CHAPTER
13 Magnetic Effects of Current and Magnetism

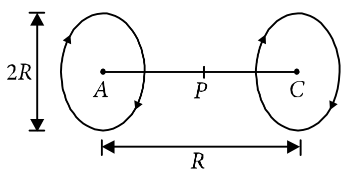
1. An electron, a proton and an alpha particle having the same kinetic energy are moving in circular orbits of radii r_e, r_p, r_α respectively in a uniform magnetic field B. The relation between r_e, r_p, r_α is

(a) $r_e > r_p = r_\alpha$ (b) $r_e < r_p = r_\alpha$
(c) $r_e < r_p < r_\alpha$ (d) $r_e < r_\alpha < r_p$ *(2018)*

2. The dipole moment of a circular loop carrying a current I, is m and the magnetic field at the centre of the loop is B_1. When the dipole moment is doubled by keeping the current constant, the magnetic field at the centre of the loop is B_2. The ratio $\frac{B_1}{B_2}$ is

(a) 2 (b) $\sqrt{3}$ (c) $\sqrt{2}$ (d) $\frac{1}{\sqrt{2}}$ *(2018)*

3. A Helmholtz coil has a pair of loops, each with N turns and radius R. They are placed coaxially at distance R and the same current I flows through the loops in the same direction. The magnitude of magnetic field at P, midway between the centres A and C, is given by [Refer to given figure]



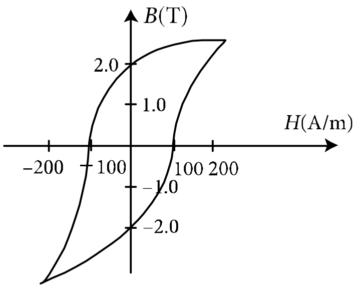
(a) $\frac{4N\mu_0 I}{5^{1/2}R}$

(b) $\frac{4N\mu_0 I}{5^{3/2}R}$

(c) $\frac{8N\mu_0 I}{5^{3/2}R}$ (d) $\frac{8N\mu_0 I}{5^{1/2}R}$

(Online 2018)

4. The B–H curve for a ferromagnet is shown in the figure. The ferromagnet is placed inside a long solenoid with 1000 turns/cm. The current that should be passed in the solenoid to demagnetise the ferromagnet completely is



(a) 1 mA
(b) 20 μA
(c) 2 mA
(d) 40 μA

(Online 2018)

5. A current of 1 A is flowing on the sides of an equilateral triangle of side 4.5×10^{-2} m. The magnetic field at the centre of the triangle will be

(a) 4×10^{-5} Wb/m^2 (b) 8×10^{-5} Wb/m^2
(c) 2×10^{-5} Wb/m^2 (d) Zero *(Online 2018)*

6. A charge q is spread uniformly over an insulated loop of radius r. If it is rotated with an angular velocity ω with respect to normal axis then the magnetic moment of the loop is

(a) $\frac{1}{2}q\omega r^2$ (b) $q\omega r^2$ (c) $\frac{3}{2}q\omega r^2$ (d) $\frac{4}{3}q\omega r^2$

(Online 2018)

7. A galvanometer with its coil resistance 25 Ω requires a current of 1 mA for its full deflection. In order to construct an ammeter to read up to a current of 2 A, the approximate value of the shunt resistance should be

(a) 1.25×10^{-3} Ω (b) 1.25×10^{-2} Ω
(c) 2.5×10^{-3} Ω (d) 2.5×10^{-2} Ω

(Online 2018)

8. A magnetic needle of magnetic moment 6.7×10^{-2} A m^2 and moment of inertia 7.5×10^{-6} kg m^2 is performing simple harmonic oscillations in a magnetic field of 0.01 T. Time taken for 10 complete oscillations is

(a) 6.65 s (b) 8.89 s
(c) 6.98 s (d) 8.76 s *(2017)*

9. When a current of 5 mA is passed through a galvanometer having a coil of resistance 15 Ω, it shows full scale deflection. The value of the resistance to be put in series with the galvanometer to convert it into a voltmeter of range 0-10 V is

(a) 1.985×10^3 Ω (b) 2.045×10^3 Ω
(c) 2.535×10^3 Ω (d) 4.005×10^3 Ω *(2017)*

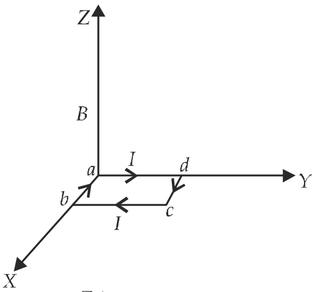
10. In a certain region static electric and magnetic fields exist. The magnetic field is given by $\vec{B} = B_0(\hat{i} + 2\hat{j} - 4\hat{k})$. If a test charge moving with a velocity $\vec{v} = v_0(3\hat{i} - \hat{j} + 2\hat{k})$ experiences no force in that region, then the electric field in the region, in SI units, is

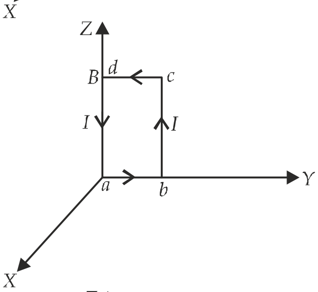
(a) $\vec{E} = -v_0B_0(14\hat{j} + 7\hat{k})$
(b) $\vec{E} = v_0B_0(14\hat{j} + 7\hat{k})$
(c) $\vec{E} = -v_0B_0(\hat{i} + \hat{j} + 7\hat{k})$
(d) $\vec{E} = -v_0B_0(3\hat{i} - 2\hat{j} - 4\hat{k})$ *(Online 2017)*

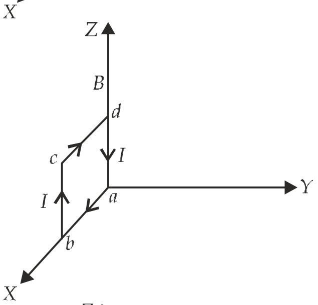
11. A magnetic dipole in a constant magnetic field has
(a) zero potential energy when the torque is maximum.
(b) minimum potential energy when the torque is maximum.
(c) maximum potential energy when the torque is maximum.
(d) zero potential energy when the torque is minimum.
(Online 2017)

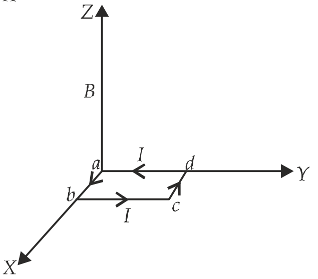
12. A negative test charge is moving near a long straight wire carrying a current. The force acting on the test charge is parallel to the direction of the current. The motion of the charge is
(a) parallel to the wire opposite to the current
(b) parallel to the wire along the current
(c) away from the wire
(d) towards the wire
(Online 2017)

13. A uniform magnetic field B of 0.3 T is along the positive Z-direction. A rectangular loop ($abcd$) of sides 10 cm × 5 cm carries a current I of 12 A. Out of the following different orientations which one corresponds to stable equilibrium?

(a) 

(b) 

(c) 

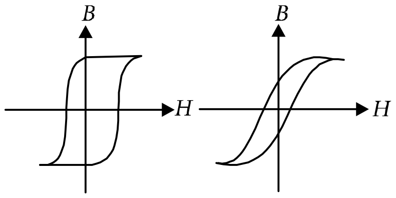
(d) 

(Online 2017)

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

(a) $\frac{\pi^2}{8}$ (b) $\frac{\pi^7}{6;\sqrt{7}}$ (c) $\frac{\pi^7}{6;}$ (d) $\frac{\pi^7}{=\sqrt{7}}$
(2016)

15. Hysteresis loops for two magnetic materials A and B are given below :



(A) (B)

These materials are used to make magnets for electric generators, transformer core and electromagnet core. Then it is proper to use :
(a) A for electric generators and transformers.
(b) A for electromagnets and B for electric generators.
(c) A for transformers and B for electric generators.
(d) B for electromagnets and transformers. *(2016)*

16. A galvanometer having a coil resistance of 100 Ω gives a full scale deflection, when a current of 1 mA is passed through it. The value of the resistance, which can convert this galvanometer into ammeter giving a full scale deflection for a current of 10 A, is
(a) 0.01 Ω (b) 2 Ω (c) 0.1 Ω (d) 3 Ω
(2016)

17. To know the resistance G of a galvanometer by half deflection method, a battery of emf V_E and resistance R is used to deflect the galvanometer by angle θ. If a shunt of resistance S is needed to get half deflection then G, R and S are related by the equation
(a) $S(R + G) = RG$ (b) $2S(R + G) = RG$
(c) $2G = S$ (d) $2S = G$ *(Online 2016)*

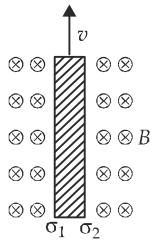
18. A magnetic dipole is acted upon by two magnetic fields which are inclined to each other at an angle of 75°. One of the fields has a magnitude of 15 mT. The dipole attains stable equilibrium at an angle of 30° with this field. The magnitude of the other field (in mT) is close to
(a) 1 (b) 11 (c) 36 (d) 1060
(Online 2016)

19. A 50 Ω resistance is connected to a battery of 5 V. A galvanometer of resistance 100 Ω is to be used as an ammeter to measure current through the resistance, for this a resistance r_s is connected to the galvanometer. Which of the following connections should be employed if the measured current is within 1% of the current without the ammeter in the circuit?

(a) $r_s = 0.5\ \Omega$ in series with the galvanometer
(b) $r_s = 1\ \Omega$ in series with galvanometer
(c) $r_s = 1\ \Omega$ in parallel with the galvanometer
(d) $r_s = 0.5\ \Omega$ in parallel with the galvanometer

(Online 2016)

20. Consider a thin metallic sheet perpendicular to the plane of the paper moving with speed 'v' in a uniform magnetic field B going into the plane of the paper (see figure). If charge densities σ_1 and σ_2 are induced on the left and right surfaces, respectively, of the sheet then (ignore fringe effects)



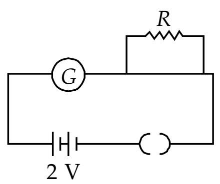
(a) $\sigma_1 = \frac{-\varepsilon_0 vB}{2},\ \sigma_2 = \frac{\varepsilon_0 vB}{2}$

(b) $\sigma_1 = \varepsilon_0 vB,\ \sigma_2 = -\varepsilon_0 vB$

(c) $\sigma_1 = \frac{\varepsilon_0 vB}{2},\ \sigma_2 = \frac{-\varepsilon_0 vB}{2}$

(d) $\sigma_1 = \sigma_2 = \varepsilon_0 vB$ *(Online 2016)*

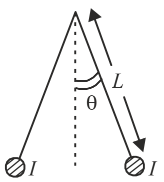
21. A galvanometer has a 50 division scale. Battery has no internal resistance. It is found that there is deflection of 40 divisions when $R = 2400\ \Omega$. Deflection becomes 20 divisions when resistance taken from resistance box is $4900\ \Omega$. Then we can conclude



(a) current sensitivity of galvanometer is 20 μA/division
(b) resistance of galvanometer is 200 Ω
(c) resistance required on R.B. for a deflection of 10 divisions is 9800 Ω
(d) full scale deflection current is 2 mA

(Online 2016)

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

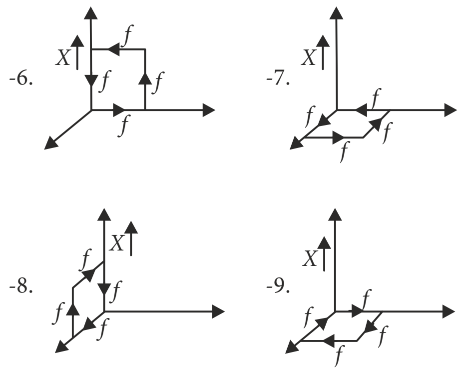


(a) $7\sqrt{\frac{\pi\ i}{\mu_5}}$ μηz θ (b) $\sqrt{\frac{\pi\lambda\ i}{\mu_5}}$ μηz θ

(c) -ιz θ $\sqrt{\frac{\pi\lambda\ i}{\mu_5\ \text{o\{}-\theta}}$ (d) 7-ιz θ $\sqrt{\frac{\pi\lambda\ i}{\mu_5\ \text{o\{}-\theta}}$

(2015)

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

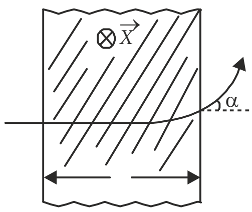


If there is a uniform magnetic field of 0.3 T in the positive z direction, in which orientations the loop would be in (i) stable equilibrium and (ii) unstable equilibrium.
(a) (2) and (4), respectively
(b) (2) and (3), respectively
(c) (1) and (2), respectively
(d) (1) and (3), respectively *(2015)*

24. Two coaxial solenoids of different radii carry current I in the same direction. Let $\vec{c}_6$ be the magnetic force on the inner solenoid due to the outer one and $\vec{c}_7$ be the magnetic force on the outer solenoid due to the inner one. Then
(a) $\vec{c}_6$ is radially inwards and $\vec{c}_7 = 5$
(b) $\vec{c}_6$ is radially outwards and $\vec{c}_7 = 5$
(c) $\vec{c}_6 = \vec{c}_7 = 5$
(d) $\vec{c}_6$ is radially inwards and $\vec{c}_7 = 5$ is radially outwards

(2015)

25. A proton (mass m) accelerated by a potential difference V flies through a uniform transverse magnetic field B. The field occupies a region of space by width d. If α be the angle of deviation of proton from initial direction of motion (see figure), the value of $\sin\alpha$ will be



(a) $\frac{X}{7}\sqrt{\frac{}{s}}$ (b) $\frac{X}{}\sqrt{\frac{}{7\ s}}$

(c) $X\sqrt{\frac{}{7\ s}}$ (d) $s\sqrt{\frac{X}{7}}$

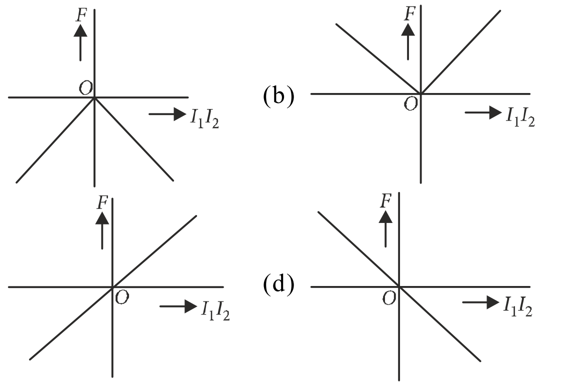
(Online 2015)

26. A 25 cm long solenoid has radius 2 cm and 500 total number of turns. It carries a current of 15 A. If it is equivalent to a magnet of the same size and magnetisation $\vec{j}$ (magnetic moment/volume), then $\vec{j}$ is

(a) 3π A m^{-1} (b) 30000 A m^{-1}
(c) 300 A m^{-1} (d) 30000π A m^{-1}

(Online 2015)

27. Two long straight parallel wires, carrying (adjustable) currents I_1 and I_2, are kept at a distance d apart. If the force F between the two wires is taken as positive when the wires repel each other and negative when the wires attract each other, the graph showing the dependence of F, on the product I_1I_2, would be



(Online 2015)

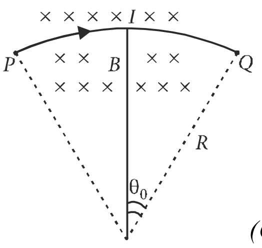
28. A wire carrying current I is tied between points P and Q and is in the shape of a circular arch of radius R due to a uniform magnetic field B (perpendicular to the plane of the paper, shown by ×××) in the vicinity of the wire. If the wire subtends an angle $2\theta_0$ at the centre of the circle (of which it forms an arch) then the tension in the wire is

(a) IBR

(b) $\frac{fXo}{-uz\,\theta_5}$

(c) $\frac{fXo}{7-uz\,\theta_5}$

(d) $\frac{fXo\,\theta_5}{-uz\,\theta_5}$



(Online 2015)

29. A short bar magnet is placed in the magnetic meridian of the earth with north pole pointing north. Neutral points are found at a distance of 30 cm from the magnet on the East - West line, drawn through the middle point of the magnet. The magnetic moment of the magnet in A m^2 is close to

(Given $\frac{\mu_5}{9\pi} = 65^{-<}$ in SI units and B_H = Horizontal component of earth's magnetic field = 3.6×10^{-5} Tesla.)

(a) 9.7 (b) 4.9 (c) 19.4 (d) 14.6

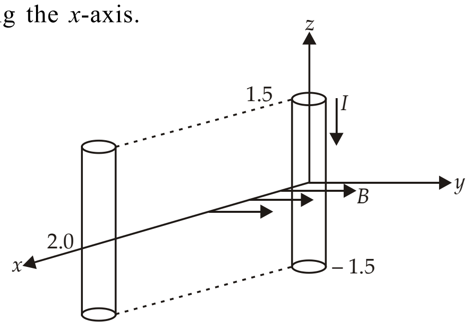
(Online 2015)

30. The coercivity of a small magnet where the ferromagnet gets demagnetized is 3×10^3 A m^{-1}. The current required to be passed in a solenoid of length 10 cm and number of turns 100, so that the magnet gets demagnetized when inside the solenoid, is

(a) 6 A (b) 30 mA (c) 60 mA (d) 3 A

(2014)

31. A conductor lies along the z-axis at $-1.5 \le z < 1.5$ m and carries a fixed current of 10.0 A in $-\hat{a}_z$ direction (see figure). For a field $\vec{B} = 3.0 \times 10^{-4} e^{-0.2x}\,\hat{a}_y$ T, find the power required to move the conductor at constant speed to $x = 2.0$ m, $y = 0$ m in 5×10^{-3} s. Assume parallel motion along the x-axis.



(a) 29.7 W (b) 1.57 W
(c) 2.97 W (d) 14.85 W *(2014)*

32. This question has Statement-I and Statement-II. Of the four choices given after the Statements, choose the one that best describes the two Statements.

Statement-I : Higher the range, greater is the resistance of ammeter.

Statement-II : To increase the range of ammeter, additional shunt needs to be used across it.

(a) Statement-I is false, Statement-II is true.
(b) Statement-I is true, Statement-II is true, Statement-II is the correct explanation of Statement-I.
(c) Statement-I is true, Statement-II is true, Statement-II is not the correct explanation of Statement-I.
(d) Statement-I is true, Statement-II is false.

(2013)

33. Two short bar magnets of length 1 cm each have magnetic moments 1.20 A m^2 and 1.00 A m^2 respectively. They are placed on a horizontal table parallel to each other with their N poles pointing towards the South. They have a common magnetic equator and are separated by a distance of 20.0 cm. The value of the resultant horizontal magnetic induction at the mid-point O of the line joining their centres is close to
(Horizontal component of earth's magnetic induction is 3.6×10^{-5} Wb/m^2)

(a) 5.80×10^{-4} Wb/m^2 (b) 3.6×10^{-5} Wb/m^2
(c) 2.56×10^{-4} Wb/m^2 (d) 3.50×10^{-4} Wb/m^2

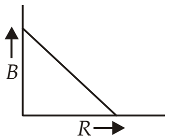
(2013)

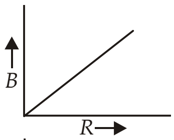
34. Proton, deuteron and alpha particle of the same kinetic energy are moving in circular trajectories in a constant magnetic field. The radii of proton, deuteron and alpha particle are respectively r_p, r_d and r_α. Which one of the following relation is correct?

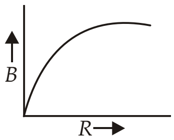
(a) $r_\alpha = r_p < r_d$ (b) $r_\alpha > r_d > r_p$
(c) $r_\alpha = r_d > r_p$ (d) $r_\alpha = r_p = r_d$ *(2012)*

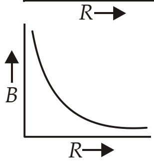
35. A coil is suspended in a uniform magnetic field, with the plane of the coil parallel to the magnetic lines of force. When a current is passed through the coil it starts oscillating; it is very difficult to stop. But if an aluminium plate is placed near to the coil, it stops. This is due to
(a) induction of electrical charge on the plate
(b) shielding of magnetic lines of force as aluminium is a paramagnetic material
(c) electromagnetic induction in the aluminium plate giving rise to electromagnetic damping
(d) development of air current when the plate is placed. *(2012)*

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

(a) 

(b) 

(c) 

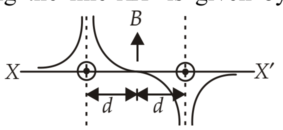
(d) 

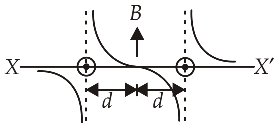
(2012)

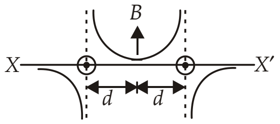
37. A current I flows in an infinitely long wire with cross-section in the form of a semicircular ring of radius R. The magnitude of the magnetic induction along its axis is

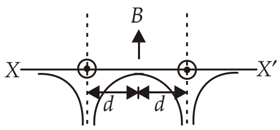
(a) $\dfrac{\mu_0 I}{\pi^2 R}$ (b) $\dfrac{\mu_0 I}{2\pi^2 R}$ (c) $\dfrac{\mu_0 I}{2\pi R}$ (d) $\dfrac{\mu_0 I}{4\pi R}$ *(2011)*

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

(a) 

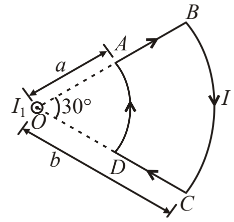
(b) 

(c) 

(d) 

(2010)

Directions : Question numbers 39 and 40 are based on the following paragraph.



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

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

(a) zero (b) $\dfrac{\mu_0 I(b-a)}{24ab}$

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

40. Due to the presence of the current I_1 at the origin
(a) the forces on AB and DC are zero
(b) the forces on AD and BC are zero
(c) the magnitude of the net force on the loop is given by $\dfrac{I_1 I}{4\pi}\mu_0\left[2(b-a)+\dfrac{\pi}{3}(a+b)\right]$
(d) the magnitude of the net force on the loop is given by $\dfrac{\mu_0 I I_1}{24ab}(b-a)$. *(2009)*

41. A horizontal overhead powerline 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 ($\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1})
(a) 2.5×10^{-7} T northward (b) 2.5×10^{-7} T southward
(c) 5×10^{-6} T northward (d) 5×10^{-6} T southward *(2008)*

42. Relative permittivity and permeability of a material are ε_r and μ_r, respectively. Which of the following values of these quantities are allowed for a diamagnetic mateiral?
(a) $\varepsilon_r = 1.5, \mu_r = 1.5$ (b) $\varepsilon_r = 0.5, \mu_r = 1.5$
(c) $\varepsilon_r = 1.5, \mu_r = 0.5$ (d) $\varepsilon_r = 0.5, \mu_r = 0.5$ *(2008)*

43. Two identical conducting wires AOB and COD are placed at right angles to each other. The wire AOB carries an electric current I_1 and COD carries a current I_2. The magnetic field on a point lying at a distance d from O, in a direction perpendicular to the plane of the wires AOB and COD, will be given by

(a) $\dfrac{\mu_0}{2\pi d}(I_1^{\,2}+I_2^{\,2})$ (b) $\dfrac{\mu_0}{2\pi}\left(\dfrac{I_1+I_2}{d}\right)^{\frac{1}{2}}$

(c) $\dfrac{\mu_0}{2\pi d}(I_1^2+I_2^2)^{\frac{1}{2}}$ (d) $\dfrac{\mu_0}{2\pi d}(I_1+I_2)$ *(2007)*

44. A charged particle moves through a magnetic field perpendicular to its direction. Then
(a) kinetic energy changes but the momentum is constant
(b) the momentum changes but the kinetic energy is constant
(c) both momentum and kinetic energy of the particle are not constant
(d) both momentum and kinetic energy of the particle are constant. *(2007)*

45. A charged particle with charge q enters a region of constant, uniform and mutually orthogonal fields $\vec{E}$ and $\vec{B}$ with a 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) $\vec{v} = \vec{B} \times \vec{E} / E^2$ (b) $\vec{v} = \vec{E} \times \vec{B} / B^2$
(c) $\vec{v} = \vec{B} \times \vec{E} / B^2$ (d) $\vec{v} = \vec{E} \times \vec{B} / E^2$ *(2007)*

46. A current I flows along the length of an infinitely long, straight, thin walled pipe. Then
(a) the magnetic field at all points inside the pipe is the same, but not zero
(b) the magnetic field is zero only on the axis of the pipe
(c) the magnetic field is different at different points inside the pipe
(d) the magnetic field at any point inside the pipe is zero. *(2007)*

47. A long straight wire of radius a carries a steady current i. The current is uniformly distributed across its cross section. The ratio of the magnetic field at $a/2$ and $2a$ is
(a) 1/2 (b) 1/4 (c) 4 (d) 1 *(2007)*

48. A long solenoid has 200 turns per cm and carries a current i. The magnetic field at its centre is 6.28×10^{-2} weber/m^2. Another long solenoid has 100 turns per cm and it carries a current $i/3$. The value of the magnetic field at its centre is
(a) 1.05×10^{-4} Wb/m^2 (b) 1.05×10^{-2} Wb/m^2
(c) 1.05×10^{-5} Wb/m^2 (d) 1.05×10^{-3} Wb/m^2 *(2006)*

49. In a region, steady and uniform electric and magnetic fields are present. These two fields are parallel to each other. A charged particle is released from rest in this region. The path of the particle will be a
(a) circle (b) helix
(c) straight line (d) ellipse *(2006)*

50. Needles N_1, N_2 and N_3 are made of a ferromagnetic, a paramagnetic and a diamagnetic substance respectively. A magnet when brought close to them will
(a) attract all three of them
(b) attract N_1 and N_2 strongly but repel N_3
(c) attract N_1 strongly, N_2 weakly and repel N_3 weakly
(d) attract N_1 strongly, but repel N_2 and N_3 weakly. *(2006)*

51. A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected along the direction of the fields with a certain velocity then
(a) it will turn towards right of direction of motion
(b) it will turn towards left of direction of motion
(c) its velocity will decrease
(d) its velocity will increase. *(2005)*

52. A charged particle of mass m and charge q travels on a circular path of radius r that is perpendicular to a magnetic field B. The time taken by the particle to complete one revolution is
(a) $\frac{2\pi qB}{m}$ (b) $\frac{2\pi m}{qB}$ (c) $\frac{2\pi mq}{B}$ (d) $\frac{2\pi mq}{qB}$ *(2005)*

53. Two concentric coils each of radius equal to 2π cm are placed at right angles to each other. 3 ampere and 4 ampere are the currents flowing in each coil respectively. The magnetic induction in weber/m^2 at the center of the coils will be ($\mu_0 = 4\pi \times 10^{-7}$ Wb/A-m)
(a) 5×10^{-5} (b) 7×10^{-5}
(c) 12×10^{-5} (d) 10^{-5} *(2005)*

54. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per milliampere and voltage sensitivity is 2 divisions per millivolt. In order that each division reads 1 volt, the resistance in ohms needed to be connected in series with the coil will be
(a) 99995 (b) 9995
(c) 10^3 (d) 10^5 *(2005)*

55. Two thin long, parallel wires, separated by a distance d carry a current of i A in the same direction. They will
(a) attract each other with a force of $\frac{\mu_0 i^2}{(2\pi d^2)}$
(b) repel each other with a force of $\frac{\mu_0 i^2}{(2\pi d^2)}$
(c) attract each other with a force of $\frac{\mu_0 i^2}{(2\pi d)}$
(d) repel each other with a force of $\frac{\mu_0 i^2}{(2\pi d)}$ *(2005)*

56. A magnetic needle is kept in a non-uniform magnetic field. It experiences
(a) a force and a torque
(b) a force but not a torque
(c) a torque but not a force
(d) neither a force nor a torque *(2005)*

57. Two long conductors, separated by a distance d carry current I_1 and I_2 in the same direction. They exert a force F on each other. Now the current in one of them is increased to 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) $F/3$
(c) $-2F/3$ (d) $-F/3$ *(2004)*

58. The magnetic field due to a current carrying circular loop of radius 3 cm at a point on the axis at a distance of 4 cm from the centre is 54 μT. What will be its value at the centre of the loop?
(a) 250 μT (b) 150 μT
(c) 125 μT (d) 75 μT *(2004)*

59. 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 be
(a) nB (b) n^2B
(c) $2nB$ (d) $2n^2B$ *(2004)*

60. A current i ampere flows along an infinitely long straight thin walled tube, then the magnetic induction at any point inside the tube is

(a) infinite (b) zero

(c) $\frac{\mu_0}{4\pi}.\frac{2i}{r}$ tesla (d) $\frac{2i}{r}$ tesla *(2004)*

61. The materials suitable for making electromagnets should have
(a) high retentivity and high coercivity
(b) low retentivity and low coercivity
(c) high retentivity and low coercivity
(d) low retentivity and high coercivity. *(2004)*

62. The length of a magnet is large compared to its width and breadth. The time period of its oscillation in a vibration magnetometer is 2 s. The magnet is cut along its length into three equal parts and three parts are then placed on each other with their like poles together. The time period of this combination will be

(a) 2 s (b) $\frac{2}{3}$ s (c) $(2\sqrt{3})$ s (d) $\left(\frac{2}{\sqrt{3}}\right)$s *(2004)*

63. An ammeter reads upto 1 ampere. Its internal resistance is 0.81 ohm. To increase the range to 10 A the value of the required shunt is
(a) 0.03 Ω (b) 0.3 Ω
(c) 0.9 Ω (d) 0.09 Ω *(2003)*

64. A particle of charge -16×10^{-18} coulomb moving with velocity 10 m s^{-1} along the x-axis enters a region where a magnetic field of induction B is along the y-axis, and an electric field of magnitude 10^4 V/m is along the negative z-axis. If the charged particle continues moving along the x-axis, the magnitude of B is
(a) 10^3 Wb/m^2 (b) 10^5 Wb/m^2
(c) 10^{16} Wb/m^2 (d) 10^{-3} Wb/m^2 *(2003)*

65. A particle of mass M and charge Q moving with velocity $\vec{v}$ describes a circular path of radius R when subjected to a uniform transverse magnetic field of induction B. The work done by the field when the particle completes one full circle is

(a) $\left(\frac{Mv^2}{R}\right)2\pi R$ (b) zero

(c) $BQ\,2\pi R$ (d) $BQv\,2\pi R$ *(2003)*

66. A thin rectangular magnet suspended freely has a period of oscillation equal to T. Now it is broken into two equal halves (each having half of the original length) and one piece is made to oscillate freely in the same field. If its period of oscillation is T', the ratio $\frac{T'}{T}$ is

(a) $\frac{1}{2\sqrt{2}}$ (b) $\frac{1}{2}$ (c) 2 (d) $\frac{1}{4}$ *(2003)*

67. Curie temperature is the temperature above which
(a) a ferromagnetic material becomes paramagnetic
(b) a paramagnetic material becomes diamagnetic
(c) a ferromagnetic material becomes diamagnetic
(d) a paramagnetic material becomes ferromagnetic. *(2003)*

68. The magnetic lines of force inside a bar magnet
(a) are from north-pole to south-pole of the magnet
(b) do not exist
(c) depend upon the area of cross-section of the bar magnet
(d) are from south-pole to north-pole of the magnet. *(2003)*

69. A magnetic needle lying parallel to a magnetic field requires W units of work to turn it through 60°. The torque needed to maintain the needle in this position will be

(a) $\sqrt{3}W$ (b) W (c) $\left(\frac{\sqrt{3}}{2}\right)W$ (d) $2W$ *(2003)*

70. The time period of a charged particle undergoing a circular motion in a uniform magnetic field is independent of its
(a) speed (b) mass
(c) charge (d) magnetic induction *(2002)*

71. If a current is passed through a spring then the spring will
(a) expand (b) compress
(c) remains same (d) none of these *(2002)*

72. If an electron and a proton having same momenta enter perpendicular to a magnetic field, then
(a) curved path of electron and proton will be same (ignoring the sense of revolution)
(b) they will move undeflected
(c) curved path of electron is more curved than that of the proton
(d) path of proton is more curved. *(2002)*

73. If in a circular coil A of radius R, current I is flowing and in another coil B of radius $2R$ a current $2I$ is flowing, then the ratio of the magnetic fields, B_A and B_B, produced by them will be
(a) 1 (b) 2 (c) 1/2 (d) 4 *(2002)*

74. If an ammeter is to be used in place of a voltmeter, then we must connect with the ammeter a
(a) low resistance in parallel
(b) high resistance in parallel
(c) high resistance in series
(d) low resistance in series. *(2002)*

ANSWER KEY

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

Explanations

1. **(b) :** Radius of circular path followed by a charged particle in a uniform magnetic field (B) is given by

$$r = \frac{mv}{qB} = \frac{p}{qB} = \frac{\sqrt{2mK}}{qB}$$

For electron, $r_e = \frac{\sqrt{2m_e K}}{eB}$; For proton, $r_p = \frac{\sqrt{2m_p K}}{eB}$

For α particle, $r_\alpha = \frac{\sqrt{2m_\alpha K}}{2eB} = \frac{\sqrt{2(4m_p K)}}{2eB} = \frac{\sqrt{2m_p K}}{eB}$

As $m_p > m_e$, so, $r_\alpha = r_p > r_e$

2. **(c) :** Initially, dipole moment of circular loop is

$m = I.A = I.\pi R^2$ and magnetic field, $B_1 = \frac{\mu_0 I}{2R}$

Finally, dipole moment becomes double, keeping current constant, so radius of the loop becomes $\sqrt{2}R$.

$$B_2 = \frac{\mu_0 I}{2(\sqrt{2}R)} = \frac{B_1}{\sqrt{2}}; \quad \therefore \quad \frac{B_1}{B_2} = \sqrt{2}$$

3. **(c) :** Required magnetic field is given by

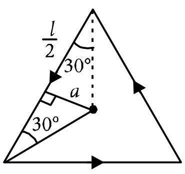
$$B = 2\left(\frac{\mu_0 NIR^2}{2\left(R^2 + \frac{R^2}{4}\right)^{3/2}}\right) = \frac{\mu_0 NIR^2}{\frac{5^{3/2}}{8}} = \frac{8\mu_0 NI}{5^{3/2} R}$$

4. **(a) :** Coercivity of ferromagnet H = 100 A/m

$nI = 100$

$$I = \frac{100}{10^5} = 1\text{ mA}$$

5. **(a) :** $B_{\text{net}} = 3\frac{\mu_0 I}{4\pi a}(\cos 30° + \cos 30°)$



$$= \frac{3 \times (10^{-7}) \times 1}{\frac{(4.5 \times 10^{-2})}{(2\sqrt{3})}}\left(2 \times \frac{\sqrt{3}}{2}\right)$$

$$\left(\because \ \tan 30° = \frac{a}{(l/2)}, a = \frac{l}{2}\tan 30° = \frac{l}{2\sqrt{3}}\right)$$

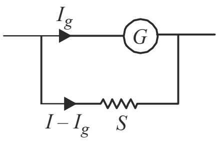
$$B_{\text{net}} = \frac{2 \times 9 \times 10^{-5}}{4.5} = 4 \times 10^{-5}\ \text{Wb/m}^2$$

6. **(a) :** Magnetic moment is given by $M = IA = \frac{q}{t}(\pi r^2)$

$$= \frac{q}{(2\pi/\omega)}(\pi r^2) \qquad \left[\because t = T = \frac{2\pi}{\omega}\right]$$

$$= \frac{1}{2}q\omega r^2$$

7. **(b) :** $I_g R_g = (I - I_g)S$



$$S \approx \frac{10^{-3} \times 25}{2}$$

($\because$ Current through galvenometer is very small).

$S \approx 12.5 \times 10^{-3} = 1.25 \times 10^{-2}\ \Omega$

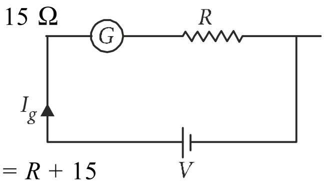
8. **(a) :** Time period of magnetic needle oscillating simple harmonically is given by $T = 2\pi\sqrt{\frac{I}{MB}}$

$$\Rightarrow \quad T = 2\pi\sqrt{\frac{7.5 \times 10^{-6}}{6.7 \times 10^{-2} \times 0.01}} \quad \Rightarrow \quad T = \frac{2\pi}{10} \times 1.05\text{ s}$$

For 10 oscillations, total time taken

$T' = 10T = 2\pi \times 1.05 \approx 6.65$ s

9. **(a) :** Given : I_g = 5 mA, G = 15 Ω



Let R be the resistance put in series with the galvanometer as shown in figure.

Now, $V = I_g(R + G)$

$10 = 5 \times 10^{-3}(R + 15)$; $2000 = R + 15$

$\Rightarrow$ $R = 1985\ \Omega = 1.985 \times 10^3\ \Omega$

10. **(a) :** Here, $\vec{B} = B_5(\hat{i} + 2\hat{j} - 4\hat{k})$; $\vec{v} = v_0(3\hat{i} - \hat{j} + 2\hat{k})$

$\vec{F} = \vec{F}_e + \vec{F}_m \quad \therefore \ \vec{F} = 0$ or $\vec{F}_e = -\vec{F}_m$

$$\vec{F}_e = -q(\vec{v} \times \vec{B}) = -qv_0 B_0[(3\hat{i} - \hat{j} + 2\hat{k}) \times (\hat{i} + 2\hat{j} - 4\hat{k})]$$

$$= -qv_0 B_0(14\hat{j} + 7\hat{k})$$

The electric field produced by the charge q, will be,

$$\vec{E} = \frac{\vec{F}_e}{q} = -\frac{qv_0 B_0(14\hat{j} + 7\hat{k})}{q} \quad \text{or} \quad \vec{E} = -v_0 B_0(14\hat{j} + 7\hat{k})$$

11. **(a) :** When a magnetic dipole of dipole moment is placed in a uniform magnetic field , it will experience a torque,

$\tau = MB \sin\theta$

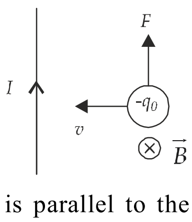
Torque is maximum when $\theta = 90°$

$\tau_{\max} = MB \sin 90° = MB$

Potential Energy of a magnetic dipole in a uniform magnetic field is,

$U = -MB\cos\theta = -MB\cos 90° = 0$

12. **(d) :** Given situation is shown in the figure



As we know,

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

$$\vec{F} = -q_0(\vec{v} \times \vec{B})$$

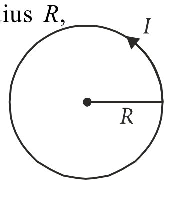
According to question, direction of current is parallel to the force acting on the electron. Hence the motion of test charge is towards the wire.

13. **(d) :** Magnetic potential energy of the dipole in a magnetic field, $U = -\vec{M}.\vec{B}$

As M and B are same in each case,

for stable equilibrium, potential energy should be minimum. Minimum potential energy is possible if $\vec{M}$ and $\vec{B}$ are in same direction. So option (d) is correct.

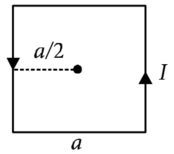
14. (d) : Wire A is bent into a circle of radius R,



$$= 7\pi o \Rightarrow o = \frac{}{7\pi}$$

$$X_W = \frac{\mu_5 f}{7o} = \frac{\mu_5 f}{7\times\left(\frac{}{7\pi}\right)} = \mu_5 \pi f$$

Wire B is bent into a square of side a,



$$= 9 \Rightarrow \; = \frac{}{9}$$

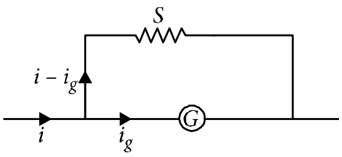
$$X_X = 9\times\left[\frac{\mu_5 f}{9\pi\text{- } 47.}\text{--ɯ } 9\text{: }°+\text{-ɯ } 9\text{: }°.\right] = \frac{7\mu_5 f}{\pi}\times\frac{7}{\sqrt{7}} = \frac{6;\,\mu_5 f}{\sqrt{7}\pi}$$

$$\therefore \quad \frac{X_W}{X_X} = \frac{\mu_5 \pi f\, 4}{6;\, \mu_5 f\, 4\sqrt{7}\pi} = \frac{\pi^7}{=\sqrt{7}}$$

15. (d) : For both, the electromagnet and transformer, the magnetic field changes with time. Hence the energy losses must be less in both devices. Hysteresis loop represented in B has less area which means it dissipates less energy.

16. (a) : Given i_g = 1 mA, G = 100 Ω, i = 10 A, S = ?

$(i - i_g)S = i_g G$

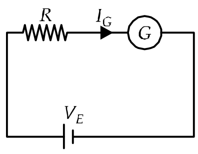


$$\therefore \quad p = \frac{d}{-} = \frac{6\times 65^{-8}\times 655}{\text{-}65 - 65^{-8}.}$$

$$\approx 65^{-7}\ \Omega$$

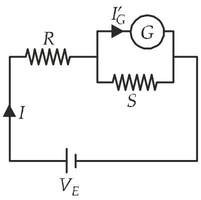
$= 0.01\ \Omega$

17. (a) : Case I :



$$I_G = \frac{V_E}{R+G} \quad \ldots(\text{i})$$

Case II :



$$I = \frac{V_E}{R + \frac{GS}{G+S}} \quad \ldots(\text{ii})$$

$$I_G{}' = \frac{I_G}{2} = \frac{IS}{G+S} \quad \ldots(\text{iii})$$

$\therefore$ From (i), (ii) and (iii)

$$\frac{V_E}{2(R+G)} = \frac{V_E}{R+\frac{GS}{G+S}}\times\frac{S}{G+S}$$

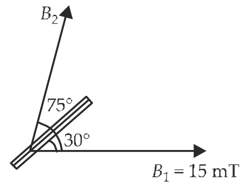
$$\Rightarrow \quad \frac{1}{2(R+G)} = \frac{(G+S)}{(RG+RS+GS)}\times\frac{S}{(G+S)}$$

$\Rightarrow$ $RG + RS + GS = 2RS + 2GS \Rightarrow RS + GS = RG$

or $S(R + G) = RG$

18. (b) : The magnetic dipole attains stable equilibrium under the influence of these two fields making an angle $\theta_1 = 30°$ with B_1 and $\theta_2 = 75° - 30° = 45°$ with B_2.

For stable equilibrium, net torque acting on dipole must be zero, *i.e.*, $\vec{\tau}_1 + \vec{\tau}_2 = 0$ or $\tau_1 = \tau_2$ or $mB_1\sin\theta_1 = mB_2\sin\theta_2$



$$\Rightarrow \quad B_2 = B_1\frac{\sin\theta_1}{\sin\theta_2} = 15\text{ mT}\times\frac{\sin 30°}{\sin 45°}$$

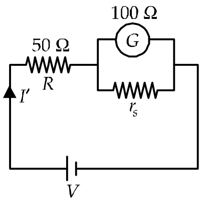
$$= 15\text{ mT}\times\frac{1}{2}\times\sqrt{2} = 10.6\text{ mT} \approx 11\text{ mT}$$

19. (d) : Current in the circuit without ammeter

$$I = \frac{V}{R} = \frac{5\text{ V}}{50\ \Omega} = 0.1\text{ A}$$

$\therefore$ Allowed current with ammeter, $I' = 0.099$ A

Also, $I' = \dfrac{V}{R_{eq}}$ where $R_{eq} = 50 + \dfrac{100\, r_s}{100 + r_s}$



$$\therefore \quad 0.099 = \frac{5}{50 + \frac{100\, r_s}{100 + r_s}}$$

or $50 + \dfrac{100\, r_s}{100 + r_s} = \dfrac{5}{0.099}$

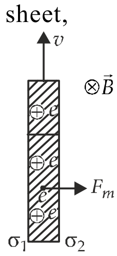
$\Rightarrow \dfrac{100\, r_s}{100 + r_s} = 0.5 \quad \Rightarrow 100\, r_s = 50 + 0.5\, r_s$

or $r_s = \dfrac{50}{99.5} = 0.5\ \Omega$

20. (b) : Magnetic force on electron in the metal sheet,

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

At equilibrium,



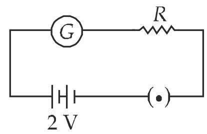
$F_m = F_e$ (induced)

and $\sigma_2 = -\sigma_1$

$evB = e\dfrac{\sigma}{\varepsilon_0} \Rightarrow \sigma = \varepsilon_0\, vB = \sigma_1$

$\sigma_2 = -\varepsilon_0\, vB$

21. (a*) : * The circuit given in the question is incorrect. The given figure shows the correct circuit.



Let the current which produces full scale deflection in the galvanometer be I_g.

Then according to question, $\dfrac{4}{5}I_g = \dfrac{V}{G+R} = \dfrac{2}{G+2400} \quad \ldots(\text{i})$

$$\frac{2}{5}I_g = \frac{2}{G+4900} \quad \ldots(\text{ii})$$

From eqns. (i) and (ii), $\dfrac{4}{2} = \dfrac{G+4900}{G+2400} \Rightarrow G = 100\ \Omega$

Putting G in eq. (i)

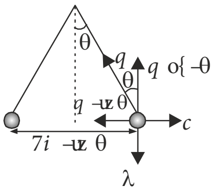
$$\frac{4}{5}I_g = \frac{2}{100+2400} \Rightarrow I_g = \frac{2\times 5}{4\times 2500} = 1\text{ mA}$$

For a deflection of 10 divisions

$$\frac{1}{5}I_g = \frac{V}{G+R} \Rightarrow \frac{1}{5}\times 10^{-3} = \frac{2}{100+R} \Rightarrow R = 9900\ \Omega$$

Now, current sensitivity $= \dfrac{I_g}{n} = \dfrac{1\text{ mA}}{50\text{ div}} = 20\ \mu\text{A / division}$

22. (d) : Let the length of right wire be l, then its mass is λl.



Forces acting on this wire are tension (T), weight (λlg) and force of repulsion due to other wire (F).

From figure, $T\cos\theta = \lambda lg$ ...(i) $T\sin\theta = F$ ...(ii)

Here, $c = \frac{\mu_5}{7\pi}\frac{f^7}{-7i\ \text{-ư}\ \theta.}$

$\{\sim\ q\ \text{-ư}\ \theta = \frac{\mu_5}{7\pi}\frac{f^7}{-7i\ \text{-ư}\ \theta.}$ (Using (ii))

$\{\sim\ \frac{\lambda}{\text{o}\{-\theta}\text{-ư}\ \theta = \frac{\mu_5}{7\pi}\frac{f^7}{-7i\ \text{-ư}\ \theta.}$ (Using (i))

$\Rightarrow f = \sqrt{\frac{9\pi i\lambda\ \text{-ư}^7\theta}{\mu_5\,\text{o}\{-\theta}} = 7\text{-ư}\,\theta\sqrt{\frac{\pi\lambda\ i}{\mu_5\,\text{o}\{-\theta}}$

23. (a) : $I = 12$ A, $\vec{X} = 538\ \hat{}\ \wedge$,

$A = 10 \times 5\ \text{cm}^2 = 50 \times 10^{-4}\ \text{m}^2$

$\vec{j} = fW\hat{} = 67\times{:}\,5\times65^{-9}\hat{}\ \text{H y}^{7} = 6 \times 10^{-2}\ \text{A m}^2$

Here, $\vec{j}_6 = ;\times65^{-7}\hat{}\ \text{H y}^7$, $\vec{j}_7 = ;\times65^{-7}\hat{}\ \text{H y}^7$

$\vec{j}_8 = -;\times65^{-7}\hat{}\ \text{H y}^7$, $\vec{j}_9 = -;\times65^{-7}\hat{}\ \text{H y}^7$

$\vec{j}_7$ is parallel to $\vec{X}$, it means potential energy is minimum, therefore in orientation (2) the loop is in stable equilibrium. $\vec{j}_9$ is antiparallel to $\vec{X}$, it means potential energy is maximum, therefore in orientation (4) the loop is in unstable equilibrium.

24. (c)

25. (c) : Energy of proton $= \frac{6}{7}\ {}^7 = s$

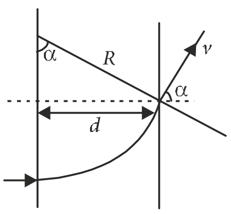
$v = \sqrt{\frac{7\ s}{}}$

magnetic force, $qvB\sin 90° = \frac{7}{o}$

$R = \frac{}{X}$

$\sin\alpha = \frac{}{o} = \frac{X}{} = \frac{X}{}\sqrt{\frac{}{7\ s}}$

$\sin\alpha = X\sqrt{\frac{}{7\ s}}$



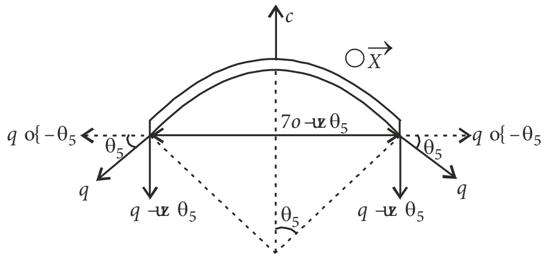
26. (b) : $l = 25$ cm, $r = 2$ cm, $N = 500$, $I = 15$ A,

$|\vec{j}| = \frac{\text{T ns z quo y \{y qz µ}}{\text{b \{xy q}} = \frac{kfW}{W} = \frac{kf}{}$

$|\vec{j}| = \frac{6{:}\times{:}55}{7{:}\times65^{-7}} = 85555\ \text{H y}^{-6}$

27. (d) : When the currents are parallel, I_1I_2 is positive and the force between them is attractive (*i.e.* negative). Similarly when currents are antiparallel, I_1I_2 is negative and the force between them is repulsive (*i.e.* positive). So option (d) satisfies the condition.

28. (a) :



Magnetic force on the circular arc

$F = I(2R\sin\theta_0)B$

For the arc to be in equilibrium, $F = 2T\sin\theta_0$

$\therefore\ 2T\sin\theta_0 = 2IR\sin\theta_0 B$; $T = IRB$

29. (a) : At 30 cm from the magnet on its equatorial plane,

$\vec{X}_{\text{y ns z qµ}} = -\vec{X}_e\ \text{-∵ z q×µ-nx| \{ ư µ}$

So, by equating their magnitude $\frac{\mu_5}{9\pi}\frac{j}{8} = 83\times65^{-:}\ \wedge\text{q-xm}$

$\frac{65^{-<}\times j}{-538.^8} = 83\times65^{-:}\ \wedge\text{q-xm}$

$M = 3.6 \times 0.027 \times 10^2 = 9.7\ \text{A m}^2$

30. (d) : Here, $\frac{B}{\mu_0} = 3\times10^3\ \text{A m}^{-1}$

$L = 10$ cm $= 0.1$ m, $N = 100$, $I = ?$

As, $B = \mu_0 nI = \mu_0\frac{N}{L}I \Rightarrow I = \frac{B}{\mu_0}\times\frac{L}{N} = 3\times10^3\times\frac{0.1}{100} = 3$ A

31. (c) : Force on conductor, $\vec{F} = I(\vec{l}\times\vec{B})$

$\Rightarrow \vec{F} = 10(-3\hat{a}_z)\times(3.0\times10^{-4}e^{-0.2x}\hat{a}_y)$

$\Rightarrow \vec{F} = 90 \times 10^{-4}\ (e^{-0.2x})$ along x-axis

Work done on the conductor in moving along x-axis,

$$W = \int_{x=0}^{x=2}\vec{F}\cdot\vec{dx} = 90\times10^{-4}\int_{x=0}^{x=2}e^{-0.2x}dx = 90\times10^{-4}\left[\frac{e^{-0.2x}}{-0.2}\right]_0^2$$

$$\Rightarrow W = 90\times10^{-4}\left[\frac{e^{-0.4}-1}{-0.2}\right]\text{J}$$

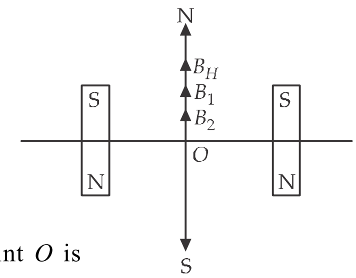
This is net work done on the conductor.

$\therefore$ Average power, $P_{av} = \frac{\text{Work}}{\text{time}}$

$$\Rightarrow P_{av} = \frac{90\times10^{-4}(e^{-0.4}-1)}{5\times10^{-3}\times(-0.2)} \Rightarrow P_{av} = 2.97\ \text{W}$$

32. (a)

33. (c) : The situation is as shown in the figure.



As the point O lies on broad-side position with respect to both the magnets. Therefore, the net magnetic field at point O is

$B_{\text{net}} = B_1 + B_2 + B_H$

$$B_{\text{net}} = \frac{\mu_0}{4\pi}\frac{M_1}{r^3} + \frac{\mu_0}{4\pi}\frac{M_2}{r^3} + B_H = \frac{\mu_0}{4\pi r^3}(M_1 + M_2) + B_H$$

Substituting the given values, we get

$$B_{net} = \frac{4\pi \times 10^{-7}}{4\pi \times (10 \times 10^{-2})^3}[1.2 + 1] + 3.6 \times 10^{-5}$$

$$= \frac{10^{-7}}{10^{-3}} \times 2.2 + 3.6 \times 10^{-5}$$

$= 2.2 \times 10^{-4} + 0.36 \times 10^{-4} = 2.56 \times 10^{-4}$ Wb/m^2

34. (a): The radius of the circular path of a charged particle in the magnetic field is given by $r = \frac{mv}{Bq}$

Kinetic energy of a charged particle,

$$K = \frac{1}{2}mv^2 \text{ or } v = \sqrt{\frac{2K}{m}} \quad \therefore \quad r = \frac{m}{qB}\sqrt{\frac{2K}{m}} = \frac{\sqrt{2Km}}{qB}$$

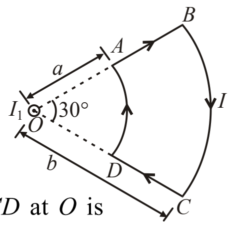
As K and B are constants $\therefore$ $r \propto \frac{\sqrt{m}}{q}$

$$r_p : r_d : r_\alpha = \frac{\sqrt{m_p}}{q_p} : \frac{\sqrt{m_d}}{q_d} : \frac{\sqrt{m_\alpha}}{q_\alpha} = \frac{\sqrt{m}}{e} : \frac{\sqrt{2m}}{e} : \frac{\sqrt{4m}}{2e} = 1 : \sqrt{2} : 1$$

$\Rightarrow$ $r_\alpha = r_p < r_d$

35. (c) **36. (d)** **37. (a)** **38. (b)**

39. (b) : O is along the line CD and AB. They do not contribute to the magnetic induction at O. The field due to DA is positive or out of the paper and that due to BC is into the paper or negative.



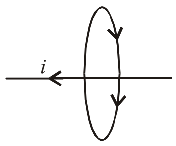
The total magnetic field due to loop $ABCD$ at O is $B = B_{AB} + B_{BC} + B_{CD} + B_{DA}$

$$\Rightarrow \quad B = 0 - \frac{\mu_0 I}{4\pi b} \times \frac{\pi}{6} + 0 + \frac{\mu_0 I}{4\pi a} \times \frac{\pi}{6}$$

$\Rightarrow$ $B = \frac{\mu_0 I}{24ab}(b - a)$, out of the paper or positive.

40. (b) : The straight wire is perpendicular to the segments and the fields are parallel. There will be no force. Due to parts AB and CD, their fields are equal and opposite and their effects also cancel each other.

41.*(d) :



By Ampere's theorem, $\vec{B} \cdot 2\pi d = \mu_0 i$

$$\vec{B} = \frac{\mu_0 i}{2\pi d} = \frac{4\pi \times 10^{-7} \times 100\,\text{A}}{2\pi \times 4\text{ m}} = 50 \times 10^{-7}\text{ T}$$

$\Rightarrow$ $B = 5 \times 10^{-6}$ T southwards.

* It is assumed that this is a direct current. If it is a.c, the current at the given instant is in the given direction.

42. (c) : The values of relative permeability of diamagnetic materials are slightly less than 1 and ε_r is quite high. According to the table given, one takes

$\varepsilon_r = 1.5$ and $\mu_r = 0.5$. Then the choice (c) is correct.

43. (c) : The field at the same point at the same distance from the mutually perpendicular wires carrying current will be having the same magnitude but in perpendicular directions.

$$\therefore \quad B = \sqrt{B_1^2 + B_2^2} \qquad \therefore \quad B = \frac{\mu_0}{2\pi d}(I_1^2 + I_2^2)^{1/2}$$

44. (b, c) : Due to Lorentzian force, $F = qv \times B$,

When a charged particle enters a field with its velocity perpendicular to the magnetic field, the motion is circular with $qvB = \frac{mv^2}{r}$. v constantly changes its direction (but not the magnitude). Therefore its tangential momentum changes its direction but its energy remains the same $\left(\frac{1}{2}I\omega^2 = \text{constant}\right)$.

Therefore the answer is (b).

If angular momentum is taken, $I\omega$ is a constant.

As $\frac{1}{2}I\omega^2$ is also constant, (c) is the answer.

* The questions could have been more specific, whether by "momentum" it is meant tangential momentum or angular momentum.

45. (b) : When $\vec{E}$ and $\vec{B}$ are perpendicular and velocity has no changes then $qE = qvB$ *i.e.*, $v = \frac{E}{B}$. The two forces oppose each other if v is along $\vec{E} \times \vec{B}$ *i.e.*, $\vec{v} = \frac{\vec{E} \times \vec{B}}{B^2}$

As $\vec{E}$ and $\vec{B}$ are perpendicular to each other

$$\frac{\vec{E} \times \vec{B}}{B^2} = \frac{EB\sin 90°}{B^2} = \frac{E}{B}$$

For historic and standard experiments like Thomson's e/m value, if v is given only as E/B, it would have been better from the pedagogic view, although the answer is numerically correct.

46. (d) : Magnetic field is shielded and no current is inside the pipe to apply Ampère's law. (Compare to electric field inside a hollow sphere).

47. (d) : Current enclosed in the 1st ampèrean path is

$$\frac{I \cdot \pi r_1^2}{\pi R^2} = \frac{I r_1^2}{R^2} \therefore B = \frac{\mu_0 \times \text{current}}{\text{path}} = \frac{\mu_0 \cdot I r_1^2}{2\pi r_1 R^2} = \frac{\mu_0 I r_1}{2\pi R^2}$$

Magnetic induction at a distance $r_2 = \frac{\mu_0 \cdot I}{2\pi r_2}$

$$\therefore \quad \frac{B_1}{B_2} = \frac{r_1 r_2}{R^2} = \frac{\frac{a}{2} \cdot 2a}{a^2} = 1$$

48. (b) : In first case, $B_1 = \mu_0 n_1 I_1$

In second case, $B_2 = \mu_0 n_2 I_2$

$$\therefore \quad \frac{B_2}{B_1} = \frac{n_2}{n_1} \times \frac{I_2}{I_1} = \frac{100}{200} \times \frac{i/3}{i} = \frac{1}{6}$$

$$\therefore \quad B_2 = \frac{B_1}{6} = \frac{6.28 \times 10^{-2}}{6} = 1.05 \times 10^{-2}\text{ Wb/m}^2$$

49. (c) : Magnetic field exerts a force = $Bev\sin\theta$ = $Bev\sin 0$ = 0

Electric field exerts force along a straight line.

The path of charged particle will be a straight line.

50. (c) : Magnet will attract N_1 strongly, N_2 weakly and repel N_3 weakly.

51. **(c) :** Magnetic field applied parallel to motion of electron exerts no force on it as $\theta = 0$ and force $= Bev\sin\theta =$ zero. Electric field opposes motion of electron which carries a negative charge

$\therefore$ velocity of electron decreases.

52. **(b) :** $T = \frac{2\pi}{\omega} = \frac{2\pi r}{v}$ ...(i)

$\because$ Centripetal force = Magnetic force

$\therefore \quad \frac{mv^2}{r} = qvB \Rightarrow v = \frac{qBr}{m}$ ...(ii)

From (i) and (ii)

$\therefore \quad T = \frac{2\pi r \times m}{qBr} = \frac{2\pi m}{qB}$

53. **(a) :** Magnetic induction at centre of one coil $B_1 = \frac{\mu_0 i_1}{2r}$

Similarly $B_2 = \frac{\mu_0 i_2}{2r}$

$$\therefore \quad B^2 = B_1^2 + B_2^2 = \left(\frac{\mu_0 i_1}{2r}\right)^2 + \left(\frac{\mu_0 i_2}{2r}\right)^2 = \frac{\mu_0^2}{4r^2}(i_1^2 + i_2^2)$$

$$\therefore \quad B = \frac{\mu_0}{2r}\sqrt{i_1^2 + i_2^2} = \frac{4\pi \times 10^{-7}}{2 \times (2\pi \times 10^{-2})}\sqrt{(3)^2 + (4)^2}$$

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

54. **(b) :** $V_{\max} = \frac{150}{2} = 75\text{ mV}$

$I_{\max} = \frac{150}{10} = 15\text{ mA} = I_g$

Resistance of galvanometer $G = 75/15 = 5\ \Omega$

For conversion into a voltmeter, a high resistance should be connected in series with the galvanometer

$$V = I_g(G + R) = \frac{15}{1000}(5 + R) \Rightarrow 150 = 15\frac{(5 + R)}{1000}$$

or $5 + R = \frac{150 \times 1000}{15} = 10000 \quad \therefore \quad R = 9995\ \Omega$

55. **(c) :** Force of attraction between wires $= \frac{\mu_0 i^2 L}{2\pi d}$.

Note: The options do not mention L, perhaps by slip.

56. **(a) :** A force and a torque act on a magnetic needle kept in a non-uniform magnetic field.

57. **(c) :** Initially, $F = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d}l$

Finally, $F' = \frac{\mu_0}{2\pi}\frac{(-2I_1)(I_2)}{3d}l \therefore \frac{F'}{F} = \frac{-\mu_0}{2\pi}\frac{2I_1I_2l}{3d} \times \frac{2\pi d}{\mu_0 I_1 I_2 l} = -\frac{2}{3}$

$\therefore \quad F' = -2F/3$

58. **(a) :** Field along axis of coil $B = \frac{\mu_0 i R^2}{2(R^2 + x^2)^{3/2}}$

At the centre of coil, $B' = \frac{\mu_0 i}{2R}$

$$\therefore \quad \frac{B'}{B} = \frac{\mu_0 i}{2R} \times \frac{2(R^2 + x^2)^{3/2}}{\mu_0 i R^2} = \frac{(R^2 + x^2)^{3/2}}{R^3}$$

$$\therefore \quad B' = \frac{B \times (R^2 + x^2)^{3/2}}{R^3} = \frac{54 \times [(3)^2 + (4)^2]^{3/2}}{(3)^3} = \frac{54 \times 125}{27}$$

or $B' = 250\ \mu$T.

59. **(b) :** Initially, r_1 = radius of coil $= l/2\pi$

$\therefore \quad B = \frac{\mu_0 i}{2r_1} = \frac{2\mu_0 i \pi}{2l}$

Finally, r_2 = radius of coil $= \frac{l}{2\pi n}$

$$\therefore \quad B' = \frac{\mu_0 i \times n}{2r_2} = \frac{n\mu_0 i \times 2\pi n}{2l} = \frac{2\mu_0 i n^2 \pi}{2l}$$

$$\therefore \quad \frac{B'}{B} = \frac{2\mu_0 i n^2 \pi}{2l} \times \frac{2l}{2\mu_0 i \pi} = n^2 \qquad \therefore B' = n^2 B$$

60. **(b) :** Magnetic field will be zero inside the straight thin walled tube according to ampere's theorem.

61. **(b) :** Materials of low retentivity and low coercivity are suitable for making electromagnets.

62. **(b) :** For a vibrating magnet, $T = 2\pi\sqrt{\frac{I}{MB}}$

where $I = ml^2/12$, $M = xl$, x = pole strength of magnet

$I' = \left(\frac{m}{3}\right)\left(\frac{l}{3}\right)^2 \times \frac{3}{12} = \frac{ml^2}{9 \times 12} = \frac{I}{9}$ (For three pieces together)

$M' = (x)\left(\frac{l}{3}\right) \times 3 = xl = M$ (For three pieces together)

$$\therefore \quad T' = 2\pi\sqrt{\frac{I'}{M'B}} = 2\pi\sqrt{\frac{I/9}{MB}} = \frac{1}{3} \times 2\pi\sqrt{\frac{I}{MB}} = \frac{T}{3}$$

$\therefore \quad T' = \frac{T}{3} = \frac{2}{3}\text{sec}$

63. **(d) :** $\frac{S}{S + G} = \frac{I_g}{I} \Rightarrow S = \frac{I_g G}{I - I_g}$

$\therefore \quad S = \frac{1 \times 0.81}{10 - 1} = \frac{0.81}{9} = 0.09\ \Omega$ in parallel.

64. **(a) :** Particle travels along x-axis. Hence $v_y = v_z = 0$

Field of induction B is along y-axis. $B_x = B_z = 0$

Electric field is along the negative z-axis.

$E_x = E_y = 0$

$\therefore$ Net force on particle $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$

Resolve the motion along the three coordinate axis

$$\therefore \quad a_x = \frac{F_x}{m} = \frac{q}{m}(E_x + v_y B_z - v_z B_y)$$

$$a_y = \frac{F_y}{m} = \frac{q}{m}(E_y + v_z B_x - v_x B_z)$$

$$a_z = \frac{F_z}{m} = \frac{q}{m}(E_z + v_x B_y - v_y B_x)$$

Since $E_x = E_y = 0$, $v_y = v_z = 0$, $B_x = B_z = 0$

$\therefore \quad a_x = a_y = 0$, $a_z = \frac{q}{m}(-E_z + v_x B_y)$

Again $a_z = 0$ as the particle traverse through the region undeflected

$\therefore \quad E_z = v_x B_y$ or $\quad B_y = \frac{E_z}{v_x} = \frac{10^4}{10} = 10^3\text{ Wb/m}^2$

65. (b) : Workdone by the field = zero.

66. (b) : For an oscillating magnet, $T = 2\pi\sqrt{\frac{I}{MB}}$
where $I = ml^2/12$, $M = xl$, x = pole strength
When the magnet is divided into 2 equal parts, the magnetic dipole moment

$$M' = \text{Pole strength} \times \text{length} = \frac{x \times l}{2} = \frac{M}{2} \quad \text{...(i)}$$

$$I' = \frac{\text{Mass} \times (\text{length})^2}{12}$$

$$= \frac{(m/2)(l/2)^2}{12} = \frac{ml^2}{12 \times 8} = \frac{I}{8} \quad \text{...(ii)}$$

$\therefore$ Time period $T' = 2\pi\sqrt{\frac{I'}{M'B}}$

$$\therefore \quad \frac{T'}{T} = \sqrt{\frac{I'}{M'} \times \frac{M}{I}} = \sqrt{\frac{I'}{I} \times \frac{M}{M'}} \quad \text{...(iii)}$$

$$\therefore \quad \frac{T'}{T} = \sqrt{\frac{1}{8} \times \frac{2}{1}} = \frac{1}{2}$$

67. (a) : A ferromagnetic material becomes paramagnetic above Curie temperature.

68. (d) : The magnetic lines of force inside a bar magnet are from south pole to north pole of magnet.

69. (a) : $W = -MB(\cos\theta_2 - \cos\theta_1)$

$$= -MB(\cos 60° - \cos 0°) = \frac{MB}{2}$$

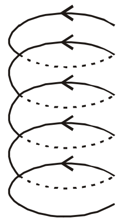
$\therefore \quad MB = 2W$ ...(i)

Torque $= MB \sin 60° = (2W) \sin 60° = \frac{2W \times \sqrt{3}}{2} = \sqrt{3}\, W$

70. (a) : $mR\omega^2 = BqR\omega \Rightarrow \omega = \frac{Bq}{m} \Rightarrow T = \frac{2\pi m}{Bq}$

T is independent of speed.

71. (b) : The spring will compress. It will be on account of force of attraction between two adjacent turns carrying currents in the same direction.



72. (a) : $Bqv = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{Bq} = \frac{p}{Bq}$

r will be same for electron and proton as p, B and q are of same magnitude.

73. (a) : $B = \frac{\mu_0}{4\pi}\frac{2\pi I}{R} = \frac{\mu_0}{2}\frac{I}{R} \quad \therefore \quad \frac{B_A}{B_B} = \frac{I_A}{I_B} \times \frac{R_B}{R_A} = \left(\frac{1}{2}\right)\left(\frac{2}{1}\right) = 1$

74. (c) : High resistance in series with a galvanometer converts it into a voltmeter.