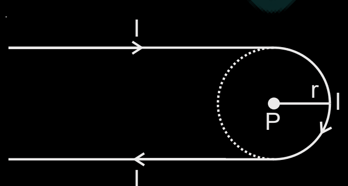
[JEE (Main)-2021]

(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]

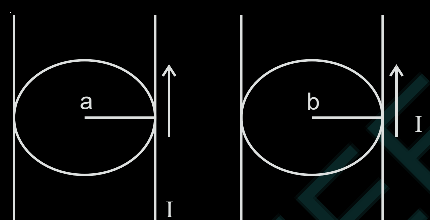
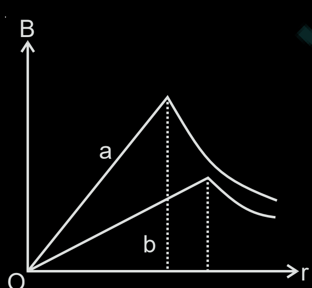
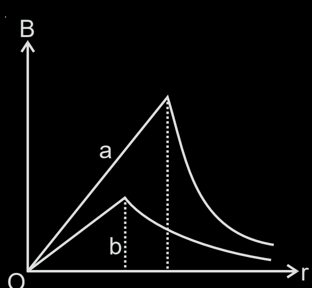
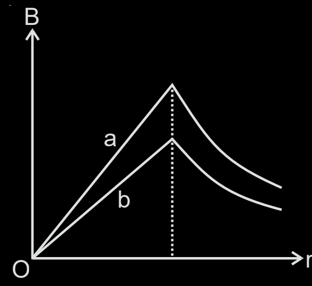
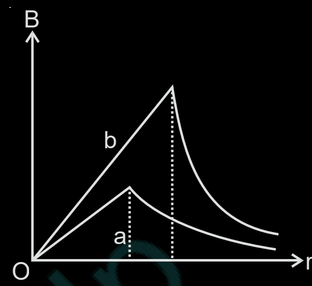


Fig. A Fig. B

(1) 

(2) 

(3) 

(4) 

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 << a). **[JEE (Main)-2021]**

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

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

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) $\frac{\mu_0 IN}{2(b-a)}\log_e\left(\frac{b}{a}\right)$

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]**

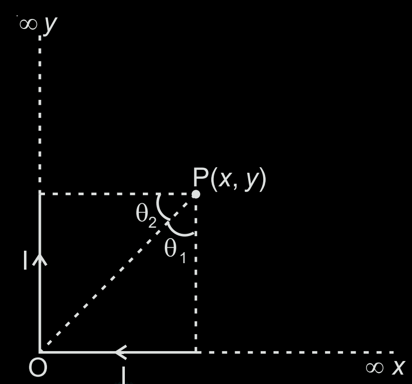
(1) $2\sqrt{3}\times10^{-7}$ T, outside the plane of triangle

(2) 3×10^{-7} T, outside the plane of triangle

(3) $2\sqrt{3}\times10^{-5}$ 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) $\frac{\mu_0 Ixy}{4\pi}\left[\sqrt{x^2+y^2}+(x+y)\right]$

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

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

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

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

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. A long 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]**

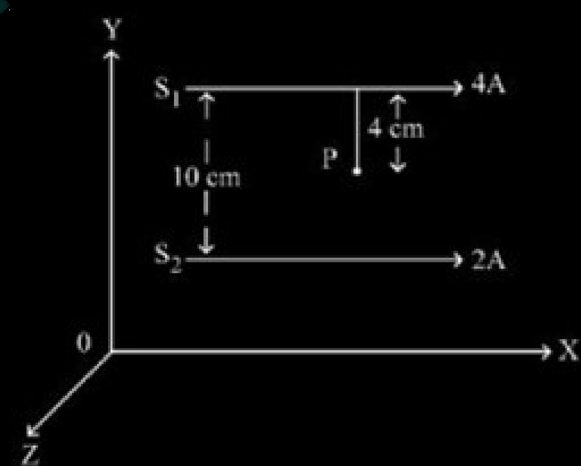
(1) 1:4 (2) 4:1

(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 $\vec{v} = \left(2\hat{i} + 3\hat{j}\right)$ m/s; where $\hat{i}$ and $\hat{j}$ represents unit vector along x & y axis respectively. The force acting on the charge particle is $4\pi \times 10^{-5}\left(-x\hat{i} + 2\hat{j}\right)N$. The value of x is:

[JEE (Main)-2022]



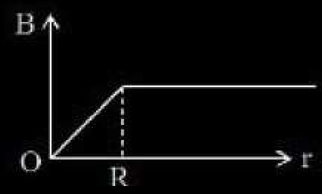
(1) 2 (2) 1

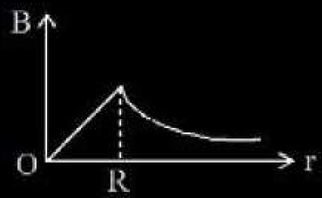
(3) 3 (4) –3

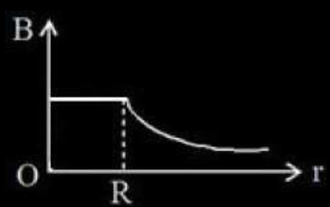
84. A deuteron and a proton moving with equal kinetic energy enter into a uniform magnetic field at right angle to the field. If r_d and r_p are the radii of their circular paths respectively, then the ratio $\frac{r_d}{r_p}$ will be $\sqrt{x}:1$ where x is __________. **[JEE (Main)-2022]**

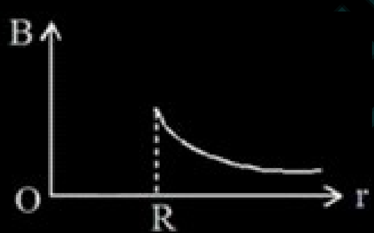
85. An infinitely long hollow conducting cylinder with radius R carries a uniform current along its surface.

Choose the correct representation of magnetic field (B) as a function of radial distance (r) from the axis of cylinder. **[JEE (Main)-2022]**

(1) 

(2) 

(3) 

(4) 

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 A in the same direction. If the force of attraction per meter of each wire is 2×10^{-6} 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 1×10^{-4} Wbm^{-2}. The frequency of revolution of the electron will be (Take mass of electron = 9.0×10^{-31} kg)

[JEE (Main)-2022]

(1) 1.6×10^5 Hz (2) 5.6×10^5 Hz

(3) 2.8×10^6 Hz (4) 1.8×10^6 Hz

94. A charge particle is moving in a uniform field $(2\hat{i} + 3\hat{j})$T. If it has an acceleration of $(\alpha\hat{i} - 4\hat{j})$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

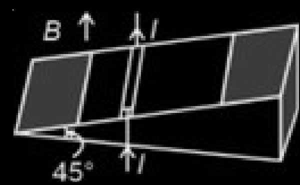
[Use $m_p = 1.6 \times 10^{-27}$ kg, $e = 1.6 \times 10^{-19}$ C]

[JEE (Main)-2022]

(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 : {Use g = 10 m/s^2} **[JEE (Main)-2022]**

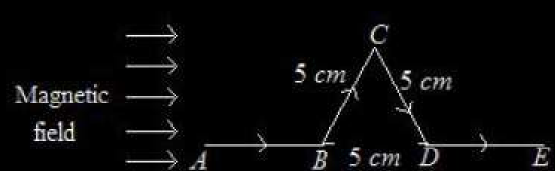


(1) 30 A (2) 15 A

(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 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) $5:\sqrt{3}$

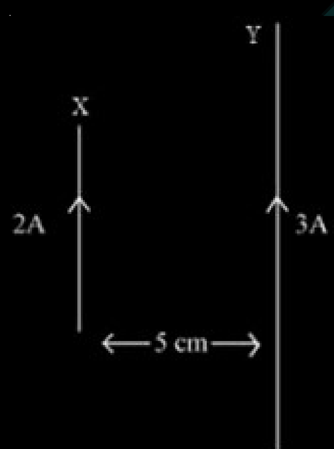
100. A closely wounded circular coil of radius 5 cm produces a magnetic field of 37.68×10^{-4} T at its center. The current through the coil is _______ A.

[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



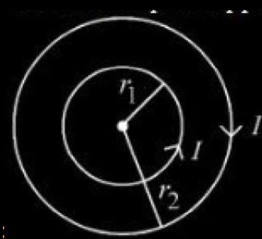
(1) 1.2×10^{-5} N directed towards wire *X*

(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 → $192\ kVm^{-1}$

(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)

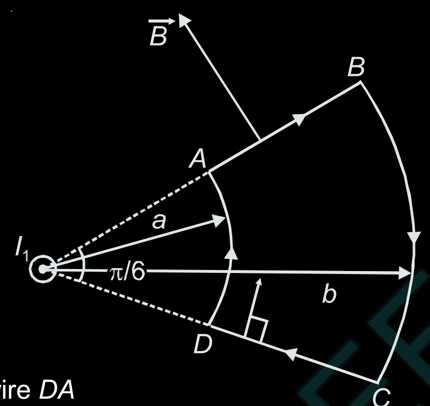
   Magnetic field due to AB and CD is zero

$$\therefore \quad \vec{B}_{net} = \frac{\mu_0}{4\pi} \times \frac{I}{a} \times \frac{\pi}{6}\hat{k} + \frac{\mu_0}{4\pi} \times \frac{I}{b} \times \frac{\pi}{6}(-\hat{k})$$

$$= \frac{\mu_0}{24} \times I\left\{\frac{1}{a} - \frac{1}{b}\right\}\hat{k}$$

$$= \frac{\mu_0 I(b-a)}{24ab}\hat{k}$$

2. Answer (1)



   In wire DA

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

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

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

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

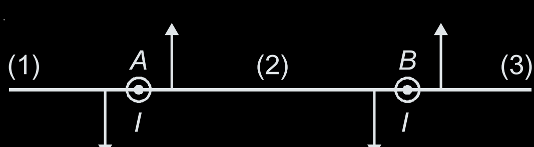
   In wire CD, $d\vec{\ell} \times \vec{B}$ is downwards.

   Since, AB and CD are symmetrical to I_1

   So, $\overrightarrow{F_{AB}} + \overrightarrow{F_{CD}} = 0.$

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)

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

5. Answer (3)

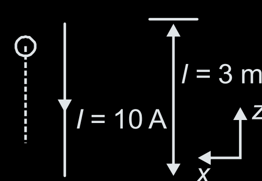
$$\vec{F} = q\vec{E} + q(\vec{v} \times \vec{B})$$

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

   y-component = $11q$

6. Answer (1)
7. Answer (2)
8. Answer (2)

$$B = 3.0 \times 10^{-4}\, e^{-0.2x}$$



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

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

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

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

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

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

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

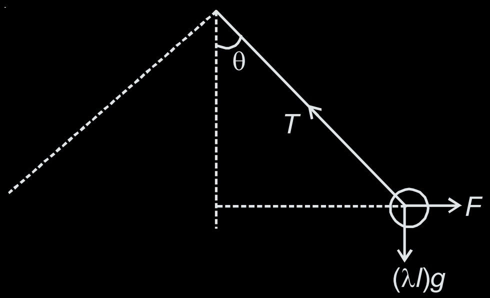
$= 2.97 \times 10^{-3}$ J

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

9. Answer (1)

Net force on each of them would be zero.

10. Answer (2)



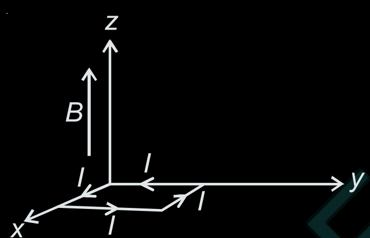
$T\cos\theta = \lambda g l$ ...(i)

$T\sin\theta = \dfrac{\mu_0}{2\pi}\cdot\dfrac{I \times Il}{(2L\sin\theta)}$ ...(ii)

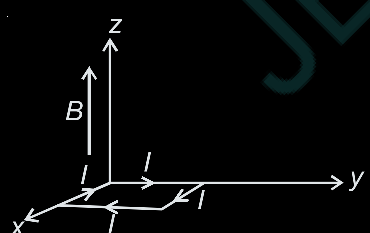
$\Rightarrow I = 2\sin\theta\sqrt{\dfrac{\pi\lambda g L}{\mu_0\cos\theta}}$

11. Answer (3)

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



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



12. Answer (3)

For A For B

$2\pi R = L$ $4a = L$

$\Rightarrow R = \dfrac{L}{2\pi}$ $\Rightarrow a = \dfrac{L}{4}$

$B_A = \dfrac{\mu_0\, i}{2R}$ $B_B = 4\left[\dfrac{\mu_0\, i}{4\pi\, a/2}\left(\sin\dfrac{\pi}{4} + \sin\dfrac{\pi}{4}\right)\right]$

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

13. Answer (2)

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

$\dfrac{r_\alpha}{r_p} = \dfrac{\sqrt{2m_\alpha}}{q_\alpha} \times \dfrac{q_p}{\sqrt{2m_p}}$ $\begin{bmatrix} m_\alpha = 4m_p \\ q_\alpha = 2q_p \end{bmatrix}$

$= 1$

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

So, $r_e < r_p = r_\alpha$

14. Answer (3)

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

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

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

$B_2 = \dfrac{\mu_0 I}{2 \times \left(\sqrt{2}R\right)}$

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

15. Answer (2)

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

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

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

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

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

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

16. Answer (4)

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

So,

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

$B = \dfrac{\mu_0 i}{120} = 1.047 \times 10^{-5} \approx 1.0 \times 10^{-5}$ 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)

$$eE = eVB$$

$$R = \frac{mV}{eB} \Rightarrow V = \frac{\text{Re}B}{m}$$

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

$$m = \frac{1.6\times10^{-19}\times(0.5)^2\times0.5\times10^{-2}}{100}$$

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

19. Answer (3)

$$dm = \rho dxn\,\pi x^2$$

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

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

20. Answer (4)

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

$$= \frac{\sqrt{2\times9.1\times10^{-31}\times500}}{100\times10^{-3}\sqrt{1.6\times10^{-19}}}$$

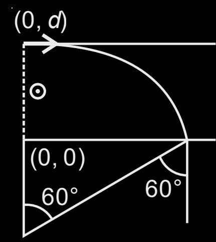
$$= \frac{1}{100\times10^{-3}}\frac{\sqrt{2\times9.1\times500\times10^{-12}}}{1.6}$$

$$= \frac{75.4\times10^{-6}}{100\times10^{-3}} = 7.5\times10^{-4}\ \text{m}$$

21. Answer (2)

Assuming particle enters from $(0, d)$

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



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

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

22. Answer (2)

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

Work is done by electric force only

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

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

23. Answer (4)

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

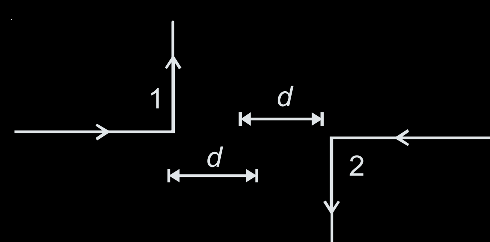
$$\Rightarrow r \propto \sqrt{\frac{m}{q}}$$

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

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

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)

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

$$= \text{NIA} \times B \qquad [A = \pi r^2]$$

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

26. Answer (1)

$$\vec{B} = \vec{B_1} + \vec{B_2} = \frac{\mu_0 1}{2\pi d}\left[\hat{k} - \hat{k}\right] = 0$$

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)

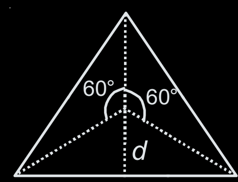
$$\Sigma\vec{F} = 0$$

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

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

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

31. Answer (1)



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

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

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

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

$$= \frac{9}{2}\left(\frac{\mu_0 I}{\pi a}\right)$$

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

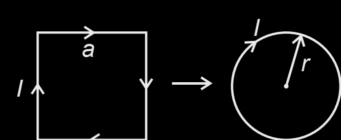
$$= 18\ \mu\text{T}$$

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

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

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

32. Answer (2)



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

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

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

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

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

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

33. Answer (2)

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

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

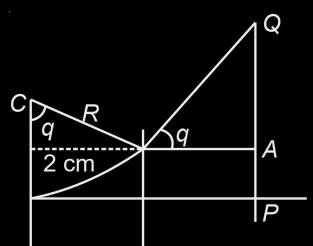
$$B=\frac{10^{-7}\times 40}{0.1}\times q\times\pi \quad\Rightarrow\quad q=3\times 10^{-5}\text{ C}$$

34. Answer (2)

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

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

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



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

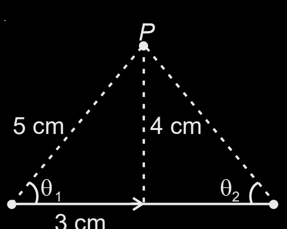
$$\sin\theta=\frac{2}{2.25}=\frac{8}{9}$$

$PQ = PA + AQ$

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

$= 1.22 + 11.64 = 12.86$ cm

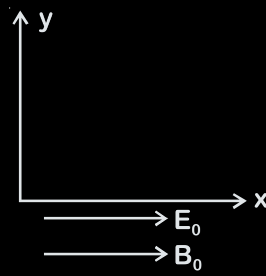
35. Answer (2)



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

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

36. Answer (2)



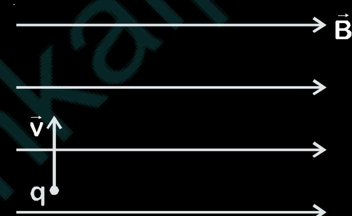
$$a_x=\frac{E_0 q}{m}$$

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

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

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

37. Answer (2)



Magnetic Force F = qvB

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

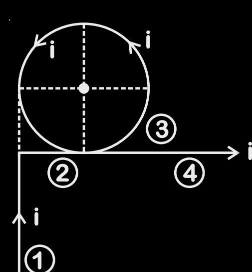
$$\therefore \quad \text{Also } v=\sqrt{\frac{2K}{m}}=\sqrt{\frac{2\times e\times 10^6}{m}}$$

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

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

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

38. Answer (3)



$$B_0 = (\overrightarrow{B_0})_1^{\otimes} + (\overrightarrow{B_0})_2^{\odot} + (\overrightarrow{B_0})_3^{\odot} + (\overrightarrow{B_0})_4^{\odot}$$

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

$$\overrightarrow{B_0^{\odot}} = \frac{\mu_0 I}{2\pi R}\left(\pi + \frac{1}{\sqrt{2}}\right)^{\odot}$$

39. Answer (1)

$W_T = \Delta KE$

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

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

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

$$\vec{L}_i^o = mva\left(-\hat{k}\right)$$

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

$$\left|\overrightarrow{\Delta L^o}\right| = 3mva$$

40. Answer (4)

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

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

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

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

41. Answer (1)

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

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

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

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

42. Answer (3)

$$B = \mu_0 ni$$

$$\frac{mV_{max}}{qB} = \frac{R}{2}$$

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

$$= \frac{qR\mu_0 ni}{2m}$$

43. Answer (4)

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

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

$= 4$ cm

44. Answer (4)

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

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

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

$\Rightarrow$ l = 0.44 m

45. Answer (2)

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

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

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

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

46. Answer (4)

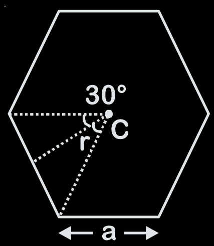
$$F = q(\vec{V}\times\vec{B})$$

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

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

47. Answer (1)

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



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

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

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

48. Answer (2)

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

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

From (1) and (2)

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

49. Answer (1)

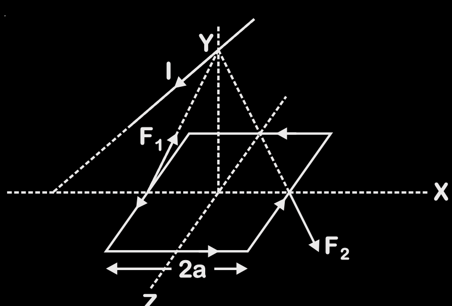
$$F_m^{\max} = (q)VB_0$$

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

$$\Rightarrow F_m^{\max} = (1.6\times10^{-19})(0.1\,c)\left(\frac{E_0}{c}\right)$$

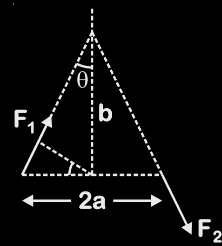
$$\simeq 4.8 \times 10^{-19}\ \text{N}$$

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

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

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

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

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

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

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

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

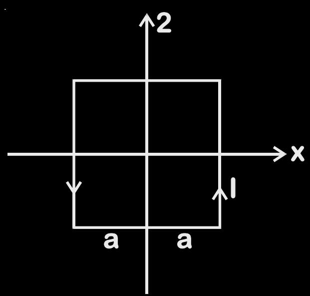
Note : It should be maximum instead of minimum.

53. Answer (1)

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

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

54. Answer (2)



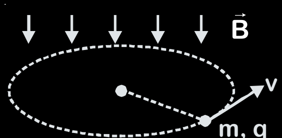
$$\tau = (f_{\perp})r$$

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

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

55. Answer (1)

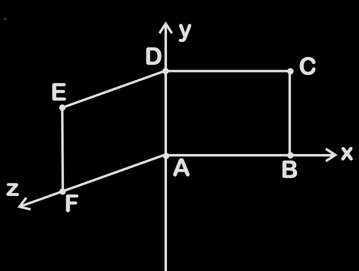
$$\vec{M} = \frac{1}{2}qvR\,(-\hat{B})$$



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

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

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)

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

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

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

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

58. Answer (2)

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

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

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

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

$R = 0.1$ 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)

$$\vec{\text{F}}_\text{m} = \text{q}\vec{\text{V}} \times \vec{\text{B}}$$

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

$\therefore \quad \text{W} = 0$

61. Answer (3)

$\text{B} = (\mu_0 \text{ni})\mu_r$

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

$= \pi$ T

62. Answer (1)

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

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

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

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)

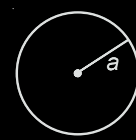
$$R = \frac{mv}{qB}$$

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

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

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

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

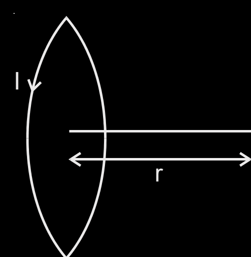
$$B = \frac{\mu_0 I}{2\pi r}$$

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

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

So option (1) is correct.

69. Answer (1)



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

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

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

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

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

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

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

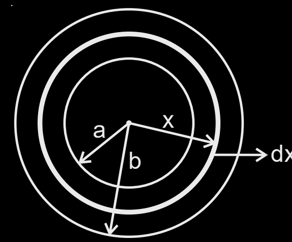
$$= \frac{V_0}{R} \times \left(\frac{\sqrt{3}}{4}a^2\right)8 = M_1$$

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

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

74. Answer (4)

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

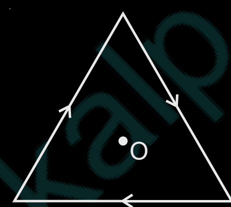


$$\therefore\ B = \int_a^b \frac{\mu_0 N \times I dx}{(b-a) \times 2x}$$

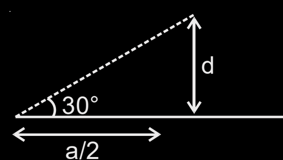
$$= \frac{\mu_0 N I}{2(b-a)}\ln\left(\frac{b}{a}\right)$$

75. Answer (4)

Field due to each wire will add up.



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



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

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

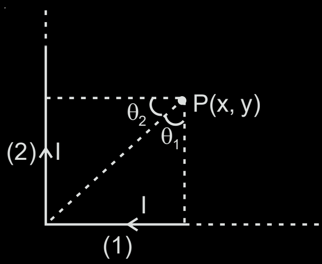
$$d = \frac{a}{2\sqrt{3}}$$

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

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

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

76. Answer (2)



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

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

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

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

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

77. Answer (1)

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

$\Rightarrow W_b = 0$

$\Rightarrow \Delta KE = 0$ 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)

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

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

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

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

80. Answer (2)

$$\int \overline{B} \cdot \overline{dl} = \mu_0 I_{in}$$

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

$\Rightarrow B \propto r$

$\Rightarrow$ option (2) is correct

81. Answer (1)

$B = \mu_0 n i$

Now $i \to 2i$

And $n \to \frac{n}{2}$

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

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)

Field at P 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 $\vec{F} = q\vec{v} \times \vec{B}$

$$= 3\pi(2\hat{i} + 3\hat{j}) \times \left(-\left(\frac{\mu_0 \times 200}{6\pi}\hat{k}\right)\right)$$

$$= 3\pi\left(\frac{200\mu_0}{3\pi}\hat{j} - \frac{100\mu_0}{\pi}\hat{i}\right)$$

$$= 200\mu_0\hat{j} - 300\mu_0\hat{i}$$

$$= 4\pi \times 10^{-5}(2\hat{j} - 3\hat{i})$$

So, $x = 3$

84. Answer (2)

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

So $\frac{r_d}{r_p} = \frac{\sqrt{m_d}/q_d}{\sqrt{m_p}/q_p}$

$$= \sqrt{2}$$

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 cm = 10 cm

87. Answer (3)

$$\frac{dF}{dl} = 2 \times 10^{-6}\ \text{N/m} = \frac{\mu_0 i_1 i_2}{2\pi d}$$

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

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

88. Answer (3)

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

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

$\Rightarrow$ ratio = 2 : 1

89. Answer (2)

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

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

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

90. Answer (3)

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

91. Answer (2)

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

$\Rightarrow$ 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)

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

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

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

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

94. Answer (2)

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

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)

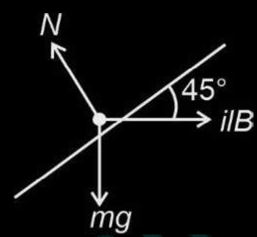
$$R = \frac{mv}{Bq} = \frac{\sqrt{2mK}}{Bq}$$

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

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

= 18 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)

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

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

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

= 0.2165 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)

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

$$37.68\times10^{-4}=\frac{4\pi\times10^{-7}100\,I}{2\times5\times10^{-2}}$$

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

$$=3\text{A}$$

101. Answer (11)

$$R=\frac{l}{2\pi}=\frac{314}{2\times3.14}=50\text{ cm}$$

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

$$=14\times3.14\times(0.5)^2$$

$$=11\text{ A–m}^2$$

102. Answer (1)

$$F_{XY}=F_{YX}=F$$

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

$$=\frac{4\pi\times10^{-7}\times3\times2\times\left[50\times10^{-2}\right]}{2\pi\left(5\times10^{-2}\right)}$$

$$=1.2\times10^{-5}\text{ N}$$

103. Answer (2)

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

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

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

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

$$=3.142\times\left(0.5^2-0.3^2\right)\times7\left(-\hat{k}\right)$$

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

104. Answer (1)

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

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

$$\Rightarrow E=\sqrt{\frac{2\times728\times1.6\times10^{-19}}{9.1\times10^{-31}}}\times12\times10^{-3}$$

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

105. Answer (5)

$$\frac{dF}{dl}=\frac{\mu_o i_1 i_2}{2\pi d}$$

So $\dfrac{2\times10^{-7}\times5\times5}{d}=\dfrac{10^{-5}}{10\times10^{-2}}$

$$d=\frac{2\times10^{-7}\times5\times5}{10^{-4}}$$

$$=50\text{ mm}$$

$$=5\text{ cm}$$

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