CHAPTER 4

Moving Charges and Magnetism

4.2 Magnetic Force

1. A metallic rod of mass per unit length 0.5 kg m^{-1} is lying horizontally on a smooth inclined plane which makes an angle of 30° with the horizontal. The rod is not allowed to slide down by flowing a current through it when a magnetic field of induction 0.25 T is acting on it in the vertical direction. The current flowing in the rod to keep it stationary is

(a) 7.14 A (b) 5.98 A
(c) 14.76 A (d) 11.32 A *(NEET 2018)*

2. When a proton is released from rest in a room, it starts with an initial acceleration a_0 towards west. When it is projected towards north with a speed v_0 it moves with an initial acceleration $3a_0$ toward west. The electric and magnetic fields in the room are

(a) $\frac{ma_0}{e}$ east, $\frac{3ma_0}{ev_0}$ up

(b) $\frac{ma_0}{e}$ east, $\frac{3ma_0}{ev_0}$ down

(c) $\frac{ma_0}{e}$ west, $\frac{2ma_0}{ev_0}$ up

(d) $\frac{ma_0}{e}$ west, $\frac{2ma_0}{ev_0}$ down *(NEET 2013)*

3. A long straight wire carries a certain current and produces a magnetic field 2×10^{-4} Wb m^{-2} at a perpendicular distance of 5 cm from the wire. An electron situated at 5 cm from the wire moves with a velocity 10^7 m/s towards the wire along perpendicular to it. The force experienced by the electron will be
(charge on electron 1.6×10^{-19} C)

(a) 3.2 N (b) 3.2×10^{-16} N
(c) 1.6×10^{-16} N (d) zero *(Karnataka NEET 2013)*

4. A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected in the region such that its velocity is pointed along the direction of fields, then the electron

(a) will turn towards right of direction of motion
(b) speed will decrease
(c) speed will increase
(d) will turn towards left of direction of motion. *(2011)*

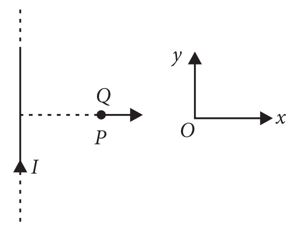
5. The magnetic force acting on a charged particle of charge −2 μC in a magnetic field of 2 T acting in y direction, when the particle velocity is $(2\hat{i}+3\hat{j})\times 10^6$ m s^{-1} is

(a) 4 N in z direction
(b) 8 N in y direction
(c) 8 N in z direction
(d) 8 N in $-z$ direction. *(2009)*

6. When a charged particle moving with velocity $\vec{v}$ is subjected to a magnetic field of induction $\vec{B}$, the force on it is non-zero. This implies that

(a) angle between is either zero or 180°
(b) angle between is necessarily 90°
(c) angle between can have any value other than 90°
(d) angle between can have any value other than zero and 180°. *(2006)*

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



(a) along Oy (b) opposite to Oy
(c) along Ox (d) opposite to Ox. *(2005)*

8. A charge q moves in a region where electric field and magnetic field both exist, then force on it is

(a) $q(\vec{v}\times\vec{B})$ (b) $q\vec{E}+q(\vec{v}\times\vec{B})$

(c) $q\vec{E}+\vec{q}\,(\vec{B}\times\vec{v})$ (d) $q\vec{B}+q(\vec{E}\times\vec{v})$ *(2002)*

9. Tesla is the unit of
(a) electric field (b) magnetic field
(c) electric flux (d) magnetic flux
(1997, 1988)

10. A charge moving with velocity v in X-direction is subjected to a field of magnetic induction in negative X-direction. As a result, the charge will
(a) remain unaffected
(b) start moving in a circular path Y-Z plane
(c) retard along X-axis
(d) moving along a helical path around X-axis. *(1993)*

11. A straight wire of length 0.5 metre and carrying a current of 1.2 ampere is placed in uniform magnetic field of induction 2 tesla. The magnetic field is perpendicular to the length of the wire. The force on the wire is
(a) 2.4 N (b) 1.2 N
(c) 3.0 N (d) 2.0 N. *(1992)*

4.3 Motion in a Magnetic Field

12. Ionized hydrogen atoms and α-particles with same momenta enters perpendicular to a constant magnetic field, B. The ratio of their radii of their paths $r_H : r_\alpha$ will be
(a) 1 : 4 (b) 2 : 1 (c) 1 : 2 (d) 4 : 1
(NEET 2019)

13. A proton and an alpha particle both enter a region of uniform magnetic field B, moving at right angles to the field B. If the radius of circular orbits for both the particles is equal and the kinetic energy acquired by proton is 1 MeV, the energy acquired by the alpha particle will be
(a) 1.5 MeV (b) 1 MeV
(c) 4 MeV (d) 0.5 MeV *(2015)*

14. A proton carrying 1 MeV kinetic energy is moving in a circular path of radius R in uniform magnetic field. What should be the energy of an α-particle to describe a circle of same radius in the same field?
(a) 2 MeV (b) 1 MeV
(c) 0.5 MeV (d) 4 MeV *(Mains 2012)*

15. Under the influence of a uniform magnetic field, a charged particle moves with a constant speed v in a circle of radius R. The time period of rotation of the particle
(a) depends on R and not on v
(b) is independent of both v and R
(c) depends on both v and R
(d) depends on v and not on R. *(2009, 2007)*

16. A particle of mass m, charge Q and kinetic energy T enters in a transverse uniform magnetic field of induction $\vec{B}$. After 3 seconds the kinetic energy of the particle will be
(a) T (b) $4T$
(c) $3T$ (d) $2T$ *(2008)*

17. A charged particle moves through a magnetic field in a direction perpendicular to it. Then the
(a) speed of the particle remains unchanged
(b) direction of the particle remains unchanged
(c) acceleration remains unchanged
(d) velocity remains unchanged. *(2003)*

18. An electron having mass m and kinetic energy E enter in uniform magnetic field B perpendicularly, then its frequency will be
(a) $\frac{eE}{qvB}$ (b) $\frac{2\pi m}{eB}$
(c) $\frac{eB}{2\pi m}$ (d) $\frac{2m}{eBE}$ *(2001)*

19. A charge having e/m equal to 10^8 C/kg and with velocity 3×10^5 m/s enters into a uniform magnetic field $B = 0.3$ tesla at an angle 30° with direction of field. The radius of curvature will be
(a) 0.01 cm (b) 0.5 cm
(c) 1 cm (d) 2 cm *(1999)*

20. A positively charged particle moving due East enters a region of uniform magnetic field directed vertically upwards. This particle will
(a) move in a circular path with a decreased speed
(b) move in a circular path with a uniform speed
(c) get deflected in vertically upward direction
(d) move in circular path with an increased speed. *(1997)*

21. A 10 eV electron is circulating in a plane at right angles to a uniform field at magnetic induction 10^{-4} Wb/m^2 (= 1.0 gauss), the orbital radius of electron is
(a) 11 cm (b) 18 cm
(c) 12 cm (d) 16 cm *(1996)*

22. A uniform magnetic field acts right angles to the direction of motion of electrons. As a result, the electron moves in a circular path of radius 2 cm. If the speed of electrons is doubled, then the radius of the circular path will be
(a) 2.0 cm (b) 0.5 cm
(c) 4.0 cm (d) 1.0 cm *(1991)*

23. A deuteron of kinetic energy 50 keV is describing a circular orbit of radius 0.5 metre in a plane perpendicular to magnetic field B. The kinetic energy of the proton that describes a circular orbit of radius 0.5 metre in the same plane with the same B is
(a) 25 keV (b) 50 keV
(c) 200 keV (d) 100 keV *(1991)*

4.4 Motion in Combined Electric and Magnetic Fields

24. An alternating electric field, of frequency υ, is applied across the dees (radius = R) of a cyclotron that is being used to accelerate protons (mass = m). The operating magnetic field (B) used in the cyclotron and the kinetic energy (K) of the proton beam, produced by it, are given by

(a) $B = \frac{m\upsilon}{e}$ and $K = 2m\pi^2\upsilon^2R^2$

(b) $B = \frac{2\pi m\upsilon}{e}$ and $K = m^2\pi\upsilon R^2$

(c) $B = \frac{2\pi m\upsilon}{e}$ and $K = 2m\pi^2\upsilon^2R^2$

(d) $B = \frac{m\upsilon}{e}$ and $K = m^2\pi\upsilon R^2$ *(2012)*

25. A particle having a mass of 10^{-2} kg carries a charge of 5×10^{-8} C. The particle is given an initial horizontal velocity of 10^5 m s^{-1} in the presence of electric field $\vec{E}$ and magnetic field $\vec{B}$. To keep the particle moving in a horizontal direction, it is necessary that

(1) $\vec{B}$ should be perpendicular to the direction of velocity and $\vec{E}$ should be along the direction of velocity

(2) Both $\vec{B}$ and $\vec{E}$ should be along the direction of velocity

(3) Both $\vec{B}$ and $\vec{E}$ are mutually perpendicular and perpendicular to the direction of velocity.

(4) $\vec{B}$ should be along the direction of velocity and $\vec{E}$ should be perpendicular to the direction of velocity

Which one of the following pairs of statements is possible?

(a) (1) and (3) (b) (3) and (4)
(c) (2) and (3) (d) (2) and (4) *(Mains 2010)*

26. A beam of electron passes undeflected through mutually perpendicular electric and magnetic fields. If the electric field is switched off, and the same magnetic field is maintained, the electrons move

(a) in a circular orbit
(b) along a parabolic path
(c) along a straight line
(d) in an elliptical orbit. *(2007)*

27. In a mass spectrometer used for measuring the masses of ions, the ions are initially accelerated by an electric potential V and then made to describe semicircular paths of radius R using a magnetic field B. If V and B are kept constant, the ratio $\left(\frac{\text{charge on the ion}}{\text{mass of the ion}}\right)$ will be proportional to

(a) $1/R^2$ (b) R^2
(c) R (d) $1/R$ *(2007)*

28. In Thomson mass spectrograph $E \perp B$ then the velocity of electron beam will be

(a) $\frac{|\vec{E}|}{|\vec{B}|}$ (b) $\vec{E} \times \vec{B}$

(c) $\frac{|\vec{B}|}{|\vec{E}|}$ (d) $\frac{\vec{E}^2}{\vec{B}^2}$ *(2001)*

29. A beam of electrons is moving with constant velocity in a region having electric and magnetic fields of strength 20 V m^{-1} and 0.5 T at right angles to the direction of motion of the electrons. What is the velocity of the electrons?

(a) 8 m s^{-1} (b) 5.5 m s^{-1}
(c) 20 m s^{-1} (d) 40 m s^{-1} *(1996)*

4.5 Magnetic Field due to a Current Element, Biot-Savart Law

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

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

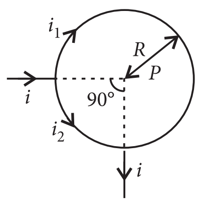
(b) $d\vec{B} = \frac{\mu_0}{4\pi} i \left(\frac{d\vec{l} \times \vec{r}}{r^3}\right)$

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

(d) $d\vec{B} = \frac{\mu_0}{4\pi} i^2 \left(\frac{d\vec{l} \times \vec{r}}{r^2}\right)$ *(1996)*

4.6 Magnetic Field on the Axis of a Circular Current Loop

31. A straight conductor carrying current i splits into two parts as shown in the figure. The radius of the circular loop is R. The total magnetic field at the centre P at the loop is



(a) Zero

(b) $3\mu_0 i/32R$, outward

(c) $3\mu_0 i/32R$, inward

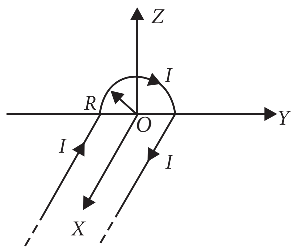
(d) $\frac{\mu_0 i}{2R}$, inward *(Odisha NEET 2019)*

32. A long wire carrying a steady current is bent into a circular loop of one turn. The magnetic field at the centre of the loop is B. It is then bent into a circular coil of n turns. The magnetic field at the centre of this coil of n turns will be

(a) nB (b) n^2B
(c) $2nB$ (d) $2n^2B$. *(NEET-II 2016)*

33. A wire carrying current I has the shape as shown in adjoining figure.

Linear parts of the wire are very long and parallel to X-axis while semicircular portion of radius R is lying in Y-Z plane. Magnetic field at point O is



(a) $\vec{B} = -\frac{\mu_0}{4\pi}\frac{I}{R}\left(\pi\hat{i} + 2\hat{k}\right)$

(b) $\vec{B} = \frac{\mu_0}{4\pi}\frac{I}{R}\left(\pi\hat{i} - 2\hat{k}\right)$

(c) $\vec{B} = \frac{\mu_0}{4\pi}\frac{I}{R}\left(\pi\hat{i} + 2\hat{k}\right)$

(d) $\vec{B} = -\frac{\mu_0}{4\pi}\frac{I}{R}\left(\pi\hat{i} - 2\hat{k}\right)$. *(2015 Cancelled)*

34. Two similar coils of radius R are lying concentrically with their planes at right angles to each other. The currents flowing in them are I and $2I$, respectively. The resultant magnetic field induction at the centre will be

(a) $\frac{\sqrt{5}\mu_0 I}{2R}$ (b) $\frac{\sqrt{5}\mu_0 I}{R}$

(c) $\frac{\mu_0 I}{2R}$ (d) $\frac{\mu_0 I}{R}$ *(2012)*

35. Charge q is uniformly spread on a thin ring of radius R. The ring rotates about its axis with a uniform frequency f Hz. The magnitude of magnetic induction at the center of the ring is

(a) $\frac{\mu_0 qf}{2\pi R}$ (b) $\frac{\mu_0 qf}{2R}$ (c) $\frac{\mu_0 q}{2fR}$ (d) $\frac{\mu_0 q}{2\pi fR}$

(Mains 2011, 2010)

36. A current loop consists of two identical semicircular parts each of radius R, one lying in the x-y plane and the other in x-z plane. If the current in the loop is i. The resultant magnetic field due to the two semicircular parts at their common centre is

(a) $\frac{\mu_0 i}{2\sqrt{2}R}$ (b) $\frac{\mu_0 i}{2R}$ (c) $\frac{\mu_0 i}{4R}$ (d) $\frac{\mu_0 i}{\sqrt{2}R}$

(Mains 2010)

37. Two circular coils 1 and 2 are made from the same wire but the radius of the 1st coil is twice that of the 2nd coil. What potential difference in volts should be applied across them so that the magnetic field at their centres is the same?

(a) 2 (b) 3 (c) 4 (d) 6 *(2006)*

38. An electron moves in a circular orbit with a uniform speed v. It produces a magnetic field B at the centre of the circle. The radius of the circle is proportional to

(a) $\sqrt{B/v}$ (b) B/v

(c) $\sqrt{v/B}$ (d) v/B *(2005)*

39. The magnetic field of given length of wire for single turn coil at its centre is B then its value for two turns coil for the same wire is

(a) $B/4$ (b) $B/2$ (c) $4B$ (d) $2B$ *(2002)*

40. Magnetic field due to 0.1 A current flowing through a circular coil of radius 0.1 m and 1000 turns at the centre of the coil is

(a) 6.28×10^{-4} T (b) 4.31×10^{-2} T

(c) 2×10^{-1} T (d) 9.81×10^{-4} T *(1999)*

41. Magnetic field intensity at the centre of the coil of 50 turns, radius 0.5 m and carrying a current of 2 A, is

(a) 3×10^{-5} T (b) 1.25×10^{-4} T

(c) 0.5×10^{-5} T (d) 4×10^{6} T *(1999)*

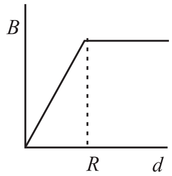
42. A coil of one turn is made of a wire of certain length and then from the same length a coil of two turns is made. If the same current is passed in both the cases, then the ratio of the magnetic inductions at their centres will be

(a) 4 : 1 (b) 1 : 4 (c) 2 : 1 (d) 1 : 2 *(1998)*

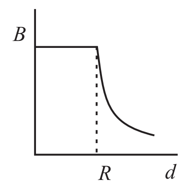
4.7 Ampere's Circuital Law

43. A cylindrical conductor of radius R is carrying a constant current. The plot of the magnitude of the magnetic field, B with the distance, d from the centre of the conductor, is correctly represented by the figure

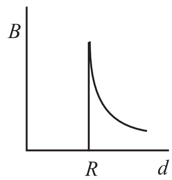
(a)



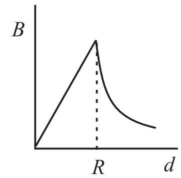
(b)



(c)



(d)



(NEET 2019)

44. A long straight wire of radius a carries a steady current I. The current is uniformly distributed over its cross-section. The ratio of the magnetic fields B and B', at radial distances $a/2$ and $2a$ respectively, from the axis of the wire is

(a) 1 (b) 4 (c) $\frac{1}{4}$ (d) $\frac{1}{2}$

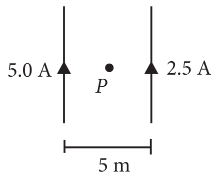
(NEET-I 2016)

45. Two identical long conducting wires AOB and COD are placed at right angle to each other, with one above other such that O is their common point for the two. The wires carry I_1 and I_2 currents, respectively. Point P is lying at distance d from O along a direction perpendicular to the plane containing the wires. The magnetic field at the point P will be

(a) $\frac{\mu_0}{2\pi d}\left(\frac{I_1}{I_2}\right)$ (b) $\frac{\mu_0}{2\pi d}(I_1 + I_2)$

(c) $\frac{\mu_0}{2\pi d}(I_1^2 - I_2^2)$ (d) $\frac{\mu_0}{2\pi d}(I_1^2 + I_2^2)^{1/2}$ *(2014)*

46. The magnetic field at centre, P will be



(a) $\frac{\mu_0}{4\pi}$

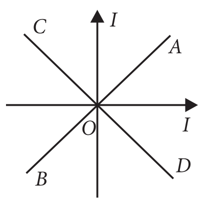
(b) $\frac{\mu_0}{\pi}$

(c) $\frac{\mu_0}{2\pi}$ (d) $4\mu_0\pi$ *(2000)*

47. A straight wire of diameter 0.5 mm carrying a current of 1 A is replaced by the another wire of 1 mm diameter carrying the same current. The strength of the magnetic field far away is
(a) one-quarter of the earlier value
(b) one-half of the earlier value
(c) twice the earlier value
(d) same as the earlier value. *(1999, 1997)*

48. If a long hollow copper pipe carries a current, then produced magnetic field will be
(a) both inside and outside the pipe
(b) outside the pipe only
(c) inside the pipe only
(d) neither inside nor outside the pipe. *(1999)*

49. Two equal electric currents are flowing perpendicular to each other as shown in the figure. AB and CD are perpendicular to each other and symmetrically placed with respect to the currents. Where do we expect the resultant magnetic field to be zero?



(a) On CD
(b) On AB
(c) On both OD and BO
(d) On both AB and CD *(1996)*

50. The magnetic field at a distance r from a long wire carrying current i is 0.4 tesla. The magnetic field at a distance $2r$ is
(a) 0.2 tesla (b) 0.8 tesla
(c) 0.1 tesla (d) 1.6 tesla *(1992)*

51. The magnetic induction at a point P which is at the distance of 4 cm from a long current carrying wire is 10^{-3} T. The field of induction at a distance 12 cm from the current will be
(a) 3.33×10^{-4} T (b) 1.11×10^{-4} T
(c) 33×10^{-3} T (d) 9×10^{-3} T *(1990)*

4.8 The Solenoid and the Toroid

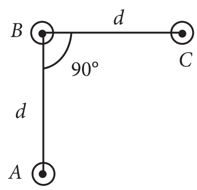
52. A long solenoid of 50 cm length having 100 turns carries a current of 2.5 A. The magnetic field at the centre of the solenoid is ($\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1})
(a) 6.28×10^{-4} T (b) 3.14×10^{-4} T
(c) 6.28×10^{-5} T (d) 3.14×10^{-5} T *(NEET 2020)*

53. Two toroids 1 and 2 have total number of turns 200 and 100 respectively with average radii 40 cm and 20 cm respectively. If they carry same current i, the radio of the magnetic fields along the two loops is
(a) 1 : 1 (b) 4 : 1 (c) 2 : 1 (d) 1 : 2
(Odisha NEET 2019)

54. 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 the magnetic field is
(a) $B/2$ (b) B (c) $2B$ (d) $4B$ *(2003)*

4.9 Force between Two Parallel Currents, the Ampere

55. An arrangement of three parallel straight wires placed perpendicular to plane of paper carrying same current 'I' along the same direction as shown in figure. Magnitude of force per unit length on the middle wire 'B' is given by

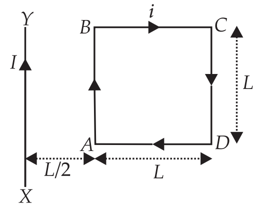


(a) $\frac{2\mu_0 I^2}{\pi d}$

(b) $\frac{\sqrt{2}\mu_0 I^2}{\pi d}$

(c) $\frac{\mu_0 I^2}{\sqrt{2}\pi d}$ (d) $\frac{\mu_0 I^2}{2\pi d}$ *(NEET 2017)*

56. A square loop $ABCD$ carrying a current i, is placed near and coplanar with a long straight conductor XY carrying a current I, the net force on the loop will be

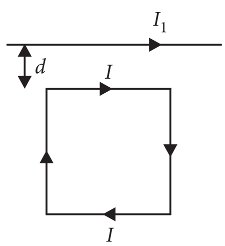


(a) $\frac{2\mu_0 IiL}{3\pi}$

(b) $\frac{\mu_0 IiL}{2\pi}$

(c) $\frac{2\mu_0 Ii}{3\pi}$ (d) $\frac{\mu_0 Ii}{2\pi}$ *(NEET-I 2016)*

57. A square loop, carrying a steady current I, is placed in a horizontal plane near a long straight conductor carrying a steady current I_1 at a distance d from the conductor as shown in figure. The loop will experience



(a) a net attractive force towards the conductor
(b) a net repulsive force away from the conductor
(c) a net torque acting upward perpendicular to the horizontal plane
(d) a net torque acting downward normal to the horizontal plane. *(Mains 2011)*

58. Two long parallel wires are at a distance of 1 metre. Both of them carry one ampere of current. The force of attraction per unit length between the two wires is
(a) 5×10^{-8} N/m (b) 2×10^{-8} N/m
(c) 2×10^{-7} N/m (d) 10^{-7} N/m *(1998)*

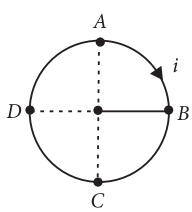
59. Two parallel wires in free space are 10 cm apart and each carries a current of 10 A in the same direction. The force exerted by one wire on the other, per metre length is
(a) 2×10^{-4} N, repulsive
(b) 2×10^{-7}N, repulsive
(c) 2×10^{-4} N, attractive
(d) 2×10^{-7}N, attractive. *(1997)*

4.10 Torque on Current Loop, Magnetic Dipole

60. A rectangular coil of length 0.12 m and width 0.1 m having 50 turns of wire is suspended vertically in a uniform magnetic field of strength 0.2 Weber/m^2. The coil carries a current of 2 A. If the plane of the coil is inclined at an angle of 30° with the direction of the field, the torque required to keep the coil in stable equilibrium will be
(a) 0.24 N m (b) 0.12 N m
(c) 0.15 N m (d) 0.20 N m *(2015)*

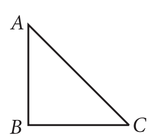
61. A current loop in a magnetic field
(a) can be in equilibrium in two orientations, both the equilibrium states are unstable.
(b) can be in equilibrium in two orientations, one stable while the other is unstable.
(c) experiences a torque whether the field is uniform or non uniform in all orientations.
(d) can be in equilibrium in one orientation. *(NEET 2013)*

62. A circular coil $ABCD$ carrying a current 'i' is placed in a uniform magnetic field. If the magnetic force on the segment AB is $\vec{F}$, the force on the remaining segment $BCDA$ is



(a) $-\vec{F}$ (b) $3\vec{F}$ (c) $-3\vec{F}$ (d) $\vec{F}$ *(Karnataka NEET 2013)*

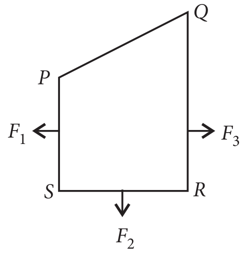
63. A current carrying closed loop in the form of a right angle isosceles triangle ABC is placed in a uniform magnetic field acting along AB. If the magnetic force on the arm BC is $\vec{F}$ the force on the arm AC is



(a) $-\sqrt{2}\vec{F}$ (b) $-\vec{F}$ (c) $\vec{F}$ (d) $\sqrt{2}\vec{F}$ *(2011)*

64. A square current carrying loop is suspended in a uniform magnetic field acting in the plane of the loop. If the force on one arm of the loop is $\vec{F}$ the net force on the remaining three arms of the loop is
(a) $3\vec{F}$ (b) $-\vec{F}$ (c) $-3\vec{F}$ (d) $\vec{F}$ *(2010)*

65. A closed loop $PQRS$ carrying a current is placed in a uniform magnetic field. If the magnetic forces on segments PS, SR and RQ are F_1, F_2 and F_3 respectively and are in the plane of the paper and along the directions shown, the force on the segment QP is



(a) $\sqrt{(F_3 - F_1)^2 - F_2^2}$ (b) $F_3 - F_1 + F_2$
(c) $F_3 - F_1 - F_2$ (d) $\sqrt{(F_3 - F_1)^2 + F_2^2}$ *(2008)*

66. A charged particle (charge q) is moving in a circle of radius R with uniform speed v. The associated magnetic moment μ is given by
(a) qvR^2 (b) $qvR^2/2$ (c) qvR (d) $qvR/2$ *(2007)*

67. A coil in the shape of an equilateral triangle of side l is suspended between the pole pieces of a permanent magnet such that $\vec{B}$ is in plane of the coil. If due to a current i in the triangle a torque τ acts on it, the side l of the triangle is
(a) $\frac{2}{\sqrt{3}}\left(\frac{\tau}{Bi}\right)$ (b) $2\left(\frac{\tau}{\sqrt{3}Bi}\right)^{1/2}$
(c) $\frac{2}{\sqrt{3}}\left(\frac{\tau}{Bi}\right)^{1/2}$ (d) $\frac{1}{\sqrt{3}}\frac{\tau}{Bi}$ *(2005)*

68. If number of turns, area and current through a coil is given by n, A and i respectively then its magnetic moment will be
(a) niA (b) n^2iA (c) niA^2 (d) $\frac{ni}{\sqrt{A}}$. *(2001)*

69. A circular loop of area 0.01 m^2 carrying a current of 10 A, is held perpendicular to a magnetic field of intensity 0.1 T. The torque acting on the loop is
(a) 0.001 N m (b) 0.8 N m
(c) zero (d) 0.01 N m. *(1994)*

70. A coil carrying electric current is placed in uniform magnetic field
(a) torque is formed
(b) e.m.f is induced
(c) both (a) and (b) are correct
(d) none of these *(1993)*

71. A current carrying coil is subjected to a uniform magnetic field. The coil will orient so that its plane becomes

(a) inclined at 45° to the magnetic field
(b) inclined at any arbitrary angle to the magnetic field
(c) parallel to the magnetic field
(d) perpendicular to magnetic field. *(1988)*

4.11 The Moving Coil Galvanometer

72. Current sensitivity of a moving coil galvanometer is 5 div/mA and its voltage sensitivity (angular deflection per unit voltage applied) is 20 div/V. The resistance of the galvanometer is
(a) 40 Ω (b) 25 Ω
(c) 250 Ω (d) 500 Ω *(NEET 2018)*

73. In an ammeter 0.2% of main current passes through the galvanometer. If resistance of galvanometer is G, the resistance of ammeter will be
(a) $\frac{1}{499}G$ (b) $\frac{499}{500}G$ (c) $\frac{1}{500}G$ (d) $\frac{500}{499}G$ *(2014)*

74. A milli voltmeter of 25 milli volt range is to be converted into an ammeter of 25 ampere range. The value (in ohm) of necessary shunt will be
(a) 0.001 (b) 0.01 (c) 1 (d) 0.05 *(2012)*

75. A galvanometer of resistance, G, is shunted by a resistance S ohm. To keep the main current in the circuit unchanged, the resistance to be put in series with the galvanometer is
(a) $\frac{G}{(S+G)}$ (b) $\frac{S^2}{(S+G)}$
(c) $\frac{SG}{(S+G)}$ (d) $\frac{G^2}{(S+G)}$ *(Mains 2011)*

76. A galvanometer has a coil of resistance 100 ohm and gives a full scale deflection for 30 mA current. If it is work as a voltmeter of 30 volt range, the resistance required to be added will be
(a) 900 Ω (b) 1800 Ω
(c) 500 Ω (d) 1000 Ω. *(2010)*

77. A galvanometer having a coil of resistance 60 Ω shows full scale deflection when a current of 1.0 amp passes through it. It can be converted into an ammeter to read currents upto 5.0 amp by
(a) putting in series a resistance of 15 Ω
(b) putting in series a resistance of 240 Ω
(c) putting in parallel a resistance of 15 Ω
(d) putting in parallel a resistance of 240 Ω. *(2009)*

78. A galvanometer of resistance 50 Ω is connected to a battery of 3 V along with a resistance of 2950 Ω in series. A full scale deflection of 30 divisions is obtained in the galvanometer. In order to reduce this deflection to 20 divisions, the resistance in series should be
(a) 6050 Ω (b) 4450 Ω
(c) 5050 Ω (d) 5550 Ω *(2008)*

79. The resistance of an ammeter is 13 Ω and its scale is graduated for a current upto 100 amps. After an additional shunt has been connected to this ammeter it becomes possible to measure currents upto 750 amperes by this meter. The value of shunt resistance is
(a) 2 Ω (b) 0.2 Ω (c) 2 kΩ (d) 20 Ω *(2007)*

80. A galvanometer of 50 ohm resistance has 25 divisions. A current of 4×10^{-4} ampere gives a deflection of one division. To convert this galvanometer into a voltmeter having a range of 25 volts, it should be connected with a resistance of
(a) 2500 Ω as a shunt (b) 2450 Ω as a shunt
(c) 2550 Ω in series (d) 2450 Ω in series. *(2004)*

81. To convert a galvanometer into a voltmeter one should connect a
(a) high resistance in series with galvanometer
(b) low resistance in series with galvanometer
(c) high resistance in parallel with galvanometer
(d) low resistance in parallel with galvanometer. *(2004, 2002)*

82. A galvanometer having a resistance of 9 ohm is shunted by a wire of resistance 2 ohm. If the total current is 1 amp, the part of it passing through the shunt will be
(a) 0.2 amp (b) 0.8 amp
(c) 0.25 amp (d) 0.5 amp *(1998)*

83. To convert a galvanometer into a ammeter, one needs to connect a
(a) low resistance in parallel
(b) high resistance in parallel
(c) low resistance in series
(d) high resistance in series. *(1992)*

ANSWER KEY

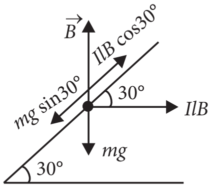
1.	(d)	**2.**	(d)	**3.**	(b)	**4.**	(b)	**5.**	(d)	**6.**	(d)	**7.**	(a)	**8.**	(b)	**9.**	(b)	**10.**	(a)
11.	(b)	**12.**	(b)	**13.**	(b)	**14.**	(b)	**15.**	(b)	**16.**	(a)	**17.**	(a)	**18.**	(c)	**19.**	(d)	**20.**	(b)
21.	(a)	**22.**	(c)	**23.**	(d)	**24.**	(c)	**25.**	(c)	**26.**	(a)	**27.**	(a)	**28.**	(a)	**29.**	(d)	**30.**	(b)
31.	(a)	**32.**	(b)	**33.**	(a)	**34.**	(a)	**35.**	(b)	**36.**	(a)	**37.**	(*)	**38.**	(c)	**39.**	(c)	**40.**	(a)
41.	(b)	**42.**	(b)	**43.**	(d)	**44.**	(a)	**45.**	(d)	**46.**	(c)	**47.**	(d)	**48.**	(b)	**49.**	(b)	**50.**	(a)
51.	(a)	**52.**	(a)	**53.**	(a)	**54.**	(b)	**55.**	(c)	**56.**	(c)	**57.**	(a)	**58.**	(c)	**59.**	(c)	**60.**	(d)
61.	(b)	**62.**	(a)	**63.**	(b)	**64.**	(b)	**65.**	(d)	**66.**	(d)	**67.**	(b)	**68.**	(a)	**69.**	(c)	**70.**	(a)
71.	(d)	**72.**	(c)	**73.**	(c)	**74.**	(a)	**75.**	(d)	**76.**	(a)	**77.**	(c)	**78.**	(b)	**79.**	(a)	**80.**	(d)
81.	(a)	**82.**	(b)	**83.**	(a)														

Hints & Explanations

1. (d) : Mass per unit length of a metallic rod is $\frac{m}{l} = 0.5 \text{ kg m}^{-1}$.

Let I be the current flowing.
For equilibrium,
$mg \sin 30° = IlB \cos 30°$

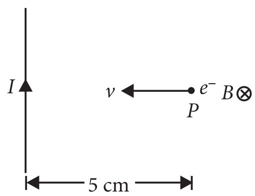
$$I = \frac{mg}{lB} \tan 30° = \frac{0.5 \times 9.8}{0.25 \times \sqrt{3}} = 11.32 \text{ A}$$



2. (d)

3. (b) : The situation is as shown in the figure.
Here, $v = 10^7$ m/s,
$B = 2 \times 10^{-4}$ Wb/m^2
The magnitude of the force experienced by the electron is

$F = evB\sin\theta$



($\because$ $\vec{v}$ and $\vec{B}$ are perpendicular to each other)

$= evB\sin 90° = 1.6 \times 10^{-19} \times 10^7 \times 2 \times 10^{-4} \times 1 = 3.2 \times 10^{-16}$ N

4. (b) : Force on electron due to electric field,

$$\vec{F}_E = -e\vec{E}$$

Force on electron due to magnetic field,

$$\vec{F}_B = -e(\vec{v} \times \vec{B}) = 0$$

Since $\vec{v}$ and $\vec{B}$ are in the same direction.
Total force on the electron,

$$\vec{F} = \vec{F}_E + \vec{F}_B = -e\vec{E}$$

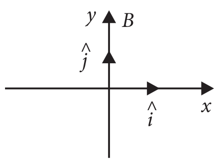
Electric field opposes the motion of the electron, hence speed of the electron will decrease.

5. (d) : Lorentz force $= q(\vec{v} \times \vec{B})$

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

$= -8\hat{k}$ N

= 8 N in $-z$ direction.



6. (d) : Force acting on a charged particle moving with velocity $\vec{v}$ is subjected to magnetic field $\vec{B}$ is given by

$$\vec{F} = q(\vec{v} \times \vec{B}); \quad F = qvB\sin\theta$$

(i) When $\theta = 0°$, $F = qvB\sin 0° = 0$
(ii) When $\theta = 90°$, $F = qvB\sin 90° = qvB$
(iii) When $\theta = 180°$, $F = qvB\sin 180° = 0$
This implies force acting on a charged particle is non-zero, when angle between $\vec{v}$ and $\vec{B}$ can have any value other than zero and 180°

7. (a) : According to Fleming's left hand rule direction of force is along Oy axis.

$\vec{F} = e(\vec{v} \times \vec{B})$.

B due to i is acting inwards *i.e.*, into the paper. v is along Ox.

$\Rightarrow \quad F = Q[v\hat{i} \times B(-\hat{k})]$

$\therefore \quad \vec{F} = +QvB\hat{j}$ *i.e.*, in Oy direction.

8. (b) : The force experienced by a charged particle moving in space where electric and magnetic field exists is called Lorentz force.
When a charged particle carrying charge q is subjected to an electric field of strength $\vec{E}$, it experiences a force given by $\vec{F}_e = q\vec{E}$ whose direction is same as $\vec{E}$ or opposite of $\vec{E}$ depending on the nature of charge, positive or negative.
If a charged particle is moving in a magnetic field of strength $\vec{B}$ with a velocity $\vec{v}$ it experiences a force given by $\vec{F}_m = q(\vec{v} \times \vec{B})$. The direction of this force is in the direction of $\vec{v} \times \vec{B}$ *i.e.*, perpendicular to the plane containing $\vec{v}$ and $\vec{B}$ is directed as given by right hand screw rule.
Due to both the electric and magnetic fields, the total force experienced by the charge q is given by

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

9. (b)

10. (a) : The force acting on a charged particle in magnetic field is given by $\vec{F} = q(\vec{v} \times \vec{B})$; $F = qvB\sin\theta$

$\therefore \quad F = 0$

when angle between $\vec{v}$ and $\vec{B}$ is 180°.

11. (b) : From, $F = il \times B = 1.2 \times 0.5 \times 2 = 1.2$ N

12. (b) : As, $r = \frac{mv}{qB} = \frac{p}{qB}$

For given p and B, $r \propto \frac{1}{q} \quad \Rightarrow \quad \frac{r_H}{r_\alpha} = \frac{q_\alpha}{q_H} = \frac{2}{1}$

13. (b) : The kinetic energy acquired by a charged particle in a uniform magnetic field B is

$$K = \frac{q^2B^2R^2}{2m} \qquad \left(\text{as} \quad R = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}\right)$$

where q and m are the charge and mass of the particle and R is the radius of circular orbit.

$\therefore$ The kinetic energy acquired by proton is

$$K_p = \frac{q_p^2B^2R_p^2}{2m_p}$$

and that by the alpha particle is $K_\alpha = \frac{q_\alpha^2B^2R_\alpha^2}{2m_\alpha}$

Thus, $\frac{K_\alpha}{K_p} = \left(\frac{q_\alpha}{q_p}\right)^2\left(\frac{m_p}{m_\alpha}\right)\left(\frac{R_\alpha}{R_p}\right)^2$

or $K_\alpha = K_p\left(\frac{q_\alpha}{q_p}\right)^2\left(\frac{m_p}{m_\alpha}\right)\left(\frac{R_\alpha}{R_p}\right)^2$

Here, $K_p = 1$ MeV, $\frac{q_\alpha}{q_p} = 2$, $\frac{m_p}{m_\alpha} = \frac{1}{4}$ and $\frac{R_\alpha}{R_p} = 1$

$\therefore \quad K_\alpha = (1 \text{ MeV})(2)^2\left(\frac{1}{4}\right)(1)^2 = 1 \text{ MeV}$

14. (b)

15. (b) : For the circular motion of a charged particle in a uniform magnetic field

$$qvB = \frac{mv^2}{R} \Rightarrow qB = m\omega = \frac{m \times 2\pi}{T}$$

$\therefore\ T = \frac{2\pi m}{qB}$ is independent of v and R.

16. (a) : When a charged particle having K.E., T enters in a field of magnetic induction, which is perpendicular to its velocity, it takes a circular trajectory. It does not increase in energy, therefore T is the K.E.

17. (a) : If a moving charged particle is subjected to a perpendicular uniform magnetic field, then according to $F = qvB\sin\theta$, it will experience a maximum force which will provide the centripetal force to particle and it will describe a circular path with uniform speed.

18. (c) : The frequency of revolution of a charged particle in a perpendicular magnetic field is

$$\upsilon = \frac{1}{T} = \frac{1}{2\pi r/v} = \frac{v}{2\pi r} = \frac{v}{2\pi} \times \frac{eB}{mv} = \frac{eB}{2\pi m}$$

19. (d) : $qvB\sin\theta = \frac{mv^2}{R}$

$$R = \frac{mv}{qB\sin\theta} = \frac{3\times10^5}{10^8 \times 0.3 \times \frac{1}{2}} = 0.02\ \text{m} = 2\ \text{cm}$$

20. (b) : When a positively charged particle enters in a region of uniform magnetic field, directed perpendicular to the velocity it experiences a centripetal force which will move it in circular path with a uniform speed.

21. (a) : Kinetic energy of electron $\left(\frac{1}{2}\times mv^2\right)$ = 10 eV

and magnetic induction (B) = 10^{-4} Wb/m^2

Therefore, $\frac{1}{2}(9.1\times10^{-31})v^2 = 10\times(1.6\times10^{-19})$

or, $v^2 = \frac{2\times10\times(1.6\times10^{-19})}{9.1\times10^{-31}} = 3.52\times10^{12}$

or, $v = 1.876 \times 10^6$ m/s

Centripetal force, $\frac{mv^2}{r} = Bev$

Therefore, $r = \frac{mv}{Be} = \frac{(9.1\times10^{-31})\times(1.876\times10^6)}{10^{-4}\times(1.6\times10^{-19})}$

$= 11 \times 10^{-2}$ m = 11 cm

22. (c) : $r = \frac{mv}{qB}$ or $r \propto v$

As v is doubled, the radius also becomes doubled. Hence new radius = 2 × 2 = 4 cm

23. (d) : For a charged particle orbiting in a circular path in a magnetic field $\frac{mv^2}{r} = Bvq \Rightarrow v = \frac{Bqr}{m}$

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}Bqvr = Bq\frac{r}{2}\cdot\frac{Bqr}{m} = \frac{B^2q^2r^2}{2m}$$

For deuteron, $E_1 = \frac{B^2q^2\times r^2}{2\times 2m}$

For proton, $E_2 = \frac{B^2q^2r^2}{2m}$

$$\frac{E_1}{E_2} = \frac{1}{2} \Rightarrow \frac{50\ \text{keV}}{E_2} = \frac{1}{2} \Rightarrow E_2 = 100\ \text{keV}$$

24. (c) : Frequency, $\upsilon = \frac{eB}{2\pi m}$ or $B = \frac{2\pi m\upsilon}{e}$

As $\frac{mv^2}{R} = evB$ or $v = \frac{eBR}{m} = 2\pi\upsilon R$

Kinetic energy, $K = \frac{1}{2}mv^2 = \frac{1}{2}m(2\pi\upsilon R)^2 = 2m\pi^2\upsilon^2R^2$

25. (c)

26. (a) : Electron travelling in a magnetic field perpendicular to its velocity follows a circular path.

27. (a) : In mass spectrometer when ions are accelerated through potential V,

$$\frac{1}{2}mv^2 = qV \qquad \text{... (i)}$$

where m is the mass of ion, q is the charge of the ion.

As the magnetic field curves the path of the ions in a semicircular orbit

$$\therefore\ Bqv = \frac{mv^2}{R} \Rightarrow v = \frac{BqR}{m} \qquad \text{... (ii)}$$

Substituting (ii) in (i), we get

$$\frac{1}{2}m\left[\frac{BqR}{m}\right]^2 = qV \quad \text{or,} \quad \frac{q}{m} = \frac{2V}{B^2R^2}$$

Since V, B are constants,

$$\frac{q}{m} \propto \frac{1}{R^2} \quad \text{or,} \quad \frac{\text{charge on the ion}}{\text{mass of the ion}} \propto \frac{1}{R^2}$$

28. (a) : $eE = evB \quad \therefore\ v = \frac{|\vec{E}|}{|\vec{B}|}$

29. (d) : Electric field (E) = 20 V/m and magnetic field (B) = 0.5 T.

The force on electron in a magnetic field = evB

Force on electron in an electric field = eE

Since the electron is moving with constant velocity, therefore the resultant force on electron is zero.

i.e., $eE = evB \Rightarrow v = E/B = 20/0.5 = 40$ m s^{-1}

30. (b) : According to Biot-Savart's law,

$$d\vec{B} \propto i\left(\frac{d\vec{l}\times\vec{r}}{r^3}\right) \text{ or } d\vec{B} = \frac{\mu_0}{4\pi}i\left(\frac{d\vec{l}\times\vec{r}}{r^3}\right).$$

31. (a) : Magnetic field due to $i_1 = \frac{\mu_0 i_1}{2R}\frac{\theta_1}{2\pi}$ (Into the plane)

Magnetic field due to $i_2 = \frac{\mu_0 i_2}{2R}\frac{\theta_2}{2\pi}$ (Out of the plane)

For parallel combination

Now, $\frac{i_1}{i_2} = \frac{\rho l_2}{A}\times\frac{A}{\rho l_1} = \frac{l_2}{l_1}$

$$\Rightarrow \frac{i_1}{i_2} = \frac{\frac{1}{4}(2\pi R)}{\frac{3}{4}(2\pi R)} = \frac{1}{3} \Rightarrow i_1 = \frac{i_2}{3} \Rightarrow i_2 = 3i_1$$

$\therefore$ Net magnetic field, $= \frac{\mu_0 i_1}{2R}\left(\frac{\theta_1}{2\pi}\right) - \frac{\mu_0 i_2}{2R}\left(\frac{\theta_2}{2\pi}\right)$

$$= \frac{\mu_0 i_1}{2R}\left(\frac{3\pi}{2\times 2\pi}\right) - \frac{\mu_0 i_2}{2R}\left(\frac{\pi}{2\times 2\pi}\right)$$

$$= \frac{\mu_0}{2R}\left[\frac{3i_1}{4} - \frac{i_2}{4}\right] = \frac{\mu_0}{2R}\left[\frac{3i_1}{4} - \frac{3i_1}{4}\right] = 0$$

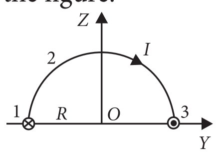
32. (b) : Let l be the length of the wire. Magnetic field at the centre of the loop is

$$B = \frac{\mu_0 I}{2R} \quad \therefore \quad B = \frac{\mu_0 \pi I}{l} \quad (\because\ l = 2\pi R) \qquad \text{...(i)}$$

$$B' = \frac{\mu_0 nI}{2r} = \frac{\mu_0 nI}{2\left(\frac{l}{2n\pi}\right)} \quad \text{or,} \quad B' = \frac{\mu_0 n^2 \pi I}{l} \qquad \text{...(ii)}$$

From eqns. (i) and (ii), we get $B' = n^2 B$

33. (a) : Given situation is shown in the figure. Parallel wires 1 and 3 are semi-infinite, so magnetic field at O due to them



$$\vec{B}_1 = \vec{B}_3 = -\frac{\mu_0 I}{4\pi R}\hat{k}$$

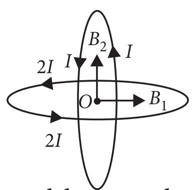
Magnetic field at O due to semi-circular arc in YZ-plane is given by $\vec{B}_2 = -\frac{\mu_0 I}{4R}\hat{i}$

Net magnetic field at point O is given by

$$\vec{B} = \vec{B}_1 + \vec{B}_2 + \vec{B}_3$$

$$= -\frac{\mu_0 I}{4\pi R}\hat{k} - \frac{\mu_0 I}{4R}\hat{i} - \frac{\mu_0 I}{4\pi R}\hat{k} = -\frac{\mu_0 I}{4\pi R}(\pi\hat{i} + 2\hat{k})$$

34. (a) : Magnetic field induction due to vertical loop at the centre O is



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

It acts in horizontal direction.

Magnetic field induction due to horizontal loop at the centre O is

$$B_2 = \frac{\mu_0 2I}{2R}$$

It acts in vertically upward direction.

As B_1 and B_2 are perpendicular to each other, therefore the resultant magnetic field induction at the centre O is

$$B_{net} = \sqrt{B_1^2 + B_2^2} = \sqrt{\left(\frac{\mu_0 I}{2R}\right)^2 + \left(\frac{\mu_0 2I}{2R}\right)^2}$$

$$B_{net} = \frac{\mu_0 I}{2R}\sqrt{(1)^2 + (2)^2} = \frac{\sqrt{5}\mu_0 I}{2R}$$

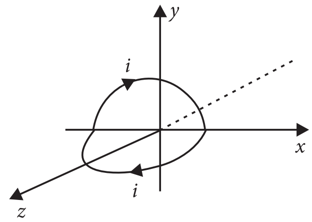
35. (b) : The current flowing in the ring is

$$I = qf \qquad \text{...(i)}$$

The magnetic induction at the centre of the ring is

$$B = \frac{\mu_0 I}{2R} = \frac{\mu_0 qf}{2R} \quad \text{(Using(i))}$$

36. (a) : The loop mentioned in the question must look like one as shown in the figure.



Magnetic field at the centre due to semicircular loop lying in x-y plane, $B_{xy} = \frac{1}{2}\left(\frac{\mu_0 i}{2R}\right)$ negative z direction.

Similarly field due to loop in x-z plane, $B_{xz} = \frac{1}{2}\left(\frac{\mu_0 i}{2R}\right)$ in negative y direction.

$\therefore$ Magnitude of resultant magnetic field,

$$B = \sqrt{B_{xy}^2 + B_{xz}^2} = \sqrt{\left(\frac{\mu_0 i}{4R}\right)^2 + \left(\frac{\mu_0 i}{4R}\right)^2} = \frac{\mu_0 i}{4R}\sqrt{2} = \frac{\mu_0 i}{2\sqrt{2}R}$$

37. (*) : The magnetic field at the centre of the coil,

$B = \frac{\mu_0 ni}{2r}$; where r is the radius.

$E/R = i$

$\therefore$ $R \propto 2\pi r \Rightarrow R = cr$, where c is a constant.

$\therefore$ In the first coil, $B_1 = \frac{\mu_0 ni_1}{2r_1} = \frac{\mu_0 nE}{2r_1(cr_1)} = \frac{\mu_0 nE}{2cr_1^2}$

If $r_1 = 2r_2$, $B_1 = \frac{\mu_0 nE_1}{2c(2r_2)^2} = \frac{\mu_0 nE_1}{2c\cdot 4r_2^2}$

$$B_2 = \frac{\mu_0 nE_2}{2cr_2^2}$$

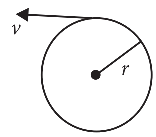
As B_1 will not be equal to B_2 unless E_1 is different from E_2, E_1 and E_2 will not be the same.

It is wrong to ask what potential difference should be applied across them. It should be perhaps the ratio of potential differences.

In that case, $B_1 = B_2$, $\frac{E_1}{4} = E_2 \Rightarrow E_1 = 4E_2 \quad \therefore \frac{E_1}{E_2} = 4.$

*Question is not correct.

38. (c) : The magnetic field is produced by moving electron in circular path $B = \frac{\mu_0 i}{2r}$



where $i = \frac{q}{t} = \frac{q}{2\pi r}\times v$

$$\therefore \quad B = \frac{\mu_0 qv}{4\pi r^2} \Rightarrow r \propto \sqrt{\frac{v}{B}}$$

39. (c) : The magnetic field B produced at the centre of a circular coil due to current I flowing through this is given by $B = \frac{\mu_0 NI}{2r}$, N is number of turns and r is radius of the coil. Here $B = \frac{\mu_0 I}{2r}[N = 1]$

Here, $2\times 2\pi r' = 2\pi r \quad \therefore \quad r' = r/2.$

$\therefore$ Magnetic field at the centre for two turns $(N = 2)$ is given by

$$B' = \frac{\mu_0 \times 2I}{2r'} = \frac{\mu_0 \times 2I}{2r/2} = \frac{4\mu_0 I}{2r} = 4B$$

40. (a): $B = \frac{\mu_0 Ni}{2r} = \frac{4\pi\times 10^{-7}\times 1000\times 0.1}{2\times 0.1} = 6.28\times 10^{-4}$ T

41. (b) : $B = \frac{\mu_0 (Ni)}{2r} = \frac{4\pi \times 10^{-7} \times 50 \times 2}{2 \times 0.5} = 1.256 \times 10^{-4}$ T

42. (b) : Magnetic field at the centre of the coil,

$$B = \frac{\mu_0}{2\pi} \frac{NI}{a}$$

Let l be the length of the wire, then

$$B_1 = \frac{\mu_0}{2\pi} \cdot \frac{1 \times I}{l/2\pi} = \frac{\mu_0 I}{l} \text{ and } B_2 = \frac{\mu_0}{2\pi} \cdot \frac{2 \times I}{l/4\pi} = \frac{4\mu_0 I}{l}$$

Therefore, $\frac{B_1}{B_2} = \frac{1}{4}$ or, $B_1 : B_2 = 1 : 4$

43. (d) : Magnetic field due to long solid cylindrical conductor of radius R,

(i) For $d < R$, $I' = \frac{Id^2}{R^2}$

$$\int \vec{B}.d\vec{l} = \mu_0 I' \Rightarrow B(2\pi d) = \frac{\mu_0 I d^2}{R^2} \Rightarrow B = \frac{\mu_0 I d}{2\pi R^2}$$

$\therefore \quad B \propto d$

(ii) For $d = R$, $B = \mu_0 I/2\pi R$ (maximum)

(iii) For $d > R$, $B = \mu_0 I/2\pi d \Rightarrow B \propto 1/d$

44. (a) : Magnetic field at a point inside the wire at distance $r\left(=\frac{a}{2}\right)$ from the axis of wire is

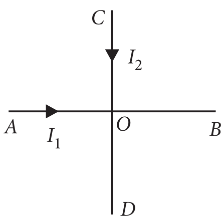
$$B = \frac{\mu_0 I}{2\pi a^2} r = \frac{\mu_0 I}{2\pi a^2} \times \frac{a}{2} = \frac{\mu_0 I}{4\pi a}$$

Magnetic field at a point outside the wire at a distance $r(= 2a)$ from the axis of wire is

$$B' = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{2\pi} \times \frac{1}{2a} = \frac{\mu_0 I}{4\pi a} \qquad \therefore \frac{B}{B'} = 1$$

45. (d) : The magnetic field at the point P, at a perpendicular distance d from O in a direction perpendicular to the plane $ABCD$ due to currents through AOB and COD are perpendicular to each other.

Hence,



$$B = (B_1^2 + B_2^2)^{1/2}$$

$$= \left[\left(\frac{\mu_0}{4\pi} \frac{2I_1}{d}\right)^2 + \left(\frac{\mu_0}{4\pi} \frac{2I_2}{d}\right)^2\right]^{1/2}$$

$$= \frac{\mu_0}{2\pi d}(I_1^2 + I_2^2)^{1/2}$$

46. (c) : $B = \frac{\mu_0}{4\pi} \frac{2i_2}{(r/2)} - \frac{\mu_0}{4\pi} \frac{2i_1}{(r/2)} = \frac{\mu_0}{4\pi} \frac{4}{r}(i_2 - i_1)$

$$= \frac{\mu_0}{4\pi} \frac{4}{5}(2.5 - 5.0) = -\frac{\mu_0}{2\pi}$$

Negative sign shows that B is acting inwards *i.e.*, into the plane.

47. (d) : Diameter of first wire $(d_1) = 0.5$ mm;
Current in first wire $(I_1) = 1$ A; Diameter of second wire $(d_2) = 1$ mm and current in second wire $(I_2) = 1$ A
Strength of magnetic field due to current flowing in a conductor, $(B) = \frac{\mu_0}{4\pi} \times \frac{2I}{a}$ or $B \propto I$
Since the current in both the wires is same, therefore there is no change in the strength of the magnetic field.

48. (b) : Use Ampère's law $\oint B.dl = \mu_0\, i_{\text{enclosed}}$
Outside : $i_{\text{enclosed}} \neq 0$ (some value) $\Rightarrow B \neq 0$
Inside = $i_{\text{enclosed}} = 0 \Rightarrow B = 0$

49. (b) : The direction of the magnetic field, due to current, is given by the right-hand rule. At axis AB, the components of magnetic field will cancel each other and the resultant magnetic field will be zero.

50. (a) : $B = \frac{\mu_0 i}{2\pi r}$ or $B \propto \frac{1}{r}$

When r is doubled, the magnetic field becomes halved *i.e.*,now the magnetic field will be 0.2 T.

51. (a) : $B \propto 1/r$, for given current.
As the distance is increased to three times, the magnetic induction reduces to one third.

Hence $B = \frac{1}{3} \times 10^{-3}$ T $= 3.33 \times 10^{-4}$ T

52. (a) : Here, $l = 50$ cm, $N = 100$, $i = 2.5$ A
Magnetic field inside the solenoid,

$$B = \mu_0 ni = \frac{\mu_0 NI}{l}$$

$$B = \frac{4\pi \times 10^{-7} \times 100 \times 2.5}{0.5} = 6.28 \times 10^{-4} \text{ T}$$

53. (a) : For a toroid magnetic field, $B = \mu_0 ni$

Where, n = number of turns per unit length $= \frac{N}{2\pi r}$

Now, $\frac{B_1}{B_2} = \frac{\mu_0 n_1 i}{\mu_0 n_2 i} = \frac{n_1}{n_2} = \frac{N_1}{2\pi r_1} \times \frac{2\pi r_2}{N_2}$

$$\Rightarrow \frac{B_1}{B_2} = \frac{200}{2\pi \times 40 \times 10^{-2}} \times \frac{2\pi \times 20 \times 10^{-2}}{100}$$

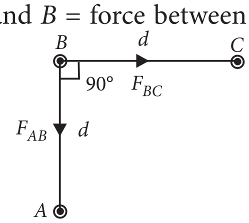
$$\Rightarrow \frac{B_1}{B_2} = \frac{1}{1} \Rightarrow B_1 : B_2 = 1 : 1$$

54. (b) : Magnetic field induction at point inside a long solenoid l, having n turns per unit length carrying current i is given by

$$B = \mu_0 ni$$

If $i \rightarrow$ doubled, $n \rightarrow$ halved then $B \rightarrow$ remains same.

55. (c) : Force between wires A and B = force between wires B and C



$$\therefore F_{BC} = F_{AB} = \frac{\mu_0 I^2 l}{2\pi d}$$

As, $\vec{F}_{AB} \perp \vec{F}_{BC}$ net force on wire B,

$$F_{\text{net}} = \sqrt{2} F_{BC} = \frac{\sqrt{2}\mu_0 I^2 l}{2\pi d} \text{ or } \frac{F_{\text{net}}}{l} = \frac{\mu_0 I^2}{\sqrt{2}\,\pi d}$$

56. (c) : Force on arm AB due to current in conductor XY is

$$F_1 = \frac{\mu_0}{4\pi} \frac{2IiL}{(L/2)} = \frac{\mu_0 Ii}{\pi}$$

acting towards XY in the plane of loop.

Force on arm CD due to current in conductor XY is

$$F_2 = \frac{\mu_0}{4\pi}\frac{2IiL}{3(L/2)} = \frac{\mu_0 Ii}{3\pi}$$

acting away from XY in the plane of loop.

$\therefore$ Net force on the loop $= F_1 - F_2$

$$= \frac{\mu_0 Ii}{\pi}\left[1 - \frac{1}{3}\right] = \frac{2}{3}\frac{\mu_0 Ii}{\pi}$$

57. (a)

58. (c) : $F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r} = \frac{10^{-7}\times 2(1)\times(1)}{1} = 2\times 10^{-7}$ N/m

59. (c) : Distance between two parallel wires,
$x = 10$ cm $= 0.1$ m;
Current in each wire $= I_1 = I_2 = 10$ A and
length of wire $(l) = 1$ m

Force on the wire $(F) = \frac{\mu_0 I_1 \cdot I_2 \times l}{2\pi x}$

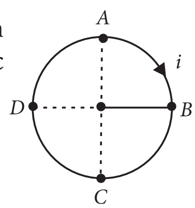
$$= \frac{(4\pi\times 10^{-7})\times 10\times 10\times 1}{2\pi\times 0.1} = 2\times 10^{-4}\ \text{N}$$

Since the current is flowing in the same direction, therefore the force will be attractive.

60. (d) : The required torque is $\tau = NIAB\sin\theta$
where N is the number of turns in the coil, I is the current through the coil, B is the uniform magnetic field, A is the area of the coil and θ is the angle between the direction of the magnetic field and normal to the plane of the coil.
Here, $N = 50$, $I = 2$ A, $A = 0.12$ m $\times$ 0.1 m $= 0.012$ m^2
$B = 0.2$ Wb/m^2 and $\theta = 90° - 30° = 60°$
$\therefore$ $\tau = (50)(2\text{ A})(0.012\text{ m}^2)(0.2\text{ Wb/m}^2)\sin 60°$
$= 0.20$ N m

61. (b) : When a current loop is placed in a magnetic field it experiences a torque. It is given by $\vec{\tau} = \vec{M}\times\vec{B}$
where, $\vec{M}$ is the magnetic moment of the loop and $\vec{B}$ is the magnetic field.
$\tau = MB\sin\theta$ where θ is angle between $\vec{M}$ and $\vec{B}$
When $\vec{M}$ and $\vec{B}$ and are parallel (*i.e.*, $\theta = 0°$) the equilibrium is stable and when they are antiparallel (*i.e.*, $\theta = \pi$) the equilibrium is unstable.

62. (a) : The net magnetic force on a current loop in a uniform magnetic field is always zero.



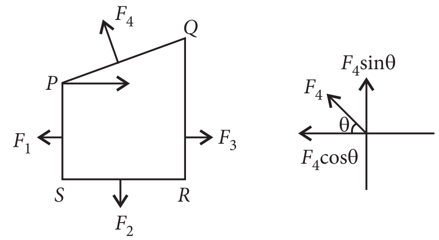
$\therefore$ $\vec{F}_{AB} + \vec{F}_{BCDA} = 0$

$\vec{F}_{BCDA} = -\vec{F}_{AB} = -\vec{F}$

63. (b) : Here, $\vec{F}_{BC} = \vec{F}$ and $\vec{F}_{AB} = I(\vec{l}\times\vec{B}) = 0$
The net magnetic force on a current carrying closed loop in a uniform magnetic field is zero.
$\therefore$ $\vec{F}_{AB} + \vec{F}_{BC} + \vec{F}_{AC} = 0$
$\Rightarrow$ $\vec{F}_{AC} = -\vec{F}_{BC}$ $\quad (\because\ \vec{F}_{AB} = 0)$

64. (b)

65. (d) :



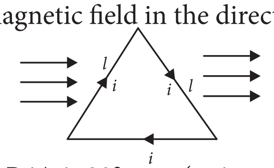
$F_4\sin\theta = F_2$
$F_4\cos\theta = (F_3 - F_1)$
$\therefore$ $F_4 = \sqrt{(F_3 - F_1)^2 + F_2^2}$
For a closed loop there is no translation.

66. (d) : Magnetic moment $\mu = IA$

Since $T = \frac{2\pi R}{v}$ Also, $I = \frac{q}{T} = \frac{qv}{2\pi R}$

$\therefore$ $\mu = \left(\frac{qv}{2\pi R}\right)(\pi R^2) = \frac{qvR}{2}$

67. (b) : The current flowing clockwise in the equilateral triangle has a magnetic field in the direction $\hat{k}$



$\tau = BiNA\sin\theta = B\,iA\sin 90°$ (as it appears that $N = 1$)

$\tau = Bi\times\frac{\sqrt{3}}{4}l^2 \Rightarrow l = 2\left(\frac{\tau}{Bi\sqrt{3}}\right)^{1/2}$

68. (a) : Magnetic moment $M = niA$

69. (c) : Area $(A) = 0.01$ m^2; Current $(I) = 10$ A;
Angle $(\phi) = 90°$ and magnetic field $(B) = 0.1$ T
Therefore actual angle $\theta = (90° - \phi)$
$= (90° - 90°) = 0°$
Torque acting on the loop $(\tau) = IAB\sin\theta$
$= 10\times 0.01\times 0.1\times\sin 0° = 0$

70. (a) : A current carrying coil has magnetic dipole moment. Hence a torque $\vec{m}\times\vec{B}$ acts on it in a magnetic field.

71. (d) : The plane of coil will orient itself so that area vector aligns itself along the magnetic field.

72. (c) : Let N = number of turns in galvanometer,
A = Area, B = magnetic field
k = the restoring torque per unit twist.

Current sensitivity, $I_S = \frac{NBA}{k}$

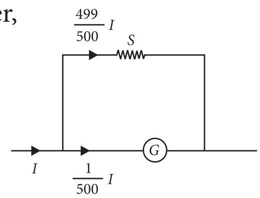
Voltage sensitivity, $V_S = \frac{NBA}{kR_G}$

So, resistance of galvanometer

$$R_G = \frac{I_S}{V_S} = \frac{5\times 1}{20\times 10^{-3}} = \frac{5000}{20} = 250\ \Omega$$

73. (c) : Here, resistance of the galvanometer = G
Current through the galvanometer,

$$I_G = 0.2\% \text{ of } I = \frac{0.2}{100}I = \frac{1}{500}I$$



$\therefore$ Current through the shunt,

$$I_S = I - I_G = I - \frac{1}{500}I = \frac{499}{500}I$$

As shunt and galvanometer are in parallel
$\therefore$ $I_G G = I_S S$

$$\left(\frac{1}{500}I\right)G = \left(\frac{499}{500}\right)S \text{ or } S = \frac{G}{499}$$

Resistance of the ammeter R_A is

$$\frac{1}{R_A} = \frac{1}{G} + \frac{1}{S} = \frac{1}{G} + \frac{1}{\frac{G}{499}} = \frac{500}{G}$$

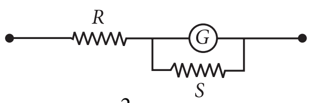
$$R_A = \frac{1}{500}G$$

74. (a) : $S = \dfrac{V_g}{(I - I_g)}$

Neglecting I_g

$$\therefore \quad S = \frac{V_g}{I} = \frac{25 \times 10^{-3}\ \text{V}}{25\ \text{A}} = 0.001\,\Omega$$

75. (d) : Let resistance R is to be put in series with galvanometer G to keep the main current in the circuit unchanged.

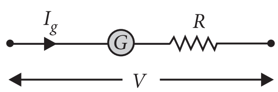


$$\therefore \quad \frac{GS}{G+S} + R = G$$

$$R = G - \frac{GS}{G+S} \Rightarrow R = \frac{G^2 + GS - GS}{G+S} = \frac{G^2}{G+S}$$

76. (a) : Here, Resistance of galvanometer,
$G = 100\ \Omega$
Current for full scale deflection, $I_g = 30$ mA
$= 30 \times 10^{-3}$ A
Range of voltmeter, $V = 30$ V
To convert the galvanometer into an voltmeter of a given range, a resistance R is connected in series with it as shown in the figure.
From figure, $V = I_g(G + R)$

or $\quad R = \dfrac{V}{I_g} - G$



$$= \frac{30}{30 \times 10^{-3}} - 100\,\Omega = 1000 - 100 = 900\,\Omega$$

77. (c) : $iG = (I - i)S$ where G is the galvanometer resistance and S is the shunt used with the ammeter.
$1.0 \times 60 = (5 - 1)S$ where S is the shunt used to read a 5 A current when the galvanometer can stand by 1 A.

$$S = \frac{1.0 \times 60}{4} = 15\ \Omega \text{ in parallel}$$

78. (b) : Total initial resistance
$= R_G + R_1 = (50 + 2950)\ \Omega = 3000\ \Omega$
$\varepsilon = 3$ V

$$\therefore \quad \text{Current} = \frac{3\ \text{V}}{3000\ \Omega} = 1 \times 10^{-3}\ \text{A} = 1\ \text{mA}$$

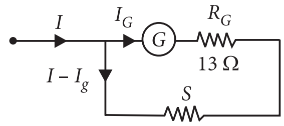
If the deflection has to be reduced to 20 divisions, current $i = 1\ \text{mA} \times \dfrac{2}{3}$ as the full deflection scale for 1 mA = 30 divisions.

$$3\ \text{V} = 3000\ \Omega \times 1\ \text{mA} = x\ \Omega \times \frac{2}{3}\ \text{mA}$$

$$\Rightarrow \quad x = 3000 \times 1 \times \frac{3}{2} = 4500\ \Omega$$

But the galvanometer resistance = 50 Ω
Therefore the resistance to be added
= (4500 – 50)Ω = 4450 Ω.

79. (a) : Let the shunt resistance be S.
Given: $I = 750$ A,
$I_g = 100$ A, $R_G = 13\ \Omega$

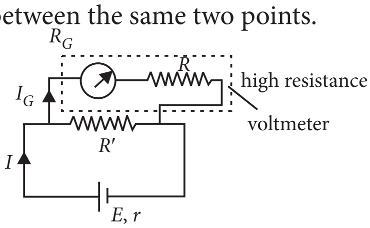


From the figure,
$I_g R_G = (I - I_g)S$
or $\quad 100 \times 13 = [750 - 100]S$
or $\quad 1300 = 650\ S$
$\therefore \quad S = 1300/650 = 2\ \Omega$

80. (d) : The total current shown by the galvanometer is $25 \times 4 \times 10^{-4}$ A.
$\therefore \quad I_g = 10^{-2}$ A
The value of resistance connected in series to convert galvanometer into voltmeter of 25 V is

$$R = \frac{V}{I_g} - G = \frac{25}{10^{-2}} - 50 = 2450\ \Omega$$

81. (a) : Voltmeter is used to measure the potential difference across a resistance and it is connected in parallel with the circuit. A high resistance is connected to the galvanometer in series so that only a small fraction (I_g) of the main circuit current (I) passes through it. If a considerable amount of current is allowed to pass through the voltmeter, then the reading obtained by this voltmeter will not be close to the actual potential difference between the same two points.



82. (b) : The shunt and galvanometer are in parallel.

Therefore, $\dfrac{1}{R_{eq}} = \dfrac{1}{9} + \dfrac{1}{2}$ or $R_{eq} = \dfrac{18}{11}\ \Omega$

Using Ohm's law, $V = IR_{eq} = 1 \times \dfrac{18}{11} = \dfrac{18}{11}$ V.

$$\therefore \quad \text{Current through shunt} = \frac{V}{R_s}$$

$$= \frac{18/11}{2} = \frac{9}{11} \simeq 0.8 \text{ amp}$$

83. (a) : To convert a galvanometer into ammeter, one needs to connect a low resistance in parallel so that maximum current passes through the shunt wire and ammeter remains protected.

❖❖❖