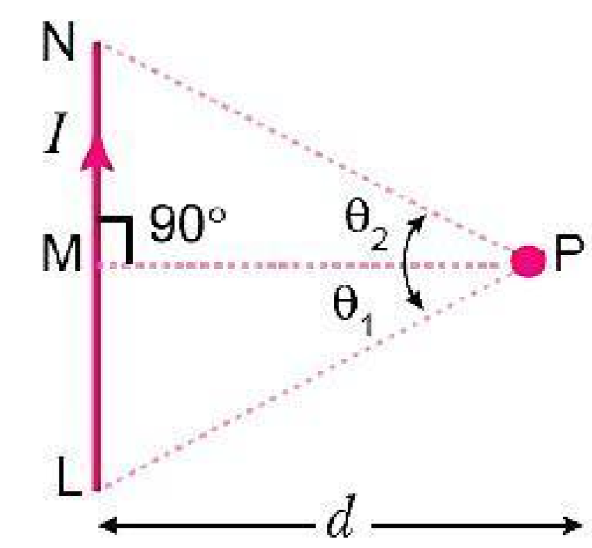
MOVING CHARGES AND MAGNETISM

IMPORTANT FORMULAE

1. **Biot–Savart Law:** Magnetic field due to a current element

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,\vec{dl}\times\vec{r}}{r^3}$$

2. **Magnetic field due to a straight current carrying wire,**



$$B = \frac{\mu_0 I}{4\pi R}(\sin\theta_1 + \sin\theta_2)$$

where q_1 and q_2 are the angles substended by ends of the conductor at the reference point with the normal. For infinitely long wire $B = \frac{\mu_0 I}{2\pi R}$

3. **Magnetic field due to a current carrying circular coil**

   (*i*) At centre $B_c = \frac{\mu_0 NI}{2R}$

   (*ii*) At a point on the axis $B_{axis} = \frac{\mu_0 NIa^2}{2(a^2+x^2)^{3/2}}$ (where a = radius of coil) and x is the distance of the point)

4. **Ampere's circuital law:** $\int \vec{B}.\vec{dl} = \mu_0 I$

5. **Magnetic field strength within solenoid**

   $B = \mu_0 nI$ where n = number of turns per metre length.

6. **Magnetic field due to toroid**

   (*i*) Within the coils $B = \frac{\mu_0 NI}{2\pi r}$

   (*ii*) Outside the toroid $B = 0$.

7. **Magnetic force on a moving charge in a magnetic field**

$$\vec{F}_m - q\,\vec{v}\times\vec{B}$$

8. **Magnetic force on a current carrying conductor**

$$\vec{F}_m = I\,\vec{l}\times\vec{B}$$

9. **Force per unit length between parallel currents:**

$$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}\,N/m$$

10. **Torque experienced by a current carrying loop in a uniform magnetic field**

$$\vec{\tau} = NI\,\vec{A}\times\vec{B} = \vec{M}\times\vec{B}$$

11. Magnetic moment of a current loop

$$\vec{M} = NI\vec{A} \text{ ampere} \times \text{metre}^2$$

12. Deflection in moving coil galvanometer

$$\phi = \frac{NAB}{C} I$$

Current sensitivity of a galvanometer $S = \frac{\theta}{I} = \frac{NAB}{C}$

13. For conversion of galvanometer into ammeter,

Shunt resistance required $S = \frac{I_g}{I - I_g} G \approx \frac{I_g}{I} G$

14. For conversion of galvanomter into voltmeter,

Series resistance required $R = \frac{V}{I_g} - G$

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. If a conducting wire carries a direct current through it, the magnetic field associated with the current will be __________ .

(*a*) both inside and outside the conductor
(*b*) neither inside nor outside the conductor
(*c*) only outside the conductor
(*d*) only inside the conductor

2. A compass needle is placed above a straight conducting wire. If current passes through the conducting wire from South to North. Then the deflection of the compass __________ .

(*a*) is towards West
(*b*) is towards East
(*c*) keeps oscillating in East-West direction
(*d*) no deflection

3. 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°

4. Consider the following two statements about the Oersted's experiment.

Statement P: The magnetic field due to a straight current carrying conductor is in the form of circular loops around it.

Statement Q: The magnetic field due to a current carrying conductor is weak at near points from the conductor, compared to the far points.

(*a*) Both P and Q are true
(*b*) Both P and Q are false
(*c*) P is true, but Q is false
(*d*) P is false, but Q is true

5. Consider the following statements about the representation of the magnetic field

Statement P: The magnetic field emerging out of the plane of the paper is denoted by a dot (⊙).

Statement Q: The magnetic field going into the plane of the paper is denoted by a cross (⊗).

(*a*) Both P and Q are true
(*b*) P is true, but Q is false
(*c*) P is false, but Q is true
(*d*) Both P and Q are false

6. Two charged particles traverse identical helical paths in a completely opposite sense in a uniform magnetic field $B = B_0\hat{k}$. **[*NCERT Exemplar*]**

(*a*) They have equal z-components of momenta

(*b*) They must have equal charges

(*c*) They necessarily represent a particle, anti-particle pair

(*d*) The charge to mass ratio satisfy: $\left(\frac{e}{m}\right)_1 + \left(\frac{e}{m}\right)_2 = 0$

7. Biot-Savart law indicates that the moving electrons (velocity v) produce a magnetic field B such that **[*NCERT Exemplar*]**

(*a*) B is perpendicular to v

(*b*) B is parallel to v

(*c*) it obeys inverse cube law

(*d*) it is along the line joining the electron and point of observation

8. An electron is projected with uniform velocity along the axis of a current carrying long solenoid. Which of the following is true? **[*NCERT Exemplar*]**

(*a*) The electron will be accelerated along the axis

(*b*) The electron path will be circular about the axis

(*c*) The electron will experience a force at 45° to the axis and hence execute a helical path

(*d*) The electron will continue to move with uniform velocity along the axis of the solenoid

9. A micro-ammeter has a resistance of 100 Ω and a full scale range of 50 μA. It can be used as a higher range ammeter or voltmeter provided resistance is added to it. Pick the correct range and resistance combinations.

(*a*) 50 V range and 10 kΩ resistance in series

(*b*) 10 V range and 200 kΩ resistance in series

(*c*) 5 mA range with 1 Ω resistance in parallel

(*d*) Both (*b*) and (*c*)

10. A current carrying circular loop of radius R is placed in the x-y plane with centre at the origin. Half of the loop with $x > 0$ is now bent so that it now lies in the y-z plane. **[*NCERT Exemplar*]**

(*a*) The magnitude of magnetic moment now diminishes.

(*b*) The magnetic moment does not change.

(*c*) The magnitude of B at (0,0, z), $z >> R$ increases.

(*d*) The magnitude of B at (0,0, z), $z >> R$ is unchanged.

11. A current carrying loop is placed in a uniform magnetic field. The torque acting on it does not depend upon the

(*a*) shape of the loop
(*b*) area of the loop
(*c*) value of current
(*d*) magnetic field

12. A circular coil of 50 turns and radius 7 cm is placed in a uniform magnetic field of 4 T normal to the plane of the coil. If the current in the coil is 6 A then total torque acting on the coil is

(*a*) 14.78 Nm
(*b*) 0
(*c*) 7.39 Nm
(*d*) 3.69 Nm

13. The gyro-magnetic ratio of an electron in an H-atom, according to Bohr model, is

(*a*) independent of which orbit it is in
(*b*) negative
(*c*) positive
(*d*) both (*a*) and (*b*)

14. The sensitivity of a moving coil galvanometer increases with the decrease in:

(*a*) number of turns
(*b*) area of coil
(*c*) magnetic field
(*d*) torsional rigidity

15. A voltmeter of range 2V and resistance 300 Ω cannot be converted to an ammeter of range:

(*a*) 5 mA (*b*) 8 mA (*c*) 1 A (*d*) 10 A

16. In an ammeter 4% of the mains current is passing through galvanometer. If the galvanometer is shunted with a 5 Ω resistance, then resistance of galvanometer will be

(*a*) 116 Ω (*b*) 117 Ω (*c*) 118 Ω (*d*) 120 Ω

17. The SI unit of magnetic flux density is

(*a*) weber (*b*) tesla (*c*) maxwell (*d*) gauss

18. Newton meter per ampere is the unit of

(*a*) magnetic induction (*b*) magnetic susceptibility

(*c*) magnetic permeability (*d*) magnetic flux

19. A moving electron enters normally into a uniform magnetic field; its

(*a*) direction of motion will change (*b*) speed will increase

(*c*) speed will decrease (*d*) velocity will remain the same

20. In a magnetic field acting along *x*-axis, a conductor carries a current along the *y*-axis. The force experienced by the conductor is along

(*a*) the +ve *z*-axis (*b*) the –ve *z*-axis

(*c*) the –ve *x*-axis (*d*) the –ve *y*-axis

21. For conversion of a galvanometer into an ammeter, one should use

(*a*) a high resistance in series (*b*) a high resistance in parallel

(*c*) a low resistance in series (*d*) a low resistance in parallel

22. The time rate of work done by a magnetic field on a charged particle moving on a helical path is

(*a*) qB (*b*) qB/v^2 (*c*) qBv^2 (*d*) zero

23. In a certain region of space, electric field $\vec{E}$ and magnetic field $\vec{B}$ are perpendicular to each other. An electron enters perpendicularly to both the fields and moves undeflected. The velocity of electron is

(*a*) $\dfrac{\vec{B}}{\vec{E}}$ (*b*) $\vec{E}\times\vec{B}$ (*c*) $\vec{E}\,.\,\vec{B}$ (*d*) $\dfrac{\vec{E}}{\vec{B}}$

24. A deuteron of kinetic energy 50 keV is describing a circular orbit of radius 0.5 m in a plane perpendicular to the magnetic field $\vec{B}$. The kinetic energy of the proton that describes a circular orbit of same radius and inside same $\vec{B}$ is

(*a*) 25 keV (*b*) 100 keV (*c*) 200 keV (*d*) 50 keV

25. Current sensitivity of a galvanometer can be increased by decreasing

(*a*) torsional constant K (*b*) area A

(*c*) magnetic field B (*d*) number of turns N

26. An electric current passes through a long straight copper wire. At a distance 5 cm from the straight wire, the magnetic field is B. The magnetic field at 20 cm from the straight wire would be

(*a*) $\dfrac{B}{2}$ (*b*) $\dfrac{B}{6}$ (*c*) $\dfrac{B}{4}$ (*d*) $\dfrac{B}{3}$

27. A wire in the form of a circular loop, of one turn carrying a current, produces magnetic induction *B* at the centre. If the same wire is looped into a coil of two turns and carries the same current, the new value of magnetic induction at the centre is

(*a*) $4B$ (*b*) $2B$ (*c*) B (*d*) $8B$

28. A circular coil of radius *a* carries an electric current. The magnetic field due the coil at a point on the axis of the coil located at a distance *r* from centre of the coil, such that *r*>>*a* varies

(*a*) $\frac{1}{r^{3/2}}$ (*b*) $\frac{1}{r^3}$ (*c*) $\frac{1}{r^2}$ (*d*) $\frac{1}{r}$

29. A solenoid has 1000 turns per metre length. If a current of 5 A is flowing through it, then magnetic field inside the solenoid is

(*a*) $2\pi \times 10^{-3}$ T (*b*) $4\pi \times 10^{-5}$ T (*c*) $2\pi \times 10^{-5}$ T (*d*) $4\pi \times 10^{-3}$ T

30. If distance between two current- carrying wires is doubled, then force between them is

(*a*) halved (*b*) doubled (*c*) tripled (*d*) quadrupled

31. The coil of a moving coil galvanometer is wound over a metal frame in order to

(*a*) increase moment of inertia (*b*) provide electromagnetic damping

(*c*) reduce hysteresis (*d*) increase sensitivity

32. If in a moving coil galvanometer, a current *I* in its coil produces a deflection θ, then

(*a*) $I \propto \tan\theta$ (*b*) $I \propto \theta^2$ (*c*) $I \propto \sqrt{\theta}$ (*d*) $I \propto \theta$

33. The ratio of voltage sensitivity (V_S) and current sensitivity (I_S) of a moving coil galvanometer is

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

34. Two thin, long and parallel wires separated by a distance '*d*' carry a current '*i*' ampere each. The magnitude of the force per unit length exerted by one wire on the other is

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

35. Two parallel wires carrying current in the same direction attract each other due to

(*a*) magnetic force (*b*) electric force

(*c*) mutual induction (*d*) electromagnetic emf

36. A strong magnetic field is applied to a proton at rest. Then

(*a*) the particle moves in opposite direction of the applied field.

(*b*) the particle moves in the direction of the applied field.

(*c*) the particle continues to be at rest (consider the proton as a charged particle only).

(*d*) the particle executes circular motion in magnetic field.

37. A charge of +5 mC enters a uniform magnetic field parallel to the direction of the field. What will happen to the motion of the charge?

(*a*) It will move undedicated.

(*b*) It will perform circular motion in a plane parallel to the field.

(*c*) It will perform circular motion in a plane perpendicular to the field.

(*d*) It will continue to move in the field direction with acceleration.

38. Which one decides the direction of magnetic lines of force due to a straight wire carrying current?

(*a*) Right hand thumb rule (*b*) Fleming's left hand rule

(*c*) Ampere's rule (*d*) Fleming's right hand rule

39. A small bar magnet held vertically is allowed to fall from a height through a metal ring of radius 0.1m. The acceleration of the magnet shall be

(*a*) greater than *g* (*b*) equal to *g*

(*c*) zero (*d*) less than *g*

40. The expression for magnetic force per unit charge $\vec{F}_m$, when a charge q moves with a velocity $\vec{v}$ in a magnetic field $\vec{B}$ is given by

(a) $\vec{F}_m = (\vec{v}.\vec{B})$ (b) $\vec{F}_m = (\vec{v} \times \vec{B})$ (c) $\vec{F}_m = \frac{1}{q}(\vec{v} \times \vec{B})$ (d) $\vec{F}_m = q(\vec{v} \times \vec{B})$

41. The force between two parallel current carrying conductors separated by a distance x is F. If the current in each conductor is doubled and the distance between them is halved, then the force between them becomes

(a) F (b) $8F$ (c) $4F$ (d) $2F$

42. Time period of a charged particle undergoing a circular motion in a uniform magnetic field is independent of

(a) speed of the particle
(b) mass of the particle
(c) charge of the particle
(d) magnetic field

43. 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.

44. Two circular coils 1 and 2 are made from the same wire but the radius of the first coil is twice that of the second coil. What ratio of the potential difference (in volt) should be applied across them, so that the magnetic field at their centres is the same?

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

45. 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) $-\vec{F}$ (b) $-3\vec{F}$ (c) $\vec{F}$ (d) $3\vec{F}$

46. A particle of mass m, charge Q and kinetic energy J enters a transverse uniform magnetic field of induction B. After 3 seconds, the kinetic energy of the particles will be:

(a) 3J (b) 2J (c) J (d) 4J

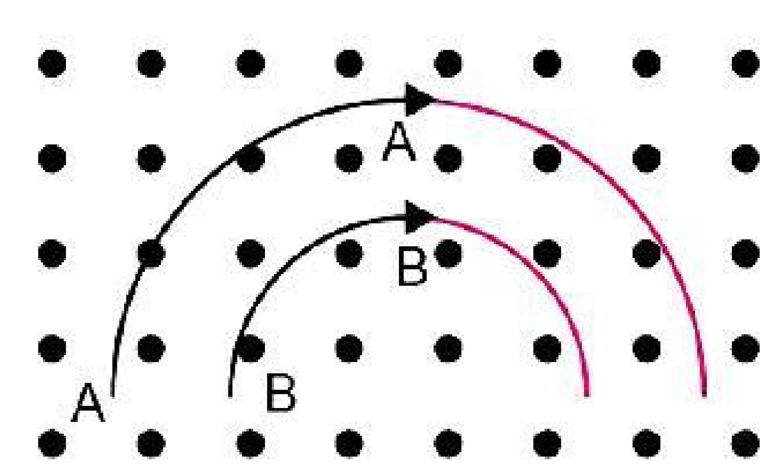
47. A galvanometer has a coil of resistance 100 Ω and gives a full scale deflection for a current of 30 mA. If it is to work as a voltmeter of 30 V range, the resistance required to be added will be

(a) 500 Ω (b) 900 Ω (c) 1000 Ω (d) 1800 Ω

48. 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 $\vec{v}$ and $\vec{B}$ can have any value other than zero and 180°
(b) angle between $\vec{v}$ and $\vec{B}$ is either zero or 180°
(c) angle between $\vec{v}$ and $\vec{B}$ is necessarily 90°
(d) angle between $\vec{v}$ and $\vec{B}$ can have any value other than 90°

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



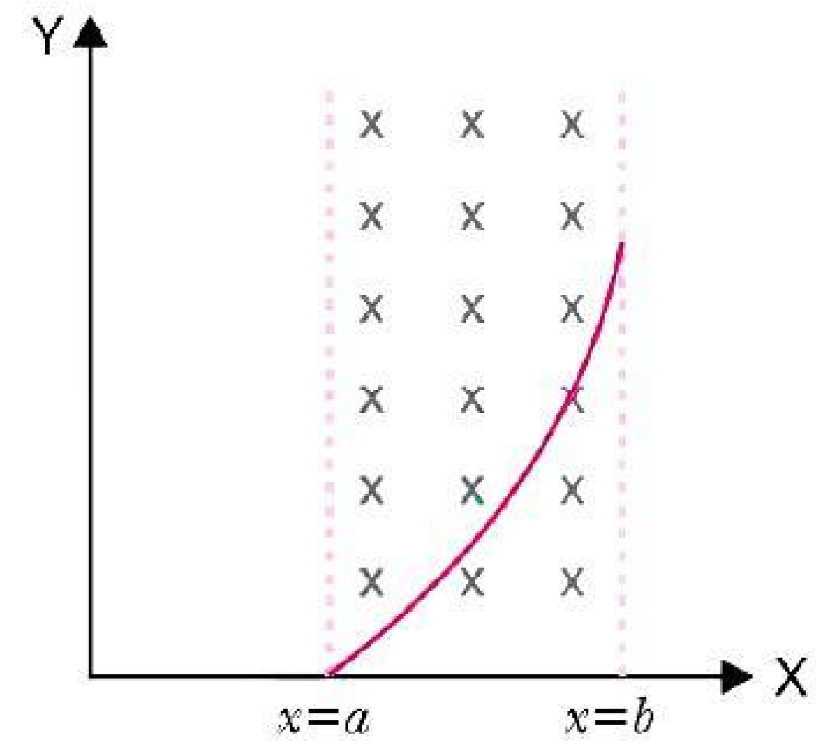
(a) $m_A v_A < m_B v_B$
(b) $m_A v_A > m_B v_B$
(c) $m_A < m_B$ and $v_A v_B$
(d) $m_A = m_B$, $v_A = v_B$

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

(*a*) $\frac{\mu_0 NI}{b}$ (*b*) $\frac{\mu_0 NI}{a}$

(*c*) $\frac{\mu_0 NI}{2(b-a)}\log_e \frac{b}{a}$ (*d*) $\frac{\mu_0 NI}{b-a}\log_e \frac{b}{a}$

51. A particle of mass m and charge q moves with a constant velocity v along positive X-axis. It enters a region containing a uniform magnetic field B directed along the negative Z-axis, extending from $x = a$ to $x = b$. The minimum value of v required so that the particle can just enter the region $x > b$ is



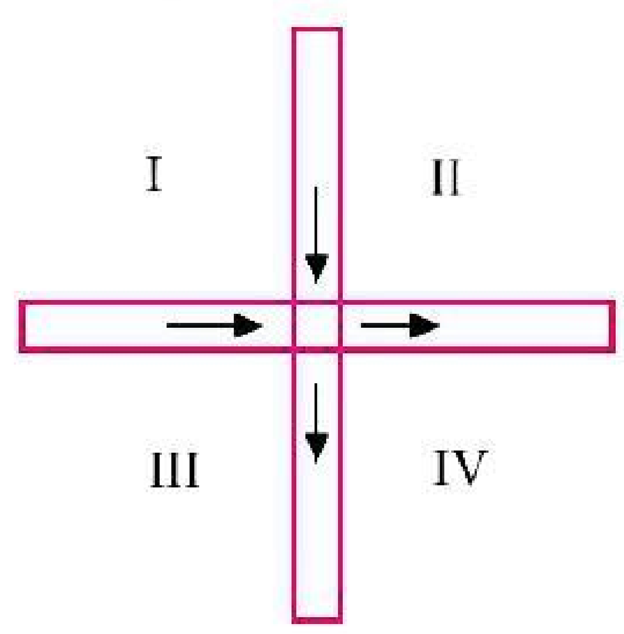
(*a*) $\frac{qbB}{M}$ (*b*) $\frac{q(b-a)B}{m}$

(*c*) $\frac{qaB}{m}$ (*d*) $\frac{q(b+a)B}{2m}$

52. A proton of mass 1.67×10^{-27} kg and charge 1.6×10^{-19} C is projected with a speed of 2×10^6 m/s at an angle 60° with x-axis. If a uniform magnetic field of 0.104 T is applied along y-axis, the path of the proton is:

(*a*) a circle of radius 0·1 m and time period $2\pi \times 10^{-7}$ s
(*b*) a circle of radius 0·2 m and time period 15×10^{-7} s
(*c*) a helix of radius 0·1 m and time period $2\pi \times 10^{-7}$ s
(*d*) a helix of radius 0·2 m and time period $4\pi \times 10^{-7}$ s

53. Two thin metallic strips carrying currents in the direction shown, cross each other perpendicularly without touching but being close to each other, as shown in fig. The regions which contain some point of zero magnetic induction are:



(*a*) I and II (*b*) I and III (*c*) II and III (*d*) I and IV

54. Two particles having masses in the ratio 1: 1 and charge 1: 2 are projected into a uniform magnetic field perpendicular to field with speeds in the ratio 2: 3. The ratio of the radii of circular path along which the two particles move is

(*a*) 4: 3 (*b*) 2: 3 (*c*) 3: 1 (*d*) 1: 4

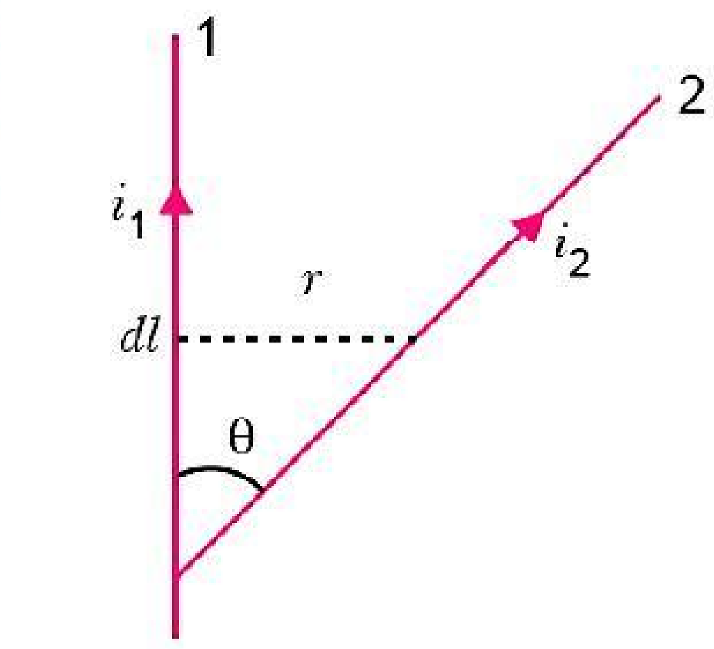
55. A long wire carries a steady current. It is bent into a circle of one turn and the magnetic field at the centre of the coil is B. It is then bent into a circular loop of n-turns. The magnetic field at the centre of the coil will now be

(*a*) nB (*b*) n^2B (*c*) $2nB$ (*d*) $2n^2$

56. Two long conductors separated by a distance 'd' carry currents I_1 and I_2 in the same direction and exert force F on each other. Now the current in one of them is increased two times and its direction is reversed. The distance is also increased to $3d$. The new value of the force between them is

(*a*) $-2F$ (*b*) $\frac{F}{3}$ (*c*) $-\frac{2F}{3}$ (*d*) $-\frac{F}{3}$

57. Wires 1 and 2 carrying currents i_1 and i_2 respectively are inclined at an angle θ to each other. What is the attractive force on a small element *dl* of wire 2 at a distance *r* from wire 1 (as shown in fig.) due to magnetic field of wire 1.



(*a*) $\dfrac{\mu_0 i_1 i_2 dl \tan\theta}{2\pi r}$ (*b*) $\dfrac{\mu_0 i_1 i_2 dl \sin\theta}{2\pi r}$

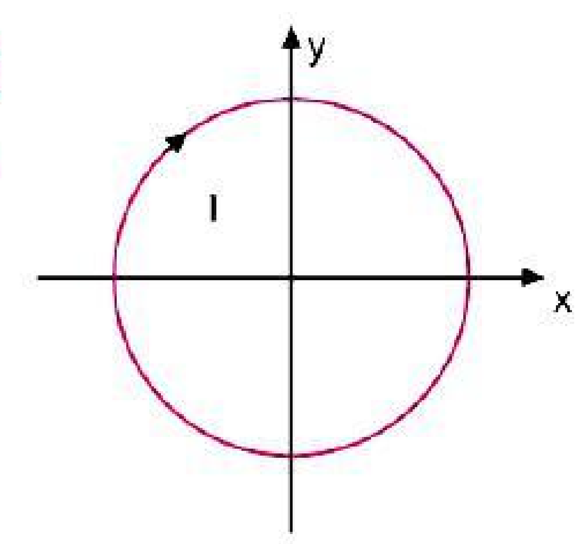
(*c*) $\dfrac{\mu_0 i_1 i_2 dl \cos\theta}{2\pi r}$ (*d*) $\dfrac{\mu_0 i_1 i_2 dl \sin\theta}{4\pi r}$

58. A long straight wire along *z*-axis carries a current '*i*' in the negative *z*-direction. The magnetic vector field $\vec{B}$ at a point having coordinates (*x*, *y*) on $z = 0$ plane is

(*a*) $\dfrac{\mu_0 i (y\hat{i} - x\hat{j})}{2\pi (x^2 + y^2)}$ (*b*) $\dfrac{\mu_0 i (x\hat{i} + y\hat{j})}{2\pi (x^2 + y^2)}$

(*c*) $\dfrac{\mu_0 i (x\hat{j} - y\hat{i})}{2\pi (x^2 + y^2)}$ (*d*) $\dfrac{\mu_0 i (x\hat{i} - y\hat{j})}{2\pi (x^2 + y^2)}$

59. A conducting loop carrying current *I* is placed in a uniform magnetic field pointing into the plane of the paper as shown in fig. The loop will have a tendency to



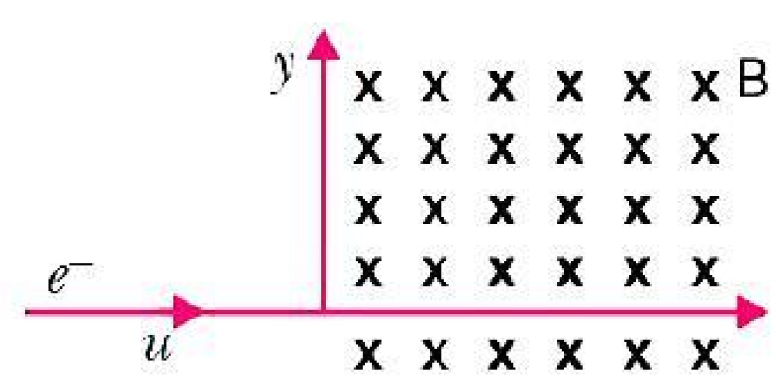
(*a*) contract

(*b*) expand

(*c*) move towards positive *x*-axis

(*d*) move towards negative *x*-axis

60. A uniform magnetic field $B = -B_{oz}$ exists in the region $x > 0$. An electron with velocity *u* travels along the positive *x*-axis. When the electron emerges out of the field, its *y*-component and velocity *v* will be



(*a*) $y > 0,\ v > u$ (*b*) $y < 0,\ v > u$

(*c*) $y < 0,\ v = u$ (*d*) $y > 0,\ v = u$

61. Two particles each of mass *m* and charge *q* are attached to the two ends of a light rod of length 2*R*. The rod is rotated at a constant angular speed about a perpendicular axis passing through its centre. The ratio of the magnitude of the magnetic moment of the system and its angular momentum about the centre of the rod is

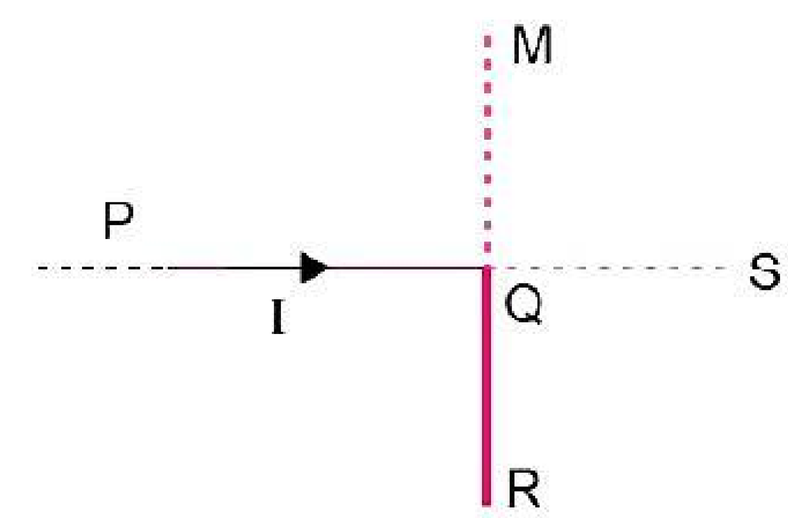
(*a*) $\dfrac{q}{2m}$ (*b*) $\dfrac{q}{m}$ (*c*) $\dfrac{2q}{m}$ (*d*) $\dfrac{q}{\pi m}$

62. Two concentric coils each of radius equal to 2π cm are placed at right angles to each other. Currents of 3 A and 4 A are flowing in the coils respectively. The magnetic induction in Wb/m^2 at the centre of the coils will be ($\mu_0 = 4\pi \times 10^{-7}$ Wb/A–m)

(*a*) 10^{-5} (*b*) 12×10^{-5}

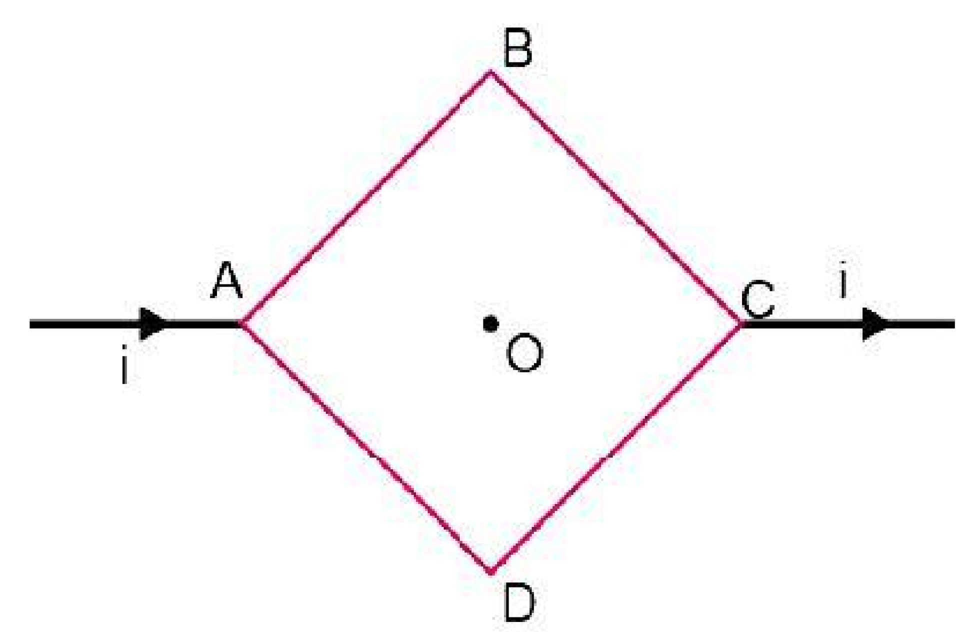
(*c*) 7×10^{-5} (*d*) 5×10^{-5}

63. An infinitely long conductor PQR is bent to form a right angle as shown in fig. A current I flows through PQR. The magnetic field due to this current at M is B_1 Now another infinitely long straight conductor QS is connected at Q, so that current is $\frac{1}{2}$ in QR as well as in QS, the current in PQ remaining unchanged. The magnetic field at M is now B_2. The ratio $\frac{B_1}{B_2}$ is



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

64. A square loop $ABCD$ of each side is formed of wire ABC of resistance r and ADC of resistance $2r$. The magnetic field B at the centre O of the loop is



(*a*) 0 (*b*) $\frac{\sqrt{2}\mu_0 i}{6\pi a}$ (*c*) $\frac{\sqrt{2}\mu_0 i}{3\pi a}$ (*d*) $\frac{2\sqrt{2}\mu_0 i}{3\pi a}$

65. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per mA and voltage sensitivity is 2 divisions per mV. In order that each division reads 1 volt, the resistance in ohm needed to be connected in series with the coil will be

(*a*) 105 Ω (*b*) 103 Ω (*c*) 9995 Ω (*d*) 99995 Ω

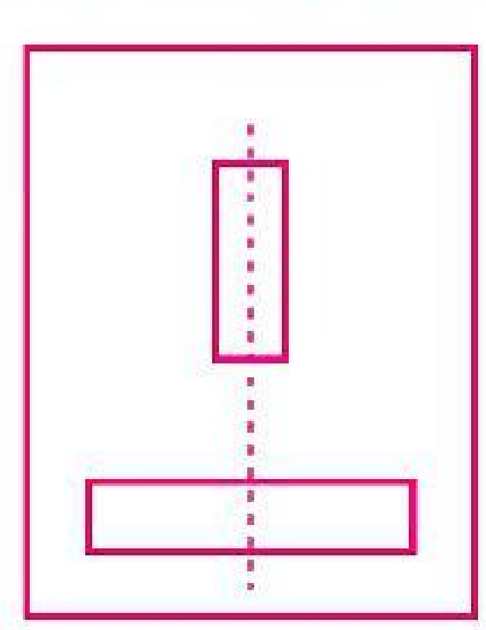
66. A galvanometer has a resistance 100 Ω and it requires current 100 μA for full scale deflection. A resistor 0.1 Ω is connected to make it ammeter. The smallest current in the circuit to produce full scale deflection is

(*a*) 1000·1 mA (*b*) 1·1 mA (*c*) 10·1 mA (*d*) 100·1 mA

67. Two small magnets, each of magnetic moment of 10 A–m^2 are placed in end on position 0·1 m apart from their centres. The force acting between them is

(*a*) $0·6 \times 10^7$ N (*b*) 6×10^7 N (*c*) 0·6 N (*d*) 0·06 N

68. Two short magnets are placed on a piece of cork which floats on water. The magnets are so placed that the axis of one produced bisects the axis of the other at right angles. Then the cork

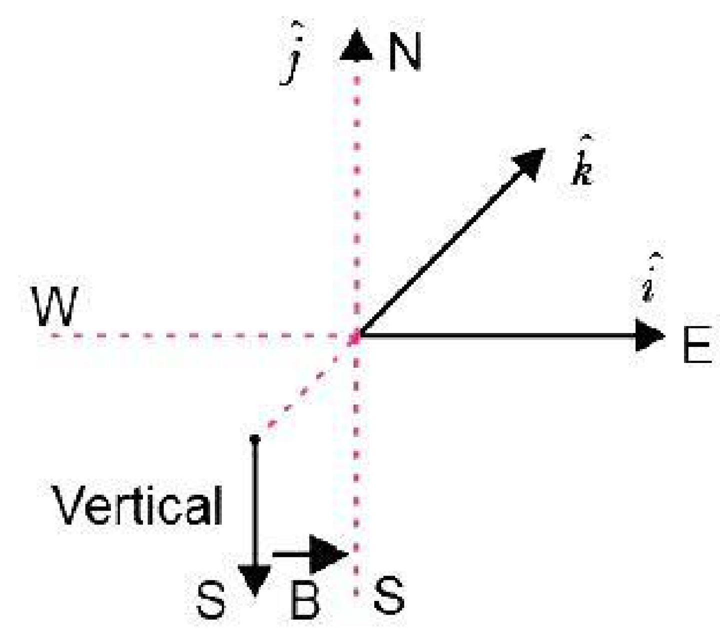


(*a*) rotates only
(*b*) moves along a straight line only
(*c*) has rotational as well as translational motion
(*d*) has neither translational nor rotational motion

69. A long solenoid has 200 turns per cm and carries a current i. The magnetic field at its centre is $6{\cdot}28 \times 10^{-2}$ Wb/m^2. Another long solenoid has 100 turns per cm and it carries a current of $\frac{i}{3}$. The value of the magnetic field at its centre is

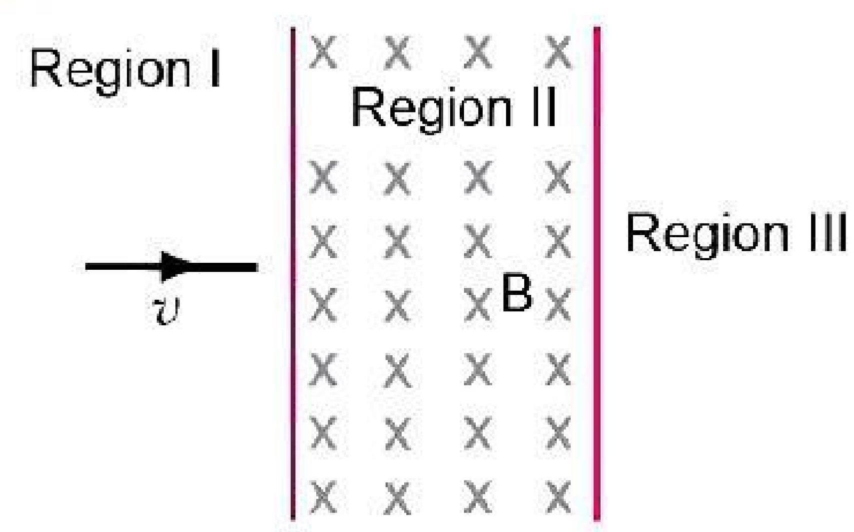
(*a*) $1{\cdot}05 \times 10^{-2}$ Wb / m^2
(*b*) $1{\cdot}05 \times 10^{-5}$ Wb / m^2
(*c*) $1{\cdot}05 \times 10^{-3}$ Wb / m^2
(*d*) $1{\cdot}05 \times 10^{-4}$ Wb / m^2

70. A horizontal overhead power line is at a height of 4 m from the ground and carries a current of 100 A from east to west. The magnetic field directly below it on the ground is ($\mu_0 = 4\pi \times 10^{-7}$ Tm A^{-1})



(*a*) 5×10^{-6} T southward
(*b*) $2{\cdot}5 \times 10^{-7}$ T northward
(*c*) $2{\cdot}5 \times 10^{-7}$ T southward
(*d*) 5×10^{-6} T northward

71. A particle of mass m and charge q, moving with velocity v enters region II normal to boundary as shown in fig. Region II has a uniform magnetic field B, perpendicular to the plane of the paper. The length of the region II is l. Then which of the following is incorrect.



(*a*) The particle enters region III only if its velocity is $v > \frac{qlB}{m}$.

(*b*) The particle enters region III only if $v < \frac{qlB}{m}$.

(*c*) Path length of particle in region II is maximum when velocity $v = \frac{qlB}{m}$.

(*d*) Time spent in region II is same for any velocity v as long as the particle returns to region I.

72. A charged particle with charge q enters a region of constant uniform and mutually orthogonal fields $\vec{E}$ and $\vec{B}$ with velocity $\vec{v}$ perpendicular to both $\vec{E}$ and $\vec{B}$ and comes out without any change in magnitude or direction of $\vec{v}$. Then

(*a*) $\vec{v} = \frac{\vec{B} \times \vec{E}}{E^2}$
(*b*) $\vec{v} = \frac{\vec{E} \times \vec{B}}{E^2}$
(*c*) $\vec{v} = \frac{\vec{B} \times \vec{E}}{E^2}$
(*d*) $\vec{v} = \frac{\vec{E} \times \vec{B}}{B^2}$

73. A charged particle moves through a magnetic field perpendicular to its direction. Then

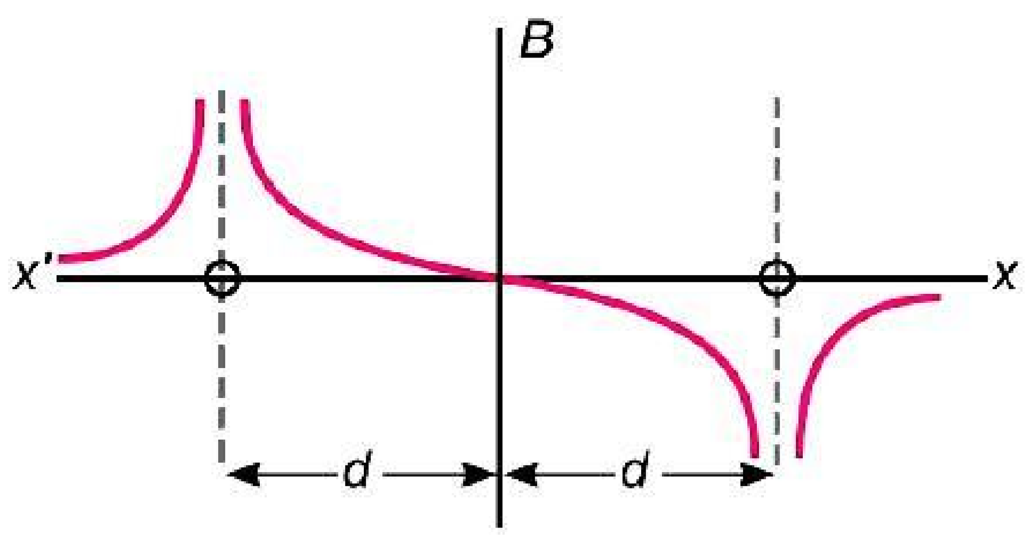
(*a*) both momentum and kinetic energy of the particles are not constant
(*b*) both momentum and kinetic energy of the particles are constant

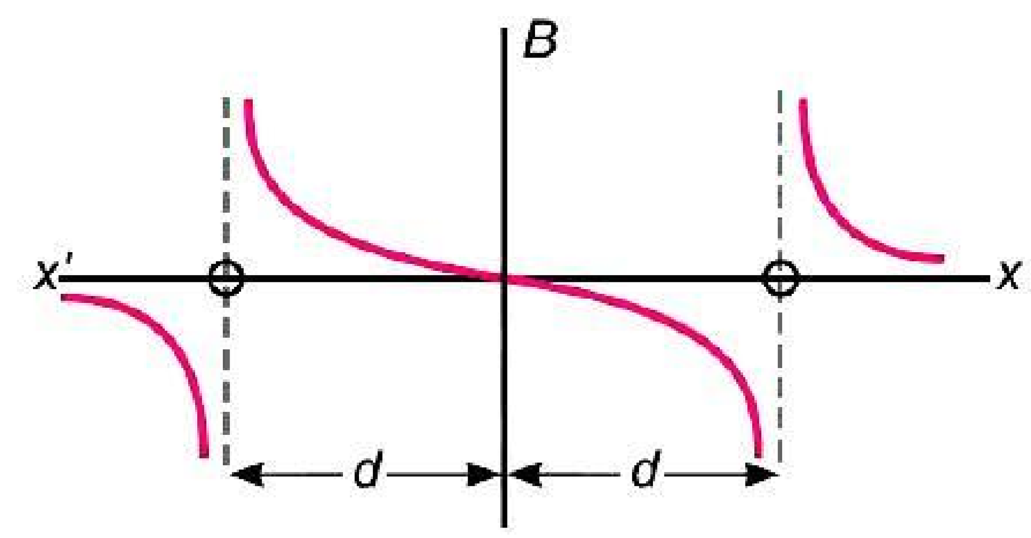
(*c*) kinetic energy changes but momentum remains constant
(*d*) momentum changes but kinetic energy remains constant

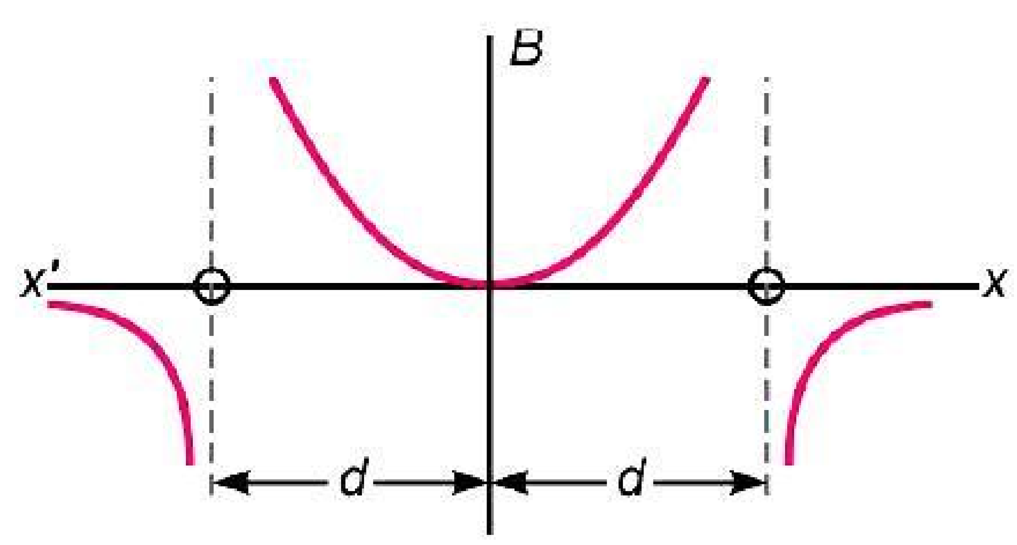
74. A long straight wire of radius *a* carries a steady current *i*. The current is uniformly distributed over its cross-section. The ratio of the magnetic field at $\frac{a}{2}$ and $2a$ is

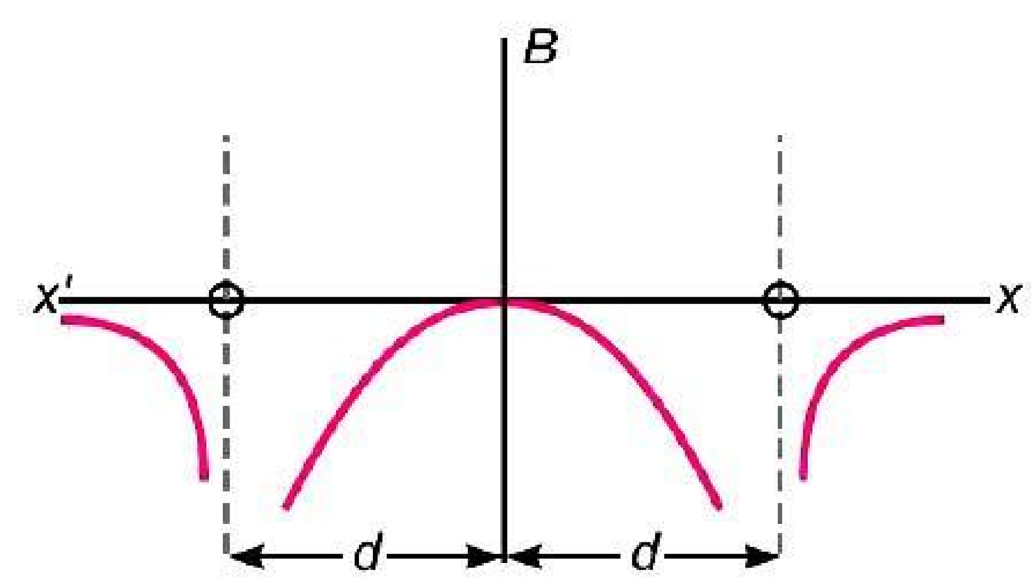
(*a*) 4 (*b*) 1 (*c*) $\frac{1}{2}$ (*d*) $\frac{1}{4}$

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

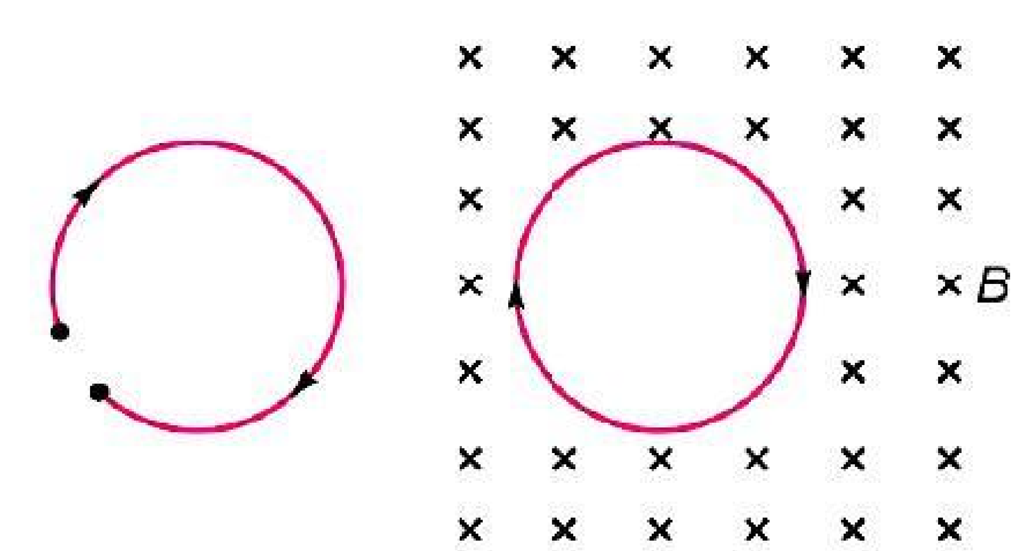
(*a*)


(*b*)


(*c*)


(*d*)


76. A thin flexible wire of length *L* is connected to two adjacent fixed points and carries a current *I* in the clockwise direction as shown in Fig. When the system is put in a uniform magnetic field of strength *B* going into the plane of the paper, the wire takes the shape of a circle. The tension in the wire is



(*a*) *IBL* (*b*) IBL/π (*c*) $\frac{IBL}{2\pi}$ (*d*) $\frac{IBL}{4\pi}$

77. A moving charge produces
(*a*) electric and magnetic fields both (*b*) electric field only
(*c*) magnetic field only (*d*) neither electric nor magnetic field

78. A proton charge (+*e* coulomb) enters in a magnetic field of strength *B* (tesla) perpendicular to the magnetic lines of force, with speed *v*. The force on the proton is
(*a*) evB (*b*) zero (*c*) ∞ (*d*) $evB/2$

79. A proton charge (+*e* coulomb) enters in a magnetic field of strength *B* tesla making an angle 30° with the direction of magnetic field with speed *v*. The magnetic force on the proton is
(*a*) evB (*b*) zero (*c*) ∞ (*d*) $evB/2$

80. A charged particle enters in a magnetic field perpendicular to the magnetic lines of force. The path of the particle is

(*a*) straight line (*b*) circular

(*c*) elliptical (*d*) spiral

81. A charged particle enters at 30° to the magnetic field. Its path becomes

(*a*) circular (*b*) helical

(*c*) elliptical (*d*) straight line

82. A current carrying wire produces

(*a*) only electric field (*b*) only magnetic field

(*c*) both electric and magnetic fields (*d*) no field

83. Two parallel wires carrying currents in the same direction attract each other because of

(*a*) potential difference between them (*b*) mutual inductance between them

(*c*) electric forces between them (*d*) magnetic forces between them

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

(*a*) the electron will turn to its left

(*b*) the electron will turn to its right

(*c*) the electron velocity will increase in magnitude

(*d*) the electron velocity will decrease in magnitude

85. A conducting circular loop of radius *r* carries a constant current *i*. It is placed in a uniform magnetic field *B* such that *B* is perpendicular to the plane of loop. The magnetic force acting on the loop is

(*a*) Bir (*b*) $2\pi irB$

(*c*) 0 (*d*) μirB

86. When a straight conductor is carrying an electric current

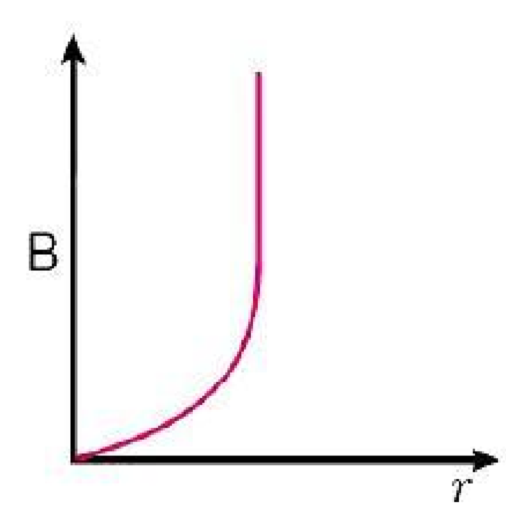
(*a*) there are circular magnetic lines of force around it.

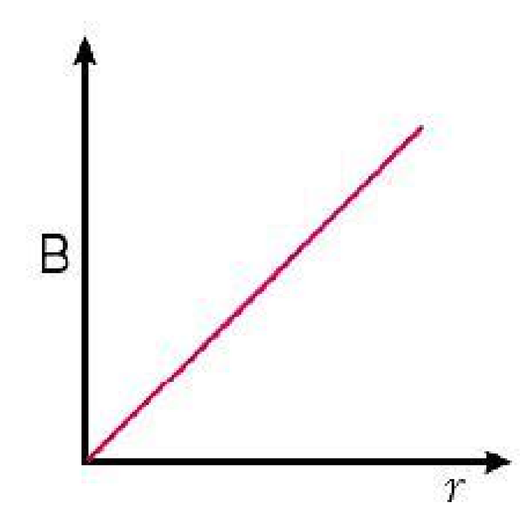
(*b*) there are no magnetic lines of force near it.

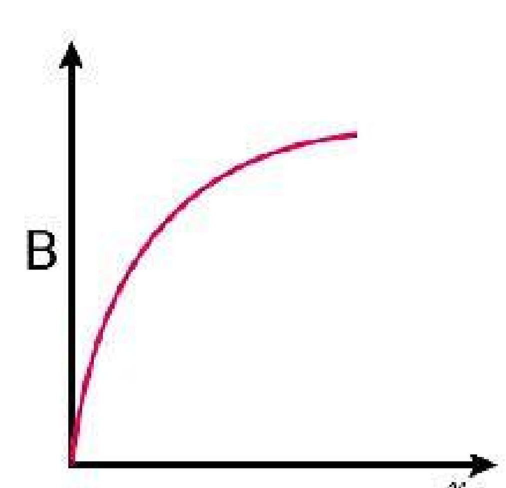
(*c*) there are magnetic lines of force parallel to conductor along the direction of current.

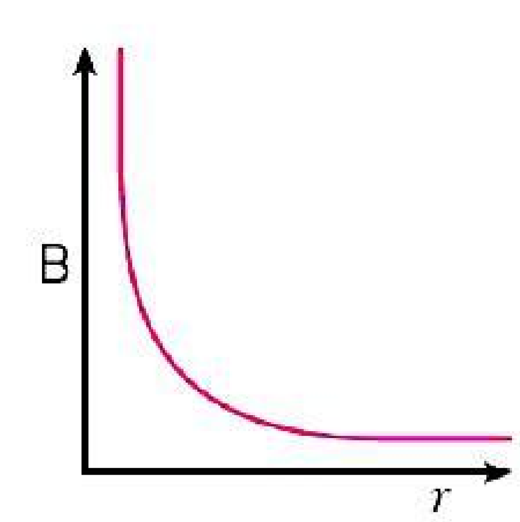
(*d*) there are magnetic lines of force parallel to conductor opposite to the direction of current.

87. Which of the following correctly represents the variation of magnetic flux density *B* with distance *r* of a long straight wire carrying a steady current?

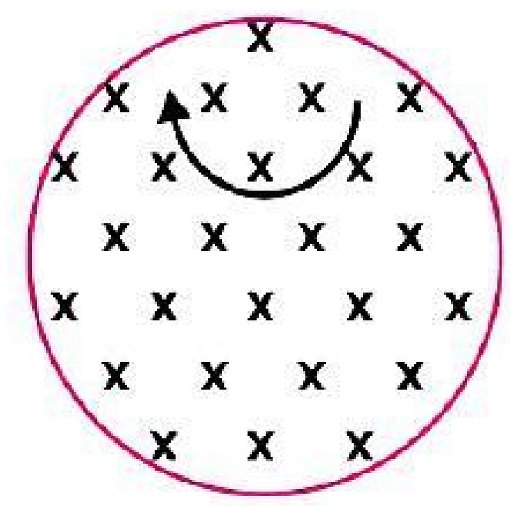
(*a*)


(*b*)


(*c*)


(*d*)


88. There is a magnetic field acting in a plane downward perpendicular to sheet of paper (Fig.). Particles in vacuum move in the plane of paper from left to right. The path indicated by an arrow could be travelled by



(*a*) proton (*b*) neutron
(*c*) electron (*d*) α-particle

89. A stream of electrons is projected horizontally to the right. A straight conductor carrying a current is supported parallel to electron stream and above it. If the current in the conductor is from left to right, then what will be the effect on electron stream?

(*a*) The electron stream will be speeded up towards the right.
(*b*) The electron stream will be retarded.
(*c*) The electron stream will be pulled upward.
(*d*) The electron stream will be pulled downward.

90. The Lorentz force experienced by a charged particle of charge q, moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$ is given by

(*a*) $\vec{F} = q(\vec{v} \cdot \vec{B})$ (*b*) $\vec{F} = q(\vec{v} \times \vec{B})$
(*c*) $\vec{F} = q(\vec{B} \times \vec{v})$ (*d*) $\vec{F} = \vec{v} \times \vec{B}/q$

91. The force on a charged particle in a magnetic field is maximum when the angle between the direction of motion and the magnetic field is

(*a*) 0° (*b*) 90°
(*c*) 45° (*d*) 180°

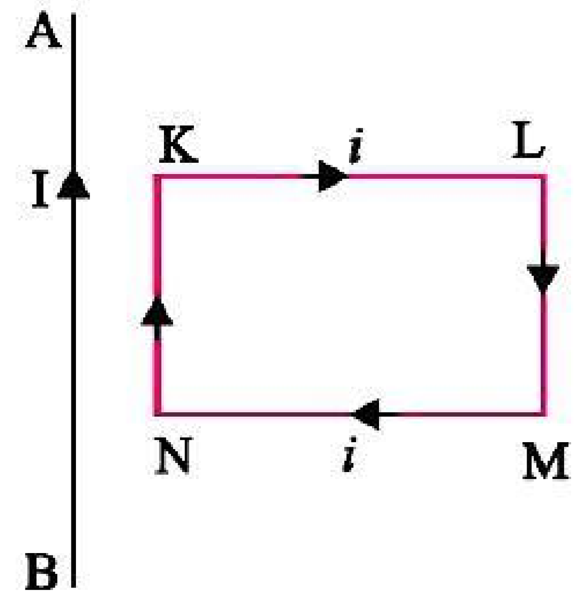
92. Two magnetic lines of force

(*a*) intersect at the neutral point (*b*) intersect near north or south poles
(*c*) cannot intersect at all (*d*) depend on the position of the magnet.

93. The radius of the path of a charged particle moving in a magnetic field is proportional to

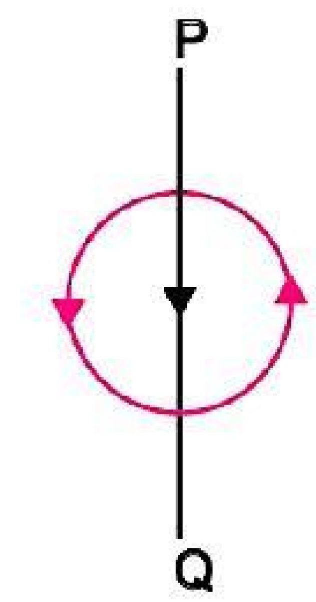
(*a*) mass (*b*) charge
(*c*) energy (*d*) momentum of the particle

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



(*a*) rotate about an axis parallel to the wire (*b*) move away from the wire
(*c*) move towards the wire (*d*) remain stationary

95. In the adjoining figure, *PQ* is a long current-carrying wire which is placed near a current-carrying coil. The direction of the force acting on *PQ* will be:



(*a*) parallel to *PQ* towards *P*

(*b*) parallel to *PQ* towards *Q*

(*c*) perpendicular to *PQ* towards right

(*d*) perpendicular to *PQ* towards left

96. Two thin, long, parallel wires separated by a distance *b* are carrying a current *i* each in the same direction. The force per unit length exerted by one wire on the other is

(*a*) $\frac{\mu_0 i^2}{2\pi b^2}$ N/m (repulsive)

(*b*) $\frac{\mu_0}{2\pi b} i^2$ N/m (attractive)

(*c*) $\frac{\mu_0 i}{2\pi b^2}$ N/m (repulsive)

(*d*) $\frac{\mu_0 i^2}{2\pi b^2}$ N/m (attractive)

97. A charge moves with velocity $\vec{v}$ in a region where electric field $\vec{E}$ and magnetic field $\vec{B}$ both exist. The force on the particle is

(*a*) $q(\vec{v} \times \vec{B})$

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

(*c*) $q\vec{E} + q(\vec{B} \times \vec{r})$

(*d*) $q\vec{E} + q(\vec{E} \times \vec{v})$

98. The magnetic force acting on a charged particle of charge –2μC moving with velocity $(2\hat{i} + 3\hat{j}) \times 10^6$ ms^{-1} in a magnetic field of 2 T directed in *y*-direction is

(*a*) 4 N in *z*-direction

(*b*) 8 N in *y*-direction

(*c*) 8 N in *z*-direction

(*d*) 8 N in negative *z*-direction

99. The magnetic field is made radial in a galvanometer

(*a*) to make field stronger

(*b*) to make field weaker

(*c*) to make scale linear

(*d*) to reduce its resistance

100. The magnetic dipole moment of a current carrying coil does not depend upon *[CBSE 2020 (55/1/1)]*

(*a*) number of turns of the coil.

(*b*) cross-sectional area of the coil.

(*c*) current flowing in the coil.

(*d*) material of the turns of the coil.

101. An electron is released from rest in a region of uniform electric and magnetic fields acting parallel to each other. The electron will *[CBSE 2020 (55/2/1)]*

(*a*) move in a straight line.

(*b*) move in a circle.

(*c*) remain stationary.

(*d*) move in a helical path.

102. A straight current carrying conductor is placed inside a uniform magnetic field. The force per unit length acting on the conductor is *[CBSE 2020 (55/2/3)]*

(*a*) maximum when the conductor is perpendicular to the direction of magnetic field.

(*b*) maximum when the conductor is along the direction of magnetic field.

(*c*) minimum when the conductor is perpendicular to the direction of magnetic field.

(*d*) minimum when the conductor makes an angle of 45° with the direction of magnetic field.

103. A region has a uniform magnetic field in it. A proton enters into the region with velocity making an angle of 45° with the direction of the magnetic field. In this region the proton will move on a path having the shape of a *[CBSE 2020 (55/3/1)]*

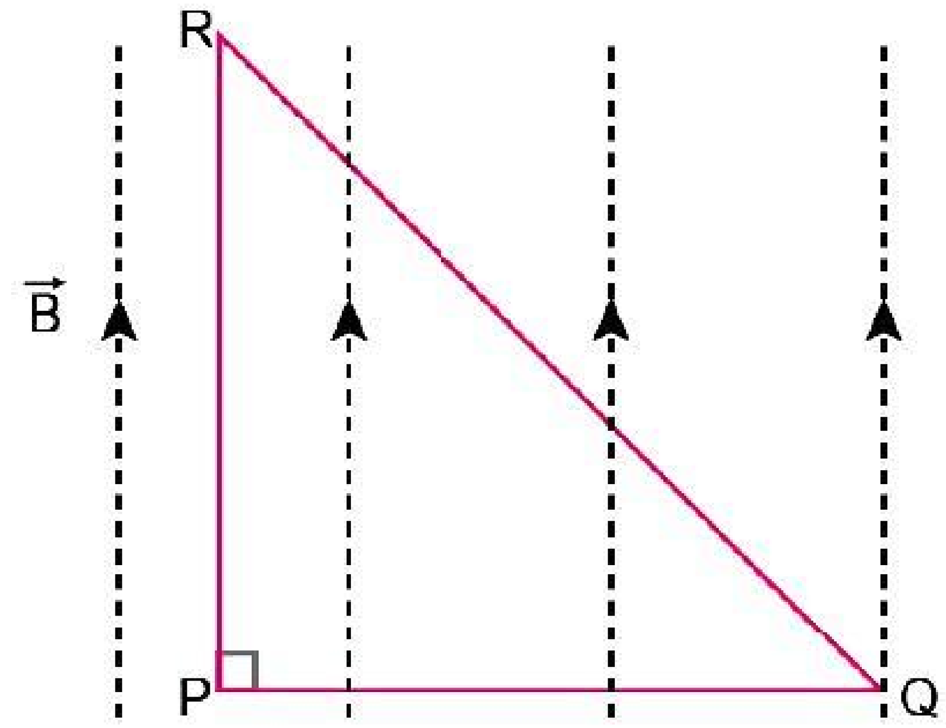
(*a*) straight line

(*b*) circle

(*c*) spiral

(*d*) helix

104. An isosceles right angled current carrying loop *PQR* is placed in a uniform magnetic field $\vec{B}$ pointing along *PR*. If the magnetic force acting on the arm *PQ* is *F*, then the magnetic force which acts on the arm *QR* will be **[*CBSE 2020 (55/3/1)*]**

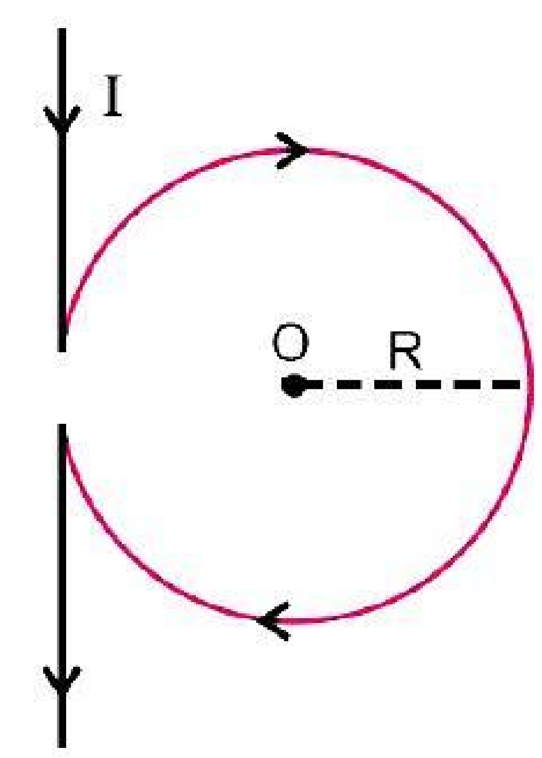


(*a*) F (*b*) $\frac{F}{\sqrt{2}}$ (*c*) $\sqrt{2}F$ (*d*) $-F$

105. A current *I* flows through a long straight conductor which is bent into circular loop of radius *R* in the middle as shown in the figure.

The magnitude of the net magnetic field at point O will be

[*CBSE 2020 (55/4/1)*]



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

(*c*) $\frac{\mu_0 I}{4\pi R}$ (*d*) $\frac{\mu_0 I}{2R}\left(1-\frac{1}{\pi}\right)$

106. A current of 10 A is flowing from east to west in a long straight wire kept on a horizontal table. The magnetic field developed at a distance of 10 cm due north on the table is:

[*CBSE 2020 (55/4/1)*]

(*a*) 2×10^{-5} T, acting downwards (*b*) 2×10^{-5} T, acting upwards

(*c*) 4×10^{-5} T, acting downwards (*d*) 4×10^{-5} T, acting upwards

107. An electron and a proton are moving along the same direction with the same kinetic energy. They enter a uniform magnetic field acting perpendicular to their velocities. The dependence of radius of their paths on their masses is: **[*CBSE 2020 (55/4/2)*]**

(*a*) $r \propto m$ (*b*) $r \propto \sqrt{m}$ (*c*) $r \propto \frac{1}{m}$ (*d*) $r \propto \frac{1}{\sqrt{m}}$

108. A charge particle after being accelerated through a potential difference '*V*' enters in a uniform magnetic field and moves in a circle of radius *r*. If *V* is doubled, the radius of the circle will become **[*CBSE 2020 (55/5/1)*]**

(*a*) $2r$ (*b*) $\sqrt{2}r$ (*c*) $4r$ (*d*) $r/\sqrt{2}$

Answers

1. (*c*)	**2.** (*a*)	**3.** (*d*)	**4.** (*c*)	**5.** (*a*)	**7.** (*d*)	**7.** (*a*)	**8.** (*d*)
9. (*d*)	**10.** (*a*)	**11.** (*a*)	**12.** (*b*)	**13.** (*d*)	**14.** (*d*)	**15.** (*a*)	**16.** (*d*)
17. (*b*)	**18.** (*d*)	**19.** (*a*)	**20.** (*b*)	**21.** (*d*)	**22.** (*d*)	**23.** (*d*)	**24.** (*b*)
25. (*a*)	**26.** (*c*)	**27.** (*a*)	**28.** (*b*)	**29.** (*a*)	**30.** (*a*)	**31.** (*b*)	**32.** (*d*)
33. (*a*)	**34.** (*a*)	**35.** (*a*)	**36.** (*c*)	**37.** (*a*)	**38.** (*a*)	**39.** (*d*)	**40.** (*b*)
41. (*b*)	**42.** (*a*)	**43.** (*b*)	**44.** (*c*)	**45.** (*a*)	**46.** (*c*)	**47.** (*b*)	**48.** (*a*)
49. (*b*)	**50.** (*c*)	**51.** (*b*)	**52.** (*c*)	**53.** (*d*)	**54.** (*a*)	**55.** (*b*)	**56.** (*c*)
57. (*c*)	**58.** (*a*)	**59.** (*b*)	**60.** (*c*)	**61.** (*a*)	**62.** (*d*)	**63.** (*c*)	**64.** (*c*)

65. (*c*)	**66.** (*d*)	**67.** (*c*)	**68.** (*d*)	**69.** (*a*)	**70.** (*a*)	**71.** (*b*)	**72.** (*d*)
73. (*d*)	**74.** (*b*)	**75.** (*b*)	**76.** (*c*)	**77.** (*a*)	**78.** (*a*)	**79.** (*d*)	**80.** (*b*)
81. (*b*)	**82.** (*b*)	**83.** (*d*)	**84.** (*d*)	**85.** (*c*)	**86.** (*a*)	**87.** (*d*)	**88.** (*c*)
89. (*b*)	**90.** (*b*)	**91.** (*b*)	**92.** (*c*)	**93.** (*d*)	**94.** (*c*)	**95.** (*d*)	**96.** (*b*)
97. (*b*)	**98.** (*d*)	**99.** (*c*)	**100.** (*d*)	**101.** (*a*)	**102.** (*a*)	**103.** (*d*)	**104.** (*d*)
105. (*d*)	**106.** (*a*)	**107.** (*b*)	**108.** (*b*)				

CASE-BASED QUESTIONS

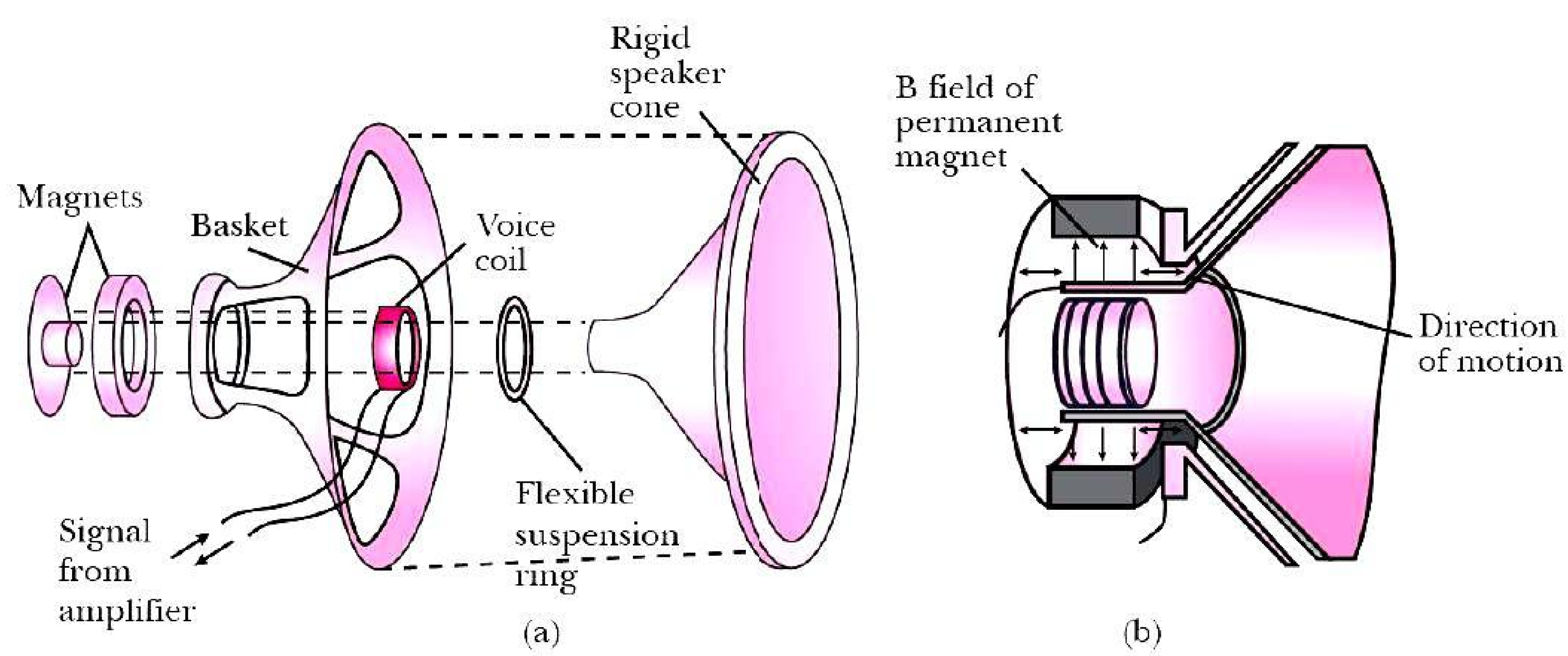
Attempt any 4 sub-parts from each question. Each question carries 1 mark.

1. LOUDSPEAKERS:

A common application of the magnetic force on a current carrying wire is found in loudspeakers. The magnetic field created by the permanent magnet exerts a force on the voice coil that is proportional to the current in the coil; the direction of the force is either to the left or to the right, depending on the direction of the current. The signal coming from the amplifier causes the current to oscillate in direction and magnitude. The coil and the speaker cone to which it is attached respond by oscillating with an amplitude proportional to the amplitude of the current in the coil. Turning up the volume knob on the amplifier increases the current amplitude and hence the amplitudes of the cone's oscillation and of the sound wave produced by the moving cone.

The force is always perpendicular to both the conductor and the field, with the direction determined by the same right-hand rule we used for a moving positive charge. Hence, this force can be expressed as a vector product, just like the force on a single moving charge. We represent the segment of wire with a vector $\vec{l}$ along the wire in the direction of the current, then force $\vec{F}$ on this segment is

$\vec{F} = I\vec{l} \times \vec{B}$ (*i.e.*, magnetic force on a straight wire segment)



(*i*) Loudspeaker works on the principle of

(*a*) detector
(*b*) generator
(*c*) amplifier
(*d*) motor

(*ii*) Electrodynamic speaker can handle which type of audio power relative to permanent magnet type speaker?

(*a*) Lower
(*b*) Equal
(*c*) Higher
(*d*) Both (*a*) and (*b*)

(*iii*) **To increase the power handling capacity in loudspeakers which type of magnet is used?**

(*a*) Temporary magnet
(*b*) Permanent magnet
(*c*) Electromagnet
(*d*) None of these

(*iv*) **A horizontal wire 0.1 m long carries a current of 5 A. Find the magnitude and direction of the magnetic field, which can balance the weight of wire. Given the mass of the wire is 3×10^{-3} kg/m and $g = 10$ m/s^2.**

(*a*) 6×10^{-3} T, acting horizontally perpendicular to wire
(*b*) 6×10^{-3} T, acting vertically upwards
(*c*) 6×10^{-2} T, acting vertically downwards
(*d*) 6×10^{-2} T, acting horizontally perpendicular to wire

(*v*) **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*) $\vec{F}$
(*b*) $-\vec{F}$
(*c*) $3\vec{F}$
(*d*) $-3\vec{F}$

Answers

1. (*i*) (*d*); A common application of the magnetic force on a current carrying wire is found in loudspeakers as similar case in motor in which current carrying coil experience force in presence of magnetic field.

(*ii*) (*c*); It is a type of higher audio power relative to permanent magnet type speaker.

(*iii*) (*c*); The electromagnet is used to increase the power handling capacity in loudspeakers.

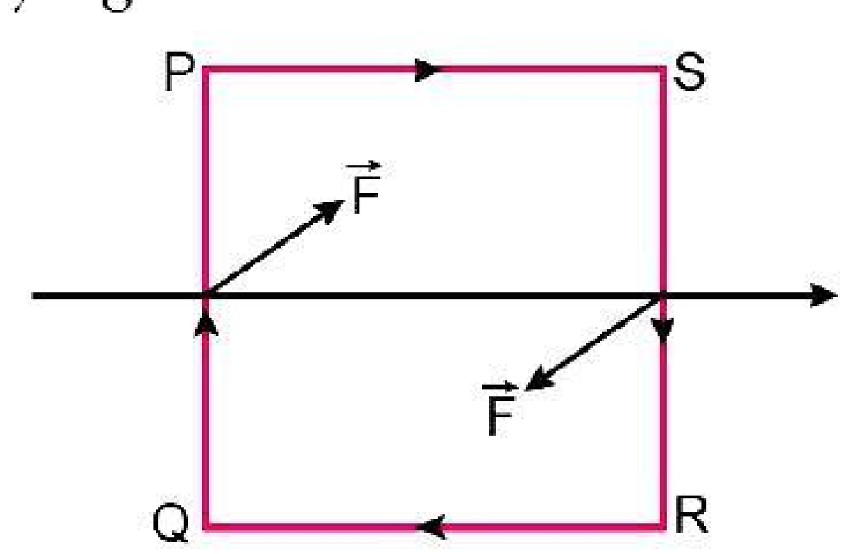
(*iv*) (*a*); Here, mass of wire, $m = 0.1 \times (3 \times 10^{-3})$ kg

In equilibrium position, $F = IlB = mg$

$$\Rightarrow \qquad B = \frac{mg}{Il} = \frac{(0.1 \times 3 \times 10^{-3}) \times 10}{5 \times 0.1} = 6 \times 10^{-3}\ \text{T}$$

The weight is wire be supported by force F if it acts vertically upwards. It will be so if the direction of $\vec{B}$ is horizontal and perpendicular to wire carrying current.

(*v*) (*b*); As clear from figure, force on arm PS and arm RQ is zero. If $\vec{F}$ is force on arm RS, the force on arm PQ is $-\vec{F}$. Therefore, net force on the remaining three arms of the loop $= -\vec{F}$.

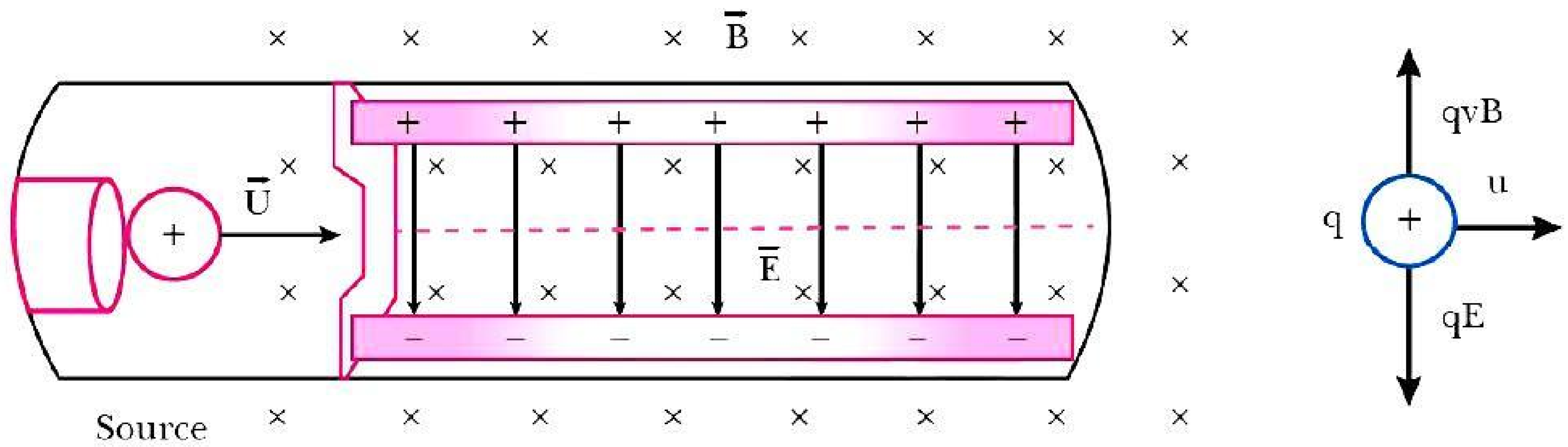


2. VELOCITY SELECTOR:

In a beam of charged particles produced by a heated cathode or a radioactive material, not all particles move with the same speed. Particles of a specific speed can be selected from the beam using an arrangement of electric and magnetic fields called a velocity selector. A charged particle with mass m, charge q and speed v enters a region of space where the electric and magnetic fields are perpendicular to the particle's velocity and to each other. The electric field $\vec{E}$ is vertically downward and the magnetic field $\vec{B}$ is into the plane. If q is positive, the electric force is downward with magnitude qE, and the magnetic force is upward with magnitude qvB. For given field magnitude E and B, for a particular value of v the electric and magnetic force will be equal in magnitude the total force is then zero, and the particles travels in a straight line with constant velocity. For zero total force, $\Sigma Fy = 0$, we need $-qE + qvB = 0$. Solving for the speed v for which there is no deflection, we find

$$v = \frac{E}{B}$$

Only particles with speeds equal to $\frac{E}{B}$ can pass through without being deflected by the fields. By adjusting E and B appropriately, we can select particles having a particular speed for use in other experiments. Because q divides out, a velocity selector for positively charged particles also works for electrons or other negatively charged particles. Therefore, from the above discussion, a velocity selector is a region in which there is a uniform electric field and uniform magnetic field. The fields are perpendicular to one another, and perpendicular to the initial velocity of the charged particles that are passing through the region.



(a) (b)

(i) An electron is projected with uniform velocity along the axis of a current carrying long solenoid. Which of the following is true?

(a) The electron will continue to move with uniform velocity along the axis of the solenoid.

(b) The electron will experience a force at 45° to the axis and hence execute a helical path.

(c) The electron path will be circular about the axis.

(d) The electron will be accelerated along the axis.

(ii) A cubical region of space is filled with some uniform electric and magnetic fields. An electron enters the cube across one of its faces with velocity v and a positron enters via opposite face with velocity $-v$. At this instant

(a) the motion of the centre of mass (CM) is determined by B alone.

(b) both particles gain or loose energy at the same rate.

(c) the magnetic forces on both the particles cause equal accelerations.

(d) all of the above

(iii) A charged particle would continue to move with a constant velocity in velocity selector, where in

(a) $E \neq 0, B \neq 0$ (b) $E = 0, B \neq 0$

(c) both (a) and (b) (d) none of these

(iv) A charged particle goes undeflected in a region of velocity selector containing electric and magnetic field. It is possible that

(a) $\vec{E}$ is not parallel to $\vec{B}$ and $\vec{v}$ (b) $\vec{E} \parallel \vec{B}, \vec{v} \parallel \vec{E}$

(c) $\vec{v} \parallel \vec{B}$ but $\vec{E}$ is not parallel to $\vec{E}$ (d) $\vec{E} \parallel \vec{B}$ but $\vec{v}$ is not parallel to $\vec{E}$

(*v*) **A charged particle with charge *q* enters a region of constant, uniform and mutually orthogonal field $E = 50\ NC^{-1}$ and magnetic field, $B = 2.5 \times 10^{-5}$ weber m^{-1} with a velocity *v* perpendicular to both *E* and *B*. It comes out without any change in velocity with a magnitude of**

(*a*) 0.5×10^6 m/s
(*b*) 10^6 m/s
(*c*) 2×10^6 m/s
(*d*) 2.5×10^6 m/s

Answers

2. (*i*) (*a*); The Lorentz force acting on a charged particle in a magnetic and electric field is $\vec{F} = q[\vec{E} + \vec{v} \times \vec{B}]$. As there is no *E*, force due to electric field is zero and force due to *B* is perpendicular to the direction of *v* and *B* which will be perpendicular to the direction of motion (*v*), so, will not affect the velocity of moving charge particle.

(*ii*) (*a*); As $F = q(\vec{v} \times \vec{B})$, *i.e.*, *F* is perpendicular to velocity and magnetic field, so particle revolves perpendicular to both $\vec{B}$ and $\vec{v}$ with uniform speed. But magnitude of acceleration by magnetic field is equal as magnitude of charge, $\vec{v}, \vec{E}$ and $\vec{B}$ are constant. So, it gain or loose the energy at the same rate. There is no change in centre of mass of particle therefore the motion of centre of mass is determined by *B* alone.

(*iii*) (*c*); When a single moving charge is placed with some uniform electric and magnetic fields in space, then they experience a force called Lorentz force given by $F_{net} = qE + q(v \times B)$.

Force experienced by charged particle = due to electric field, $F_e = qE$

Force experienced by charged particle due to magnetic field, $F_m = q\ (v \times B)$

The particle is moving with constant velocity that means acceleration of particle is zero and also it is not changing its direction of motion. This will happen when the net force is zero *i.e.*,

(*a*) If $E = 0$, and $v \parallel B$, then $F_{net} = 0$

(*b*) If $E \neq 0$, and $B \neq 0$, and *E*, *v* and *B* are mutually perpendicular.

(*iv*) (*b*); A charged particle will go undeflected in an electric field if the direction of force on particle due to electric field only acts in the direction of motion of the particle *i.e.*, the charged particle moves parallel to the electric field. A moving charged particle cannot be deflected while passing through a region if the force on it due to electric field is equal and opposite to the force due to magnetic field. It will be so if magnetic field is perpendicular to electric field and is perpendicular to the direction of motion of charged particle.

(*v*) (*c*); When charged particle goes undeflected then,

$$qE = qvB \Rightarrow v = \frac{E}{B}$$

$$\therefore v = \frac{50\ NC^{-1}}{2.5 \times 10^{-5}} = 2 \times 10^6\ m/s$$

$$\therefore v = 2 \times 10^6\ m/s$$

ASSERTION-REASON QUESTIONS

In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices.

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false and R is also false.

1. Assertion (A) : Motion of electron around a positively charged nucleus is different from the motion of a planet around the sun.

Reason (R) : The force acting in both the cases is same in nature.

2. Assertion (A) : When a magnetic dipole is placed in a non uniform magnetic field, only a torque acts on the dipole.

Reason (R) : Force would not act on dipole if magnetic field were non uniform.

3. Assertion (A) : Magnetic field lines always form closed loops.

Reason (R) : Moving charges or currents produce a magnetic field.

4. Assertion (A) : Galvanometer cannot as such be used as an ammeter to measure the value of the current in a given circuit.

Reason (R) : It gives a full-scale deflection for a current of the order of micro ampere.

5. Assertion (A) : Magnetic lines of force form continuous closed loops whereas electric lines of force do not.

Reason (R) : Magnetic poles always occur in pairs as north pole and south pole.

6. Assertion (A) : Magnetic field is caused by current element.

Reason (R) : Magnetic field due to a current element $I\,\overrightarrow{dl}$ is $\overrightarrow{dB} = \frac{\mu_0}{4\pi}\frac{I\overrightarrow{dl}\times\vec{r}}{r^3}$

7. Assertion (A) : A charge, whether stationary or in motion produces a magnetic field around it. *[AIIMS 2009]*

Reason (R) : Moving charges produce only electric field in the surrounding space.

8. Assertion (A) : If a proton and an α-particle enter a uniform magnetic field perpendicularly with the same speed, the time period of revolution of α-particle is double that of proton. *[AIIMS 2010]*

Reason (R) : In a magnetic field, the period of revolution of a charged particle is directly proportional to the mass of the particle and is inversely proportional to charge of particle.

9. Assertion (A) : The resistance of an ideal voltmeter should be infinite. *[AIIMS 2011]*

Reason (R) : The lower resistance of voltmeter gives a reading lower than the actual potential difference across the terminals.

10. Assertion (A) : Magnetic field cannot change kinetic energy of a moving charge. *[AIIMS 2018]*

Reason (R) : Magnetic field cannot change velocity vector.

Answers

1. (*d*) **2.** (*d*) **3.** (*b*) **4.** (*a*) **5.** (*a*) **6.** (*b*) **7.** (*d*) **8.** (*a*)
9. (*a*) **10.** (*c*)

HINTS/SOLUTIONS OF SELECTED MCQs

1. (*c*) $B_{in} = O, B_{out} = \frac{\mu_0 I}{2\pi r}$, where r = radius of cross-section loop

2. (*a*) According to right hand thumb rule, magnetic field produced along East to West.

3. (*d*) $\vec{F} = q\vec{V} \times \vec{B} \Rightarrow F = q\,VB\sin\theta$

For $F \neq 0$, θ lies between 0 to 180°.

4. (*c*) P is true and the magnetic field due to a current carrying wire is strong at near points from the conductor as compared to the far points.

6. (*d*) For given pitch d, $d = \frac{2\pi mv\cos\theta}{qB}$

So, charge by mass ratio, $\frac{q}{m} = \frac{2\pi v\cos\theta}{dB}$

Now, change partially traverse identical helical path in a completely opposite direction in a magnetic field B. Two particles should be same and of opposite sign, therefore,

$i.e., \left(\frac{e}{m}\right)_1 + \left(\frac{e}{m}\right)_2 = 0$

7. (*a*) In Biot-Savart's law, magnetic field B parallel to $i\vec{dl} \times \vec{r}$ and $i\,dl$ due to flow of electron is in opposite direction of v and by direction of vector product of two vectors, $\vec{B} \perp \vec{v}$

8. (*d*) Magnetic Lorontz force, electron is projected with uniform velocity along the axis of a current carrying long solenoid $F = -eVB\sin 180° = 0$ and also ($\theta = 0°$), as $\vec{B} \,||\, \vec{v}$. The electron will continue to move with uniform velocity along the axis of the solenoid.

9. (*d*) $R_{total} = R + r = \frac{v}{i}$ and $s = \frac{G}{\frac{i}{i_g} - 1}$

By checking the option (*b*) and (*c*), has satisfied their range.

(*b*); $R = \frac{v}{i} = \frac{10}{50 \times 10^{-6}} \simeq 200\text{ k}\Omega$

(*c*); $S = \frac{100}{\frac{i}{50 \times 10^{-6}} - 1} \Rightarrow 1 = \frac{100}{\frac{i}{50 \times 10^{-6}} - 1} \Rightarrow i \simeq 5\text{ mA}$

10. (*a*) The magnetic moment of circular loop and the net magnitudes of moment of each semi-circular loop of radius R lie in x-y plane and y-z plane.

So, $M_{net} = \sqrt{M'^2 + M'^2} = \sqrt{2}M' = \sqrt{2}\,IA' = \sqrt{2}\,I(\pi r^2)/4$

where, $M = I(\pi r^2)$, so, $M_{net} < M$.

11. (*a*) $\tau = MB\sin\theta = NIAB\sin\theta$.

Hence, τ acting on it does not depend upon shape of the loop.

12. (*b*) $\tau = MB\sin\theta = NIAB\sin 0° = 0$, as ($\theta = 0°$)

13. (*d*) The gyro-magnetic ratio of an electron in H-atom is negative and independent of orbit which electron revolves around it.

14. (*d*) Sensitivity, $S = \frac{NBa}{K}$, where K = torsional rigidity

Hence, S increases when K is decreases.

15. (*a*) $I_g = \frac{2}{300} = \frac{2}{300} \times 1000 \text{ mA} = \frac{20}{3} \text{mA} = 6.67 \text{ mA}$

As range of ammeter cannot be decreased but increased only. So the instrument cannot be converted to measure the range 5 mA.

16. (*d*) Shunt is a low resistance connected in parallel with the galvanometer or ammeter.

$$i.e., \ S = \frac{I_g G}{I - Ig} \Rightarrow 5 = \frac{\left(\frac{4}{100}\right)IG}{I - \left(\frac{4}{100}\right)I} = \frac{4G}{96} \qquad \left[\text{Where } I_g = 4\% \text{ of } I = \frac{4}{100}I\right]$$

$$\text{or} \quad G = \frac{96 \times 5}{4} = 120\Omega$$

21. (*d*) Shunting (a low resistance in parallel)

23. (*d*) $\vec{E} = c\vec{B}$

24. (*b*) $K = \frac{q^2 B^2 r^2}{2m} \Rightarrow K \propto \frac{1}{m} \Rightarrow K_2 = 100 \text{ keV}$

26. (*c*) $B = \frac{\mu_0 i}{2\pi r} \Rightarrow B \,\alpha\, \frac{1}{r} \Rightarrow \frac{B_1}{B_2} = \frac{r_2}{r_1} = \frac{20}{5}$

$$\frac{B}{B_2} = 4 \quad \Rightarrow B_2 = \frac{B}{4}$$

27. (*a*) $B = \frac{\mu_0 I}{2r}, B' = \frac{\mu_0 (2)I}{2(r/2)} = 4B$

29. (*a*) $B - \mu_0 nI - 4\pi \times 10^{-7} \times 5 \times 1000 - 2\pi \times 10^{-3}$ T

30. (*a*) $F_m = \frac{\mu_0 I_1 I_2 l}{2\pi d}, F_m \propto \frac{1}{d}$

31. (*b*) Arrangement provides electromagnetic damping due to production of eddy currents

33. (*a*) $V_s = \frac{I_s}{G} \Rightarrow \frac{V_s}{I_s} = \frac{1}{G}$

34. (*b*) We know that $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d} = \frac{\mu_0 i^2}{2\pi d}$, $[I_1 = I_2 = i]$

37. (*a*) As $\theta = 0° \Rightarrow F = qVB \sin\theta = 0$

39. (*d*) Less than g as $a_{net} = g - a$

41. (*b*) $F = \frac{\mu_0 i_1 i_2 l}{2\pi x}$

$$F' = \frac{\mu_0 2i_1 . 2i_2 . l}{2\pi \frac{x}{2}} = 8F$$

42. (*a*) $T = \frac{2\pi m}{qB}$

43. (*b*) $\theta = 0°$ & $180°$

44. (*c*) Let the radii of the two coils be $2a$ and a, then their resistances will be $2R$ and R respectively.

Given $B_1 = B_2$

or $\dfrac{\mu_0 I_1}{2\times 2a} = \dfrac{\mu_0 I_2}{2a}$

or $\dfrac{\mu_0}{4a}\cdot\dfrac{V_1}{2R} = \dfrac{\mu_0}{2a}\cdot\dfrac{V_2}{R}$

or $\dfrac{V_1}{V_2} = 4$

45. (*a*) Net force on a square circular loop in a uniform magnetic field is zero.

$$\vec{F_1} + \vec{F_2} + \vec{F_3} + \vec{F_4} = 0$$

$$\Rightarrow \vec{F_2} + \vec{F_3} + \vec{F_4} = \left(-\vec{F_1}\right) = -\vec{F}$$

46. (*c*) K.E. of charged particle remains unchanged in a uniform magnetic field.

47. (*b*) $I_g = \dfrac{V}{R + G}$

$$30 \times 10^{-3} = \frac{30}{R + 100}$$

$$R + 100 = 1000$$

$$\Rightarrow \quad R = 900\ \Omega$$

48. (*a*) For non-zero force $\sin\theta \neq 0$ or $\theta \neq 0^\circ$ or 180°

49. (*b*) $r = \dfrac{mv}{qB} \propto mv$; As $r_A > r_B \Rightarrow m_A v_A > m_B v_B$

50. (*c*) The spiral may be supposed to be formed of a number of thin charged rings.

Consider a ring of radius x and thickness dx then $dN = \left(\dfrac{N}{b-a}\right)dx$

$$\therefore\ dB = \frac{\mu_0 dNI}{2x} = \frac{\mu_0\left(\dfrac{N\,dx}{b-a}\right)I}{2x}$$

$$B = \int_a^b dB = \frac{\mu_0 NI}{2(b-a)}\int_a^b \frac{dx}{x} = \frac{\mu_0 NI}{2(b-a)}\log e\frac{b}{a}$$

51. (*b*) For entering the particle in the region $x > b$, the radius of circular path $x \geq b - a$

or $\dfrac{mv}{qB} \geq (b-a) \quad \Rightarrow \quad v_{\min} = \dfrac{qB(b-a)}{m}$

52. (*c*) The path of particle is a helix of radius

$$r = \frac{mv\sin\theta}{qB}, \quad T = \frac{2\pi m}{qB}$$

$$r = \frac{1.67\times 10^{-27}\times 2\times 10^{6}\times\sqrt{3}}{1.6\times 10^{-19}\times 0.104\times 2} = 0.1\text{ m}$$

$$T = \frac{2\pi\times 1.67\times 10^{-27}}{1.6\times 10^{-19}\times 0.104} = 2\pi\times 10^{-7}\text{ s}$$

53. (*d*) In regions I and IV, the magnetic fields due to two currents are opposite.

54. (*a*) $r = \dfrac{mv}{qB} \Rightarrow \dfrac{r_1}{r_2} = \dfrac{m_1}{m_2}\cdot\dfrac{v_1}{v_2}\cdot\dfrac{q_2}{q_1} = 1\times\left(\dfrac{2}{3}\right)\times\left(\dfrac{2}{1}\right) = \dfrac{4}{3}$

55. (*b*) Initially $B = \frac{\mu_0 I}{2r_1}$

If r_2 is new radius, then

$$2\pi r_1 = n.2\pi r_2 \Rightarrow r_2 = \frac{r_1}{n}$$

Finally, $B' = \frac{\mu_0 nI}{2r_2} = \frac{\mu_0 n^2 I}{2r_1} = n^2 B$

56. (*c*) $F = \frac{\mu_0 I_1 I_2}{2\pi d}$ N / m

Now $I_1' = -2I_1$ and $d' = 3d$

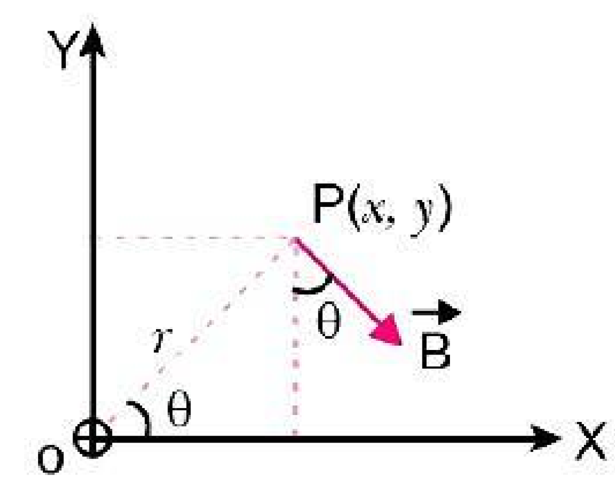
$$\therefore \ F' = \frac{\mu_0(-2I_1)I_2}{2\pi(3d)} = -\frac{2}{3}F$$

57. (*c*) Component of current element $i_2 \overrightarrow{dl}$ parallel to wire.

$= i_2 \, dl \cos\theta$

$$\therefore \ F \text{ (attractive)} = \frac{\mu_0 i_1 i_2 dl \cos\theta}{2\pi r}$$

58. (*a*) The direction of magnetic field $\vec{B}$ is shown in fig.



$$\vec{B} = B\sin\theta\,\hat{i} - B\cos\theta\,\hat{j}$$

$$B = \frac{\mu_0 i}{2\pi r}, \sin\theta = \frac{y}{r}, \cos\theta = \frac{x}{r};$$

$$r = \sqrt{x^2 + y^2}$$

$$\therefore \ \vec{B} = \frac{\mu_0 i}{2\pi r}(\sin\theta\,\hat{i} - \cos\theta\,\hat{j})$$

$$= \frac{\mu_0 i}{2\pi r}\left[\frac{y}{r}\hat{i} - \frac{x}{r}\hat{j}\right] = \frac{\mu_0 i}{2\pi}\frac{(y\,\hat{i} - x\,\hat{j})}{x^2 + y^2}$$

59. (*b*) By Fleming left hand rule, magnetic force on any current element is directed radially outwards, so loop has tendency to expand.

60. (*c*) In a uniform magnetic field the velocity of charged particle remains unchanged.

Magnetic force on electron $(= q\vec{v} \times \vec{B})$

$$= -e(v\,\hat{i}) \times (-B\,\hat{k}) = -evB\,\hat{j}$$

As force is along negative y-axis, so y-coordinate will be $y < 0$ and $v = u$.

61. (*a*) Magnetic moment of system

$$M = IA = \left(\frac{q}{T} + \frac{q}{T}\right)\pi R^2 = \frac{2\pi}{T} qR^2 = \omega qR^2$$

Angular momentum about axis of rotation

$$L = I\omega = (mR^2 + mR^2)\,\omega = 2mR^2\omega$$

$$\frac{M}{L} = \frac{\omega qR^2}{2mR^2\omega} = \frac{q}{2m}$$

62. (*d*) $B = \sqrt{B_1^2 + B_2^2} = \sqrt{\left(\frac{\mu_0 I_1}{2r_1}\right)^2 + \left(\frac{\mu_0 I_2}{2r_2}\right)^2} = \frac{\mu_0}{2}\sqrt{\frac{I_1^2}{r_1^2} + \frac{I_2^2}{r_2^2}}$

$$= \frac{4\pi \times 10^{-7}}{2}\sqrt{\left(\frac{3}{2\pi \times 10^{-2}}\right)^2 + \left(\frac{4}{2\pi \times 10^{-2}}\right)^2}$$

$= 5 \times 10^{-5}\ \text{Wb / m}^2$

63. (*c*) A point M, no magnetic field is caused due to QR.

$$B_1 = \frac{\mu_0 I}{4\pi d}, B_2 = \frac{\mu_0 I}{4\pi d} + \frac{\mu_0 (I/2)}{4\pi d} \Rightarrow \frac{B_1}{B_2} = \frac{2}{3}$$

64. (*c*) If i_1 and i_2 are currents in arms ABC and ADC respectively, then $\frac{i_1}{i_2} = \frac{2r}{r} = \frac{2}{1}$ and $i_1 + i_2 = i$.

$\therefore\ i_1 = \frac{2}{3}i \quad$ and $\quad i_2 = \frac{1}{3}i$

Magnetic field due to ABC,

$$B_1 = 2\left[\frac{\mu_0 i_1}{4\pi\left(\frac{a}{2}\right)}(\sin 45^\circ + \sin 45^\circ)\right]$$

$$= \frac{\sqrt{2}\mu_0 i_1}{\pi a} \text{ downward}$$

Magnetic field due to ADC,

$$B_2 = \frac{\sqrt{2}\mu_0 i_2}{\pi a}, \text{upward}$$

Net Magnetic field,

$$B = \frac{\sqrt{2}\mu_0}{\pi a}(i_1 - i_2) = \frac{\sqrt{2}\mu_0 (i/3)}{\pi a} = \frac{\sqrt{2}\mu_0 i}{3\pi a}$$

65. (*c*) $i_g = \frac{150}{10}\ \text{mA} = 15\ \text{mA},$

$v_g = \frac{150}{2}\ \text{mV} = 75\ \text{mV}$

$\text{V} = 150 \times 1 = 150\ \text{V}$

$G = \frac{v_g}{i_g} = \frac{75\ \text{mA}}{15\ \text{mA}} = 5\ \Omega$

Series resistance,

$$R = \frac{V}{i} - G = \frac{150}{15 \times 10^{-3}} - 5 = 9995\ \Omega$$

66. (*d*) $\frac{i_g}{i} = \frac{S}{S+G}$

$\Rightarrow\ i = \frac{S+G}{S}i_g = \frac{(0 \cdot 1 + 100)}{0 \cdot 1} \times 100 \times 10^{-6}\ \text{A}$

$= 100.1\ \text{mA}$

67. (*c*) Magnetic force between two magnets

$$F = \frac{\mu_0}{4\pi}\frac{6m_1 m_2}{r^4} = 0 \cdot 6\ \text{N}$$

68. (*d*) The internal interaction can not cause external motion

69. (*a*) For a solenoid

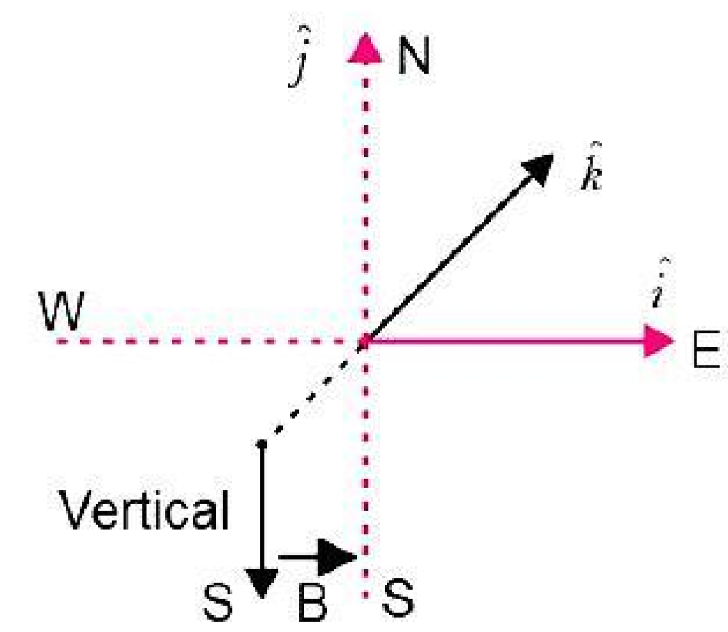
$$B = \mu_0 ni$$

$$\Rightarrow \quad \frac{B_2}{B_1} = \left(\frac{n_2}{n_1}\right)\left(\frac{i_2}{i_1}\right) \quad \therefore\ B_2 = \left(\frac{n_2}{n_1}\right)\left(\frac{i_2}{i_1}\right)B_1$$

$$= \left(\frac{100}{200}\right).\left(\frac{i/3}{i}\right)\times 6.28\times 10^{-2}$$

$$= \left(\frac{6\cdot 28\times 10^{-2}}{6}\right) = 1\cdot 05\times 10^{-2}\ \text{Wb/m}^2$$

70. (*a*) $B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\times 10^{-7}\times 100}{2\pi\times 4} = 5\times 10^{-6}$ T



Direction of $\vec{B}$

As $\vec{B} = \frac{\mu_0 I}{4\pi}\frac{\vec{dl}\times\vec{r}}{r^3}$

$\Rightarrow \quad \hat{B} = (-\hat{i}\times -\hat{k}) = -\hat{j}$ (or southward)

71. (*b*) $r = \frac{mv}{qB}$ For entry in region III, $r > l$

$\Rightarrow \quad \frac{mv}{qB} > l \Rightarrow v > \frac{qBl}{m}$ [Choice (*a*) is correct.]

Maximum path length in region II

$$L_{max} = \pi r_{max} = \pi l$$

It is the case for $v = \frac{qBl}{m}$ [Choice (*c*) is correct.]

The particle transverses half the circle, when it return to region I.

$$t = \frac{T}{2} = \frac{1}{2}\left(\frac{2\pi m}{qB}\right) = \frac{\pi m}{qB} \text{ (independent or } r)$$

[Choice (*d*) is correct.]

So, (*b*) is incorrect answer.

72. (*d*) $q\vec{E} + q\vec{v}\times\vec{B} = 0 \Rightarrow \vec{v}\times\vec{B} = -\vec{E}$

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

or $(\vec{B}\cdot\vec{B})\vec{v} - (\vec{B}\cdot\vec{v})\vec{B} = \vec{E}\times\vec{B}$

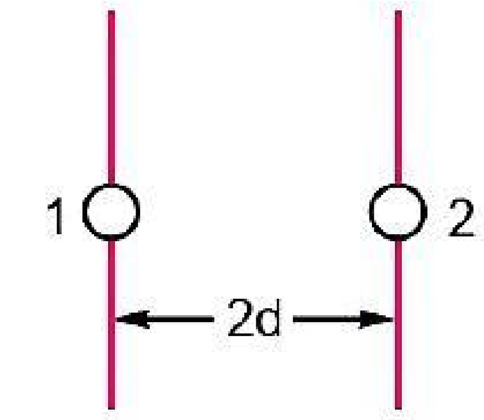
$\Rightarrow$ As $\vec{B}$ is perpendicular to $\vec{v}$; $\vec{B}\cdot\vec{v} = 0$

$$\therefore \quad \vec{v} = \frac{\vec{E}\times\vec{B}}{B^2}$$

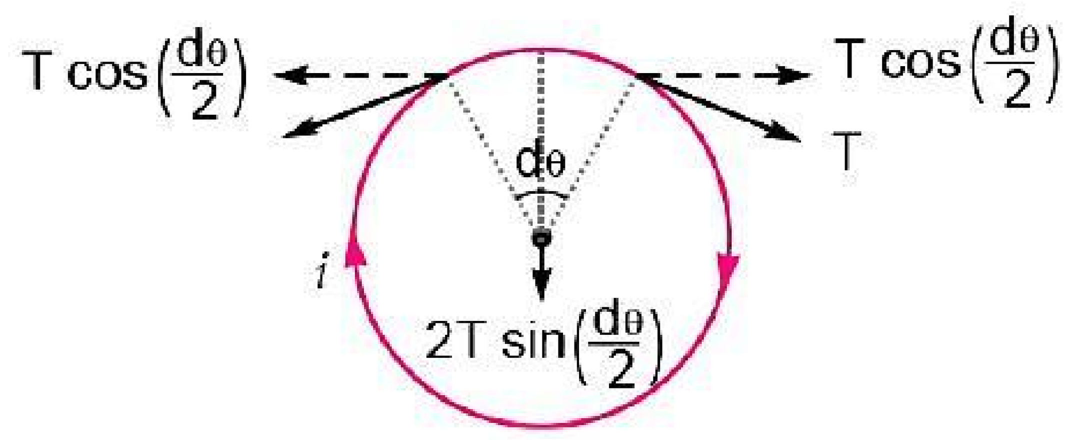
73. (*d*) Magnetic force changes the direction of particle, so momentum of particle changes.

74. (*b*) $B_1 = \frac{\mu_0 ix}{2\pi a^2} = \frac{\mu_0 i\left(\frac{a}{2}\right)}{2\pi a^2}$, $B_2 = \frac{\mu_0 i}{2\pi x} = \frac{\mu_0 i}{2\pi(2a)} = \frac{B_1}{B_2} = 1$

75. (*b*) By Maxwell right hand rule the magnetic field to the loop of wire '1' will be downward and to the right of wire '2' it is upward $\left(B \propto \frac{1}{r}\right)$. On the right of wire '1' it is upward and on the left of wire '2' it is downward. The field between the two wires at the centre is zero



76. (*c*)



$$2T\sin\left(\frac{d\theta}{2}\right) = BI(Rd\theta)$$

For small $d\theta$; $2T\left(\frac{d\theta}{2}\right) = BIRd\theta$

$\Rightarrow \quad T = BIR$

But $\quad R = \frac{L}{2\pi}$

$\therefore \quad T = \frac{BIL}{2\pi}$

78. (*a*) $F = q(\vec{v} \times \vec{B}) = qvB\sin\theta = e \times vB \times \sin 90° = evB$

79. (*d*) $F = qvB\sin\theta = evB\sin 30° = \frac{1}{2}evB$

80. (*b*) circular at 90°

81. (*a*) At any angle except 0° & 90° the path is always helical.

84. (*d*) As force by electric field on electron is opposite to motion so velocity will decrease.

85. (*c*) $F = ilB\sin\theta$ Here $\theta = 0$

87. (*d*) $B \propto \frac{1}{r}$

89. (*b*) Electron stream will be retarded as force is acting opposite to the motion of electron.

91. (*b*) $\theta = 90°$ $F = qvB\sin\theta$, $\sin\theta$ (max) $= 1$ at $\theta = 90°$

93. (*d*) $r = \frac{mv}{qB} = \frac{p}{qB} \Rightarrow r \propto p$

94. (*c*) Move towards the wire as force on *KL* & *MN* are equal & opposite so cancel each other while force on *KN* is more than *LM* towards the wire from Fleming left hand rule.

98. (*d*) $\vec{F} = q(\vec{v} \times \vec{B})$

$= -2\times10^{-6}(2\hat{i} + 3\hat{j})\times10^{6}\times2\hat{j}$ $\quad (\because B = 2\hat{j})$

$= -8\hat{k} = 8\,\text{N}(-\hat{k})$

104. (*d*) $F_{PQ} = Il_{PQ}B$

$F_{QR} = I\,l_{QR}B\sin\theta$

$\theta = 45°$

$L_{QR} = \sqrt{2}\,l_{PQ}$

$F_{QR} = I\sqrt{2}\,l_{PQ}B\frac{1}{\sqrt{2}} = Il_{PQ}B = F_{PQ}$

Since FQR and FPQ have opposite direction FQR = –F.

105. (*d*) Magnetic field due to straight part of the wire is,

$$B_1 = \frac{\mu_0}{2\pi}\frac{I}{R}, \text{ normally into the plane of paper.}$$

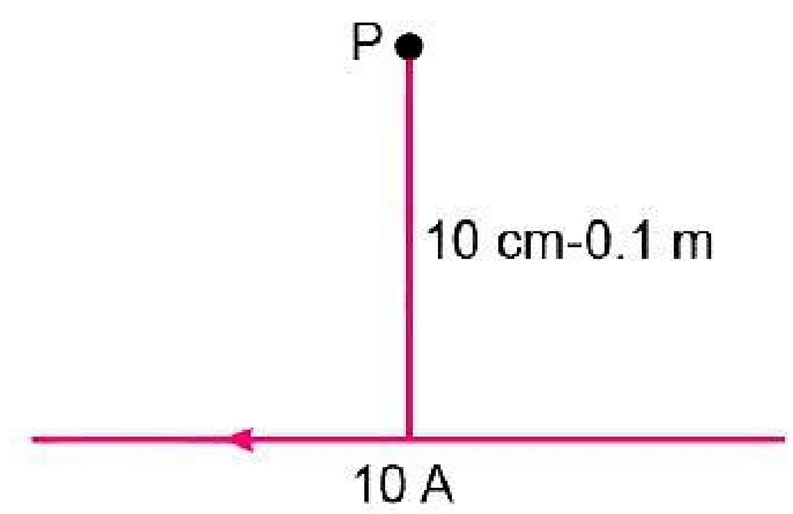
Magnetic field at the centre O due to the current loop of radius R is

$$B_2 = \frac{\mu_0 I}{2R}, \text{ normally into the plane of paper.}$$

Resultant field at O is $B = B_2 - B_1 = \frac{\mu_0 I}{2R}\left(1 - \frac{1}{\pi}\right)$

106. (*a*) $d = 0.1$ m

Magnetic field at P is,



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

$$= 2 \times 10^{-7} \times \frac{10}{0.1}$$

$= 2 \times 10^{-5}$ T, acting downwards.

107. (*b*) $r = \frac{mv}{qB}$

$$KE = \frac{mv^2}{2} = \frac{(mv)^2}{2m}$$

$$mv = \sqrt{2mKE}$$

$$r = \frac{\sqrt{2mKE}}{qB} \Rightarrow r \propto \sqrt{m}$$

108. (*b*) Radius of circular path $r = \frac{mv}{qB} = \frac{\sqrt{2\,mE_k}}{qB}$

$$E_k = eV \Rightarrow r \propto \sqrt{V}$$

$$\frac{r'}{r} = \sqrt{\frac{V'}{V}}$$

As $V' = 2V$

$$r' = \sqrt{2}\, r$$