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Moving Charges and Magnetism

TOPIC 1 Motion of Charged Particle in Magnetic Field

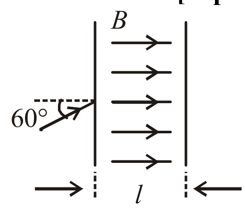
1. An electron is moving along $+x$ direction with a velocity of 6×10^6 ms^{-1}. It enters a region of uniform electric field of 300 V/cm pointing along $+y$ direction. The magnitude and direction of the magnetic field set up in this region such that the electron keeps moving along the x direction will be : **[Sep. 06, 2020 (I)]**
   (a) 3×10^{-4} T, along $+z$ direction
   (b) 5×10^{-3} T, along $-z$ direction
   (c) 5×10^{-3} T, along $+z$ direction
   (d) 3×10^{-4} T, along $-z$ direction

2. A particle of charge q and mass m is moving with a velocity $-v\hat{i}(v \neq 0)$ towards a large screen placed in the Y-Z plane at a distance d. If there is a magnetic field $\vec{B} = B_0\hat{k}$, the minimum value of v for which the particle will not hit the screen is: **[Sep. 06, 2020 (I)]**
   (a) $\frac{qdB_0}{3m}$ (b) $\frac{2qdB_0}{m}$
   (c) $\frac{qdB_0}{m}$ (d) $\frac{qdB_0}{2m}$

3. A charged particle carrying charge 1 μC is moving with velocity $(2\hat{i}+3\hat{j}+4\hat{k})$ ms^{-1}. If an external magnetic field of $(5\hat{i}+3\hat{j}-6\hat{k})\times 10^{-3}$ T exists in the region where the particle is moving then the force on the particle is $\vec{F}\times 10^{-9}$ N. The vector $\vec{F}$ is : **[Sep. 03, 2020 (I)]**
   (a) $-0.30\hat{i}+0.32\hat{j}-0.09\hat{k}$
   (b) $-30\hat{i}+32\hat{j}-9\hat{k}$
   (c) $-300\hat{i}+320\hat{j}-90\hat{k}$
   (d) $-3.0\hat{i}+3.2\hat{j}-0.9\hat{k}$

4. A beam of protons with speed 4×10^5 ms^{-1} enters a uniform magnetic field of 0.3 T at an angle of 60° to the magnetic field. The pitch of the resulting helical path of protons is close to : (Mass of the proton $= 1.67 \times 10^{-27}$ kg, charge of the proton $= 1.69 \times 10^{-19}$ C) **[Sep. 02, 2020 (I)]**
   (a) 2 cm (b) 5 cm (c) 12 cm (d) 4 cm

5. The figure shows a region of length 'l' with a uniform magnetic field of 0.3 T in it and a proton entering the region with velocity 4×10^5 ms^{-1} making an angle 60° with the field. If the proton completes 10 revolution by the time it cross the region shown, 'l' is close to (mass of proton $= 1.67 \times 10^{-27}$ kg, charge of the proton $= 1.6 \times 10^{-19}$ C) **[Sep. 02, 2020 (II)]**
   (a) 0.11 m
   (b) 0.88 m
   (c) 0.44 m
   (d) 0.22 m

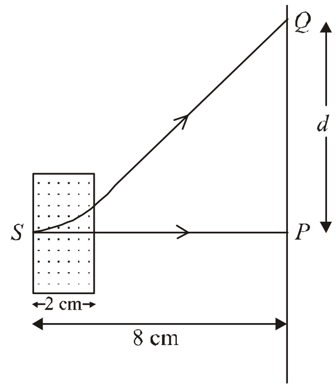


6. Proton with kinetic energy of 1 MeV moves from south to north. It gets an acceleration of 10^{12} m/s^2 by an applied magnetic field (west to east). The value of magnetic field: (Rest mass of proton is 1.6×10^{-27} kg) **[8 Jan 2020, I]**
   (a) 0.71 mT (b) 7.1 mT
   (c) 0.071 mT (d) 71 mT

7. A particle having the same charge as of electron moves in a circular path of radius 0.5 cm under the influence of a magnetic field of 0.5T. If an electric field of 100V/m makes it to move in a straight path then the mass of the particle is (Given charge of electron $= 1.6 \times 10^{-19}$C) **[12 April 2019, I]**
   (a) 9.1×10^{-31} kg (b) 1.6×10^{-27} kg
   (c) 1.6×10^{-19} kg (d) 2.0×10^{-24} kg

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

placed 8 cm away from the point S. The distance d between P and Q (on the screen) is :
(Electron's charge = 1.6×10^{-19} C, mass of electron = 9.1×10^{-31} kg) **[12 April 2019, II]**



(a) 11.65 cm (b) 12.87 cm
(c) 1.22 cm (d) 2.25 cm

9. A proton, an electron, and a Helium nucleus, have the same energy. They are in circular orbits in a plane due to magnetic field perpendicular to the plane. Let r_p, r_e and r_{He} be their respective radii, then, **[10 April 2019, I]**
(a) $r_e > r_p = r_{He}$ (b) $r_e < r_p = r_{He}$
(c) $r_e < r_p < r_{He}$ (d) $r_e > r_p > r_{He}$

10. A proton and an α-particle (with their masses in the ratio of 1 : 4 and charges in the ratio 1 : 2) are accelerated from rest through a potential difference V. If a uniform magnetic field (B) is set up perpendicular to their velocities, the ratio of the radii $r_p : r_\alpha$ of the circular paths descrfibed by them will be: **[12 Jan 2019, I]**
(a) $1:\sqrt{2}$ (b) $1:2$ (c) $1:3$ (d) $1:\sqrt{3}$

11. In an experiment, electrons are accelerated, from rest, by applying a voltage of 500 V. Calculate the radius of the path if a magnetic field 100 mT is then applied.
[Charge of the electron = 1.6×10^{-19} C
Mass of the electron = 9.1×10^{-31} kg] **[11 Jan 2019, I]**
(a) 7.5×10^{-3} m (b) 7.5×10^{-2} m
(c) 7.5 m (d) 7.5×10^{-4} m

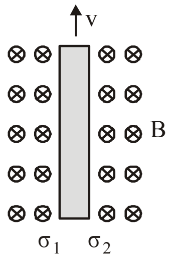
12. The region between $y = 0$ and $y = d$ contains a magnetic field $\vec{B} = B\hat{z}$. A particle of mass m and charge q enters the region with a velocity $\vec{v} = v\hat{i}$. if $d = \frac{mv}{2qB}$, the acceleration of the charged particle at the point of its emergence at the other side is : **[11 Jan 2019, II]**
(a) $\frac{qvB}{m}\left(\frac{1}{2}\hat{i} - \frac{\sqrt{3}}{2}\hat{j}\right)$ (b) $\frac{qvB}{m}\left(\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\right)$
(c) $\frac{qvB}{m}\left(\frac{-\hat{j}+\hat{i}}{\sqrt{2}}\right)$ (d) $\frac{qvB}{m}\left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

13. An electron, a proton and an alpha particle having the same kinetic energy are moving in circular orbits of radii r_e, r_p, r_α respectively in a uniform magnetic field B. The relation between r_e, r_p, r_α is : **[2018]**
(a) $r_e > r_p = r_\alpha$ (b) $r_e < r_p = r_\alpha$
(c) $r_e < r_p < r_\alpha$ (d) $r_e < r_\alpha < r_p$

14. 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 : **[Online April 9, 2017]**
(a) away from the wire
(b) towards the wire
(c) parallel to the wire along the current
(d) parallel to the wire opposite to the current

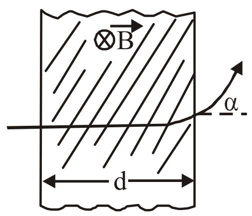
15. In a certain region static electric and magnetic fields exist. The magnetic field is given by $\vec{B} = B_0(\hat{i} + 2\hat{j} - 4\hat{k})$. If a test charge moving with a velocity $\vec{v} = v_0(3\hat{i} - \hat{j} + 2\hat{k})$ experiences no force in that region, then the electric field in the region, in SI units, is : **[Online April 8, 2017]**
(a) $\vec{E} = -v_0B_0(3\hat{i} - 2\hat{j} - 4\hat{k})$ (b) $\vec{E} = -v_0B_0(\hat{i} + \hat{j} + 7\hat{k})$
(c) $\vec{E} = v_0B_0(14\hat{j} + 7\hat{k})$ (d) $\vec{E} = -v_0B_0(14\hat{j} + 7\hat{k})$

16. 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): **[Online April 10, 2016]**



(a) $\sigma_1 = \frac{-\epsilon_0 vB}{2}, \sigma_2 = \frac{\epsilon_0 vB}{2}$
(b) $\sigma_1 = \epsilon_0 vB, \sigma_2 = -\epsilon_0 vB$
(c) $\sigma_1 = \frac{\epsilon_0 vB}{2}, \sigma_2 = \frac{-\epsilon_0 vB}{2}$
(d) $\sigma_1 = \sigma_2 = \epsilon_0 vB$

17. 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 : **[Online April 10, 2015]**



(a) $qV\sqrt{\frac{Bd}{2m}}$ (b) $\frac{B}{2}\sqrt{\frac{qd}{mV}}$
(c) $\frac{B}{d}\sqrt{\frac{q}{2mV}}$ (d) $Bd\sqrt{\frac{q}{2mV}}$

18. A positive charge 'q' of mass 'm' is moving along the + x axis. We wish to apply a uniform magnetic field B for time Δt so that the charge reverses its direction crossing the y axis at a distance d. Then: **[Online April 12, 2014]**

(a) $B = \frac{mv}{qd}$ and $\Delta t = \frac{\pi d}{v}$ (b) $B = \frac{mv}{2qd}$ and $\Delta t = \frac{\pi d}{2v}$

(c) $B = \frac{2mv}{qd}$ and $\Delta t = \frac{\pi d}{2v}$ (d) $B = \frac{2mv}{qd}$ and $\Delta t = \frac{\pi d}{v}$

19. A particle of charge 16×10^{-16} C moving with velocity 10 ms^{-1} along x-axis enters a region where magnetic field of induction $\vec{B}$ is along the y-axis and an electric field of magnitude 10^4 Vm^{-1} is along the negative z-axis. If the charged particle continues moving along x-axis, the magnitude of $\vec{B}$ is : **[Online April 23, 2013]**

(a) 16×10^3 Wb m^{-2} (b) 2×10^3 Wb m^{-2}
(c) 1×10^3 Wb m^{-2} (d) 4×10^3 Wb m^{-2}

20. Proton, deuteron and alpha particle of 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? **[2012]**

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

21. This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.
Statement 1: A charged particle is moving at right angle to a static magnetic field. During the motion the kinetic energy of the charge remains unchanged.
Statement 2: Static magnetic field exert force on a moving charge in the direction perpendicular to the magnetic field. **[Online May 26, 2012]**

(a) Statement 1 is false, Statement 2 is true.
(b) Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1.
(c) Statement 1 is true, Statement 2 is false.
(d) Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation of Statement 1.

22. A proton and a deuteron are both accelerated through the same potential difference and enter in a magnetic field perpendicular to the direction of the field. If the deuteron follows a path of radius R, assuming the neutron and proton masses are nearly equal, the radius of the proton's path will be **[Online May 19, 2012]**

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

23. The magnetic force acting on charged particle of charge 2 μC in magnetic field of 2 T acting in y-direction, when the particle velocity is $\left(2\hat{i} + 3\hat{j}\right) \times 10^6\ \text{ms}^{-1}$ is **[Online May 12, 2012]**

(a) 8 N in z-direction (b) 8 N in y-direction
(c) 4 N in y-direction (d) 4 N in z-direction

24. The velocity of certain ions that pass undeflected through crossed electric field E = 7.7 k V/m and magnetic field B = 0.14 T is **[Online May 7, 2012]**

(a) 18 km/s (b) 77 km/s
(c) 55 km/s (d) 1078 km/s

25. An electric charge $+q$ moves with velocity $\vec{v} = 3\hat{i} + 4\hat{j} + \hat{k}$ in an electromagnetic field given by $\vec{E} = 3\hat{i} + \hat{j} + 2\hat{k}$ and $\vec{B} = \hat{i} + \hat{j} - 3\hat{k}$ The y - component of the force experienced by $+q$ is : **[2011 RS]**

(a) $11q$ (b) $5q$ (c) $3q$ (d) $2q$

26. 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 **[2007]**

(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) $\vec{v} = \vec{E} \times \vec{B} / E^2$

27. A charged particle moves through a magnetic field perpendicular to its direction. Then **[2007]**

(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

28. 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 **[2006]**

(a) helix (b) straight line
(c) ellipse (d) circle

29. 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 **[2005]**

(a) $\frac{2\pi q^2 B}{m}$ (b) $\frac{2\pi mq}{B}$ (c) $\frac{2\pi m}{qB}$ (d) $\frac{2\pi qB}{m}$

30. 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 **[2005]**

(a) its velocity will increase
(b) Its velocity will decrease
(c) it will turn towards left of direction of motion
(d) it will turn towards right of direction of motion

31. A particle of mass M and charge Q moving with velocity $\vec{v}$ describe 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 **[2003]**

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

(c) $BQ2\pi R$ (d) $BQv2\pi R$

32. If an electron and a proton having same momenta enter perpendicular to a magnetic field, then **[2002]**

(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.

33. The time period of a charged particle undergoing a circular motion in a uniform magnetic field is independent of its

(a) speed (b) mass **[2002]**

(c) charge (d) magnetic induction

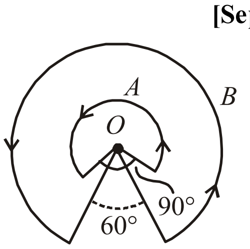
TOPIC 2 Magnetic Field Lines, Biot-Savart's Law and Ampere's Circuital

34. A charged particle going around in a circle can be considered to be a current loop. A particle of mass m carrying charge q is moving in a plane wit speed v under the influence of magnetic field $\vec{B}$. The magnetic moment of this moving particle : **[Sep. 06, 2020 (II)]**

(a) $\frac{mv^2 \vec{B}}{2B^2}$ (b) $-\frac{mv^2 \vec{B}}{2\pi B^2}$

(c) $-\frac{mv^2 \vec{B}}{B^2}$ (d) $-\frac{mv^2 \vec{B}}{2B^2}$

35. A wire A, bent in the shape of an arc of a circle, carrying a current of 2 A and having radius 2 cm and another wire B, also bent in the shape of arc of a circle, carrying a current of 3 A and having radius of 4 cm, are placed as shown in the figure. The ratio of the magnetic fields due to the wires A and B at the common centre O is : **[Sep. 04, 2020 (I)]**



(a) $4:6$ (b) $6:4$

(c) $2:5$ (d) $6:5$

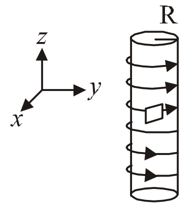
36. Magnitude of magnetic field (in SI units) at the centre of a hexagonal shape coil of side 10 cm, 50 turns and carrying current I (Ampere) in units of $\frac{\mu_0 I}{\pi}$ is : **[Sep. 03, 2020 (I)]**

(a) $250\sqrt{3}$ (b) $50\sqrt{3}$ (c) $500\sqrt{3}$ (d) $5\sqrt{3}$

37. A long, straight wire of radius a carries a current distributed uniformly over its cross-section. The ratio of the magnetic fields due to the wire at distance $\frac{a}{3}$ and $2a$, respectively from the axis of the wire is: **[9 Jan 2020, I]**

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

38. An electron gun is placed inside a long solenoid of radius R on its axis. The solenoid has n turns/length and carries a current I. The electron gun shoots an electron along the radius of the solenoid with speed v. If the electron does not hit the surface of the solenoid, maximum possible value of v is (all symbols have their standard meaning): **[9 Jan 2020, II]**

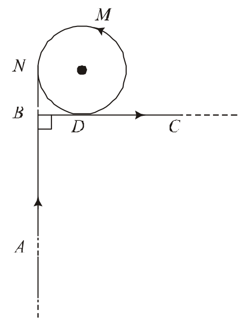


(a) $\frac{e\mu_0 n\text{IR}}{m}$ (b) $\frac{e\mu_0 n\text{IR}}{2m}$

(c) $\frac{e\mu_0 n\text{IR}}{4m}$ (d) $\frac{2e\mu_0 n\text{IR}}{m}$

39. A very long wire $ABDMNDC$ is shown in figure carrying current I. AB and BC parts are straight, long and at right angle. At D wire forms a circular turn $DMND$ of radius R.

AB, BC parts are tangential to circular turn at N and D. Magnetic field at the centre of circle is: **[8 Jan 2020, II]**



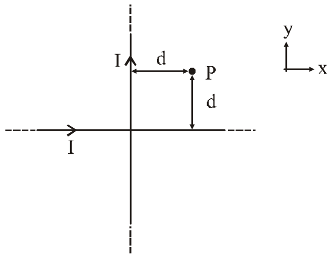
(a) $\frac{\mu_0 I}{2\pi R}\left(\pi+\frac{1}{\sqrt{2}}\right)$

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

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

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

40. Two very long, straight, and insulated wires are kept at 90° angle from each other in xy-plane as shown in the figure.



These wires carry currents of equal magnitude I, whose directions are shown in the figure. The net magnetic field at point P will be : **[12 April 2019, I]**

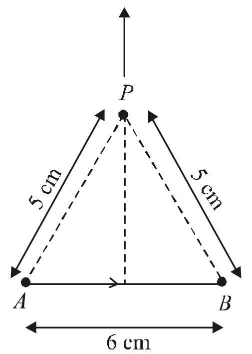
(a) Zero (b) $-\frac{\mu_0 I}{2\pi d}(\hat{x}+\hat{y})$

(c) $\frac{+\mu_0 I}{\pi d}(\hat{z})$ (d) $\frac{\mu_0 I}{2\pi d}(\hat{x}+\hat{y})$

41. A thin ring of 10 cm radius carries a uniformly distributed charge. The ring rotates at a constant angular speed of 40 À rad s^{-1} about its axis, perpendicular to its plane. If the magnetic field at its centre is 3.8×10^{-9} T, then the charge carried by the ring is close to ($\mu_0 = 4\pi \times 10^{-7}$ N/A^2). **[12 April 2019, I]**

(a) 2×10^{-6}C (b) 3×10^{-5}C (c) 4×10^{-5}C (d) 7×10^{-6}C

42. Find the magnetic field at point P due to a straight line segment AB of length 6 cm carrying a current of 5 A. (See figure) ($\mu_o=4\pi\times10^{-7}$ N-A^{-2}) **[12 April 2019, II]**



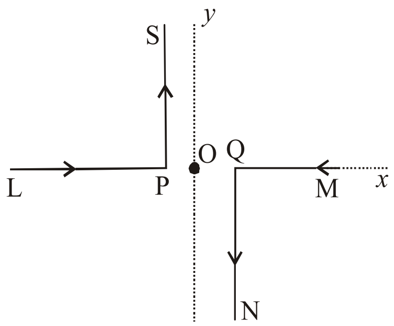
(a) 2.0×10^{-5}T (b) 1.5×10^{-5}T
(c) 3.0×10^{-5}T (d) 2.5×10^{-5}T

43. The magnitude of the magnetic field at the center of an equilateral triangular loop of side 1 m which is carrying a current of 10 A is : **[10 April 2019, II]**
[Take $\mu_o = 4\pi\times10^{-7}$ NA^{-2}]
(a) 18 μT (b) 9 μT (c) 3 μT (d) 1 μT

44. A square loop is carrying a steady current I and the magnitude of its magnetic dipole moment is m. If this square loop is changed to a circular loop and it carries the same current, the magnitude of the magnetic dipole moment of circular loop will be : **[10 April 2019, II]**

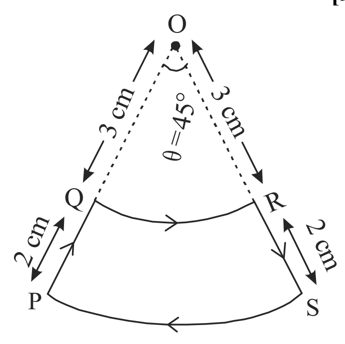
(a) $\frac{m}{\pi}$ (b) $\frac{3m}{\pi}$ (c) $\frac{2m}{\pi}$ (d) $\frac{4m}{\pi}$

45. As shown in the figure, two infinitely long, identical wires are bent by 90° and placed in such a way that the segments LP and QM are along the x-axis, while segments PS and QN are parallel to the y-axis. If OP = OQ = 4 cm, and the magnitude of the magneticf field at O is 10^{-4} T, and the two wires carry equal currents (see figure), the magnitude of the current in each wire and the direction of the magnetic field at O will be ($\mu_0 = 4\pi \times 10^{-7}$ NA^{-2}): **[12 Jan 2019, I]**



(a) 20 A, perpendicular out of the page
(b) 40 A, perpendicular out of the page
(c) 20 A, perpendicular into the page
(d) 40 A, perpendicular into the page

46. A current loop, having two circular arcs joined by two radial lines is shown in the figure. It carries a current of 10 A. The magnetic field at point O will be close to: **[9 Jan. 2019 I]**



i = 10A

(a) 1.0×10^{-7} T (b) 1.5×10^{-7} T
(c) 1.5×10^{-5} T (d) 1.0×10^{-5} T

47. One of the two identical conducting wires of length L is bent in the form of a circular loop and the other one into a circular coil of N identical turns. If the same current is passed in both, the ratio of the magnetic field at the central of the loop (B_l) to that at the centre of the coil (B_C), *i.e.*, $\frac{B_L}{B_C}$ will be: **[9 Jan 2019, II]**

(a) N (b) $\frac{1}{N}$

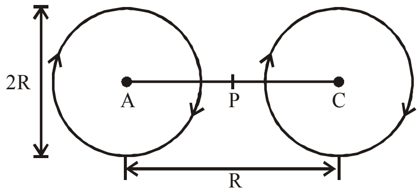
(c) N^2 (d) $\frac{1}{N^2}$

48. 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

current constant, the magnetic field at the centre of the loop is B_2. The ratio $\frac{B_1}{B_2}$ is: **[2018]**

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

49. A Helmholtz coil has 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 figure): **[Online April 15, 2018]**



(a) $\frac{4N\mu_0 I}{5^{3/2}R}$ (b) $\frac{8N\mu_0 I}{5^{3/2}R}$ (c) $\frac{4N\mu_0 I}{5^{1/2}R}$ (d) $\frac{8N\mu_0 I}{5^{1/2}R}$

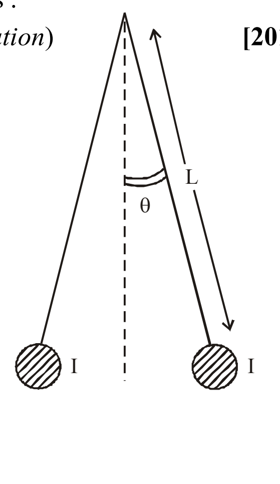
50. A current of 1A is flowing on the sides of an equilateral triangle of side 4.5×10^{-2}m . The magnetic field at the centre of the triangle will be: **[Online April 15, 2018]**

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

51. 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 $\frac{B_A}{B_B}$ is: **[2016]**

(a) $\frac{\pi^2}{16}$ (b) $\frac{\pi^2}{8\sqrt{2}}$ (c) $\frac{\pi^2}{8}$ (d) $\frac{\pi^2}{16\sqrt{2}}$

52. 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*) **[2015]**



(a) $2\sqrt{\frac{\pi gL}{\mu_0}\tan\theta}$

(b) $\sqrt{\frac{\pi\lambda gL}{\mu_0}\tan\theta}$

(c) $\sin\theta\sqrt{\frac{\pi\lambda gL}{\mu_0\cos\theta}}$

(d) $2\sin\theta\sqrt{\frac{\pi\lambda gL}{\mu_0\cos\theta}}$

53. Consider two thin identical conducting wires covered with very thin insulating material. One of the wires is bent into a loop and produces magnetic field B_1, at its centre when a current I passes through it. The ratio B_1 : B_2 is: **[Online April 12, 2014]**

(a) 1 : 1 (b) 1 : 3 (c) 1 : 9 (d) 9 : 1

54. A parallel plate capacitor of area 60 cm^2 and separation 3 mm is charged initially to 90 μC. If the medium between the plate gets slightly conducting and the plate loses the charge initially at the rate of 2.5×10^{-8} C/s, then what is the magnetic field between the plates ? **[Online April 23, 2013]**

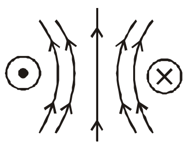
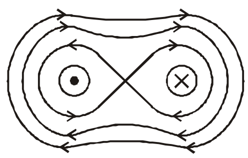
(a) 2.5×10^{-8}T (b) 2.0×10^{-7}T
(c) 1.63×10^{-11}T (d) Zero

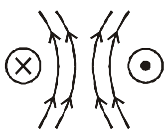
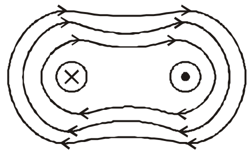
55. A current i is flowing in a straight conductor of length L. The magnetic induction at a point on its axis at a distance $\frac{L}{4}$ from its centre will be : **[Online April 22, 2013]**

(a) Zero (b) $\frac{\mu_0 i}{2\pi L}$

(c) $\frac{\mu_0 i}{\sqrt{2}L}$ (d) $\frac{4\mu_0 i}{\sqrt{5}\pi L}$

56. Choose the correct sketch of the magnetic field lines of a circular current loop shown by the dot ⊙ and the cross ⊗. **[Online April 22, 2013]**

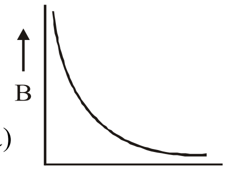
(a)  (b) 

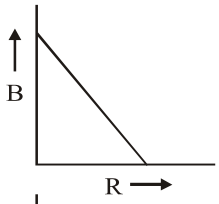
(c)  (d) 

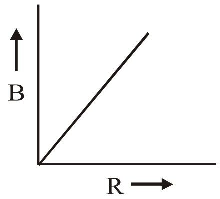
57. An electric current is flowing through a circular coil of radius R. The ratio of the magnetic field at the centre of the coil and that at a distance $2\sqrt{2}R$ from the centre of the coil and on its axis is : **[Online April 9, 2013]**

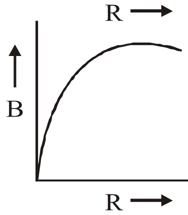
(a) $2\sqrt{2}$ (b) 27 (c) 36 (d) 8

58. 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 : **[2012]**

(a) 

(b) 

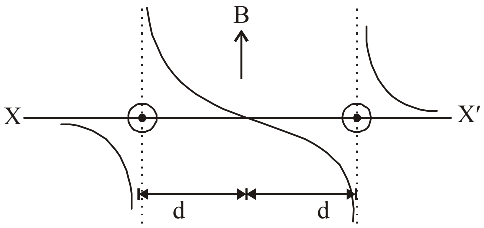
(c) 

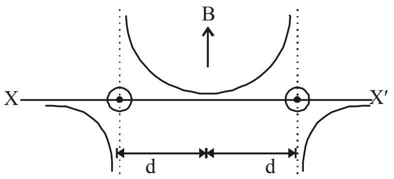
(d) 

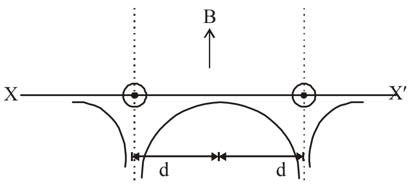
59. A current I flows in an infinitely long wire with cross section in the form of a semi-circular ring of radius R. The magnitude of the magnetic induction along its axis is: **[2011]**

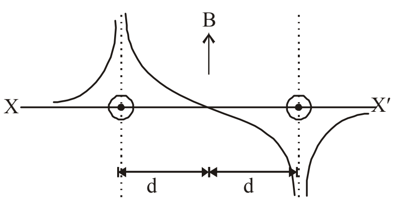
(a) $\frac{\mu_0 I}{2\pi^2 R}$ (b) $\frac{\mu_0 I}{2\pi R}$ (c) $\frac{\mu_0 I}{4\pi R}$ (d) $\frac{\mu_0 I}{\pi^2 R}$

60. 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 **[2010]**

(a) 

(b) 

(c) 

(d) 

61. A horizontal overhead powerline is at height of 4m from the ground and carries a current of 100A from east to west. The magnetic field directly below it on the ground is ($\mu_0 = 4\pi\times10^{-7}$ Tm A^{-1}) **[2008]**

(a) 2.5×10^{-7} T southward
(b) 5×10^{-6} T northward
(c) 5×10^{-6} T southward
(d) 2.5×10^{-7} T northward

62. 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 **[2007]**

(a) 1/2 (b) 1/4 (c) 4 (d) 1

63. A current I flows along the length of an infinitely long, straight, thin walled pipe. Then **[2007]**

(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

64. 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 **[2007]**

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

(c) $\frac{\mu_0}{2\pi d}\left(I_1^2 + I_2^2\right)^{\frac{1}{2}}$ (d) $\frac{\mu_0}{2\pi d}(I_1 + I_2)$

65. 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 $\frac{i}{3}$. The value of the magnetic field at its centre is **[2006]**

(a) 1.05×10^{-2} Weber/m^2 (b) 1.05×10^{-5} Weber/m^2
(c) 1.05×10^{-3} Weber/m^2 (d) 1.05×10^{-4} Weber/m^2

66. 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 centre of the coils will be $(\mu_0 = 4\pi\times10^{-7}\,\mathrm{Wb/A.m})$ **[2005]**

(a) 10^{-5} (b) 12×10^{-5}
(c) 7×10^{-5} (d) 5×10^{-5}

67. A current i ampere flows along an infinitely long straight thin walled tube, then the magnetic induction at any point inside the tube is **[2004]**

(a) $\frac{\mu_0}{4\pi}.\frac{2i}{r}$ tesla (b) zero
(c) infinite (d) $\frac{2i}{r}$ tesla

68. 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 **[2004]**

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

69. 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 loop? **[2004]**

(a) 125 μT (b) 150 μT (c) 250 μT (d) 75 μT

70. 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 **[2002]**

(a) 1 (b) 2 (c) 1/2 (d) 4

TOPIC 3 Force and Torque on Current Carrying Conductor

71. A square loop of side $2a$ and carrying current I is kept is xz plane with its centre at origin. A long wire carrying the same current I is placed parallel to z-axis and passing through point $(0, b, 0)$, $(b >> a)$. The magnitude of torque on the loop about z-axis will be : **[Sep. 06, 2020 (II)]**

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

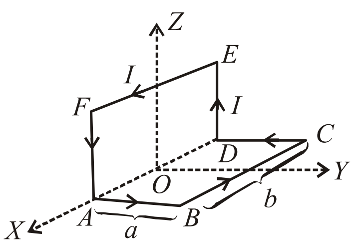
(c) $\dfrac{\mu_0 I^2 a^2 b}{2\pi(a^2+b^2)}$ (d) $\dfrac{\mu_0 I^2 a^2}{2\pi b}$

72. A square loop of side $2a$, and carrying current I, is kept in XZ plane with its centre at origin. A long wire carrying the same current I is placed parallel to the z-axis and passing through the point $(0, b, 0)$, $(b >> a)$. The magnitude of the torque on the loop about z-axis is given by : **[Sep. 05, 2020 (I)]**

(a) $\dfrac{\mu_0 I^2 a^2}{2\pi b}$ (b) $\dfrac{\mu_0 I^2 a^3}{2\pi b^2}$

(c) $\dfrac{2\mu_0 I^2 a^2}{\pi b}$ (d) $\dfrac{2\mu_0 I^2 a^3}{\pi b^2}$

73. A wire carrying current I is bent in the shape $ABCDEFA$ as shown, where rectangle $ABCDA$ and $ADEFA$ are perpendicular to each other. If the sides of the rectangles are of lengths a and b, then the magnitude and direction of magnetic moment of the loop $ABCDEFA$ is : **[Sep. 02, 2020 (II)]**



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

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

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

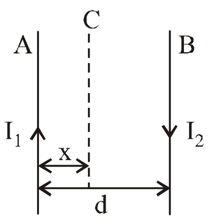
(d) abI, along $\left(\dfrac{\hat{j}}{\sqrt{5}}+\dfrac{2\hat{k}}{\sqrt{5}}\right)$

74. A small circular loop of conducting wire has radius a and carries current I. It is placed in a uniform magnetic field B perpendicular to its plane such that when rotated slightly about its diameter and released, it starts performing simple harmonic motion of time period T. If the mass of the loop is m then : **[9 Jan 2020, II]**

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

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

75. Two wires A & B are carrying currents I_1 and I_2 as shown in the figure. The separation between them is d. A third wire C carrying a current I is to be kept parallel to them at a distance x from A such that the net force acting on it is zero. The possible values of x are : **[10 April 2019, I]**



(a) $x=\left(\dfrac{I_1}{I_1-I_2}\right)d$ and $x=\dfrac{I_2}{(I_1+I_2)}d$

(b) $x=\left(\dfrac{I_2}{(I_1+I_2)}\right)d$ and $x=\left(\dfrac{I_2}{(I_1-I_2)}\right)d$

(c) $x=\left(\dfrac{I_1}{(I_1+I_2)}\right)d$ and $x=\left(\dfrac{I_2}{(I_1-I_2)}\right)d$

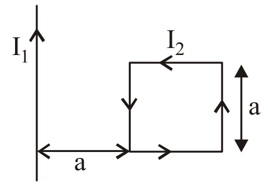
(d) $x=\pm\dfrac{I_1 d}{(I_1-I_2)}$

76. A rectangular coil (Dimension 5 cm × 2.5 cm) with 100 turns, carrying a current of 3 A in the clock-wise direction, is kept centered at the origin and in the X-Z plane. A magnetic field of 1 T is applied along X-axis. If the coil is tilted through 45° about Z-axis, then the torque on the coil is: **[9 April 2019 I]**

(a) 0.38 Nm (b) 0.55 Nm

(c) 0.42 Nm (d) 0.27 Nm

77. A rigid square of loop of side 'a' and carrying current I_2 is lying on a horizontal surface near a long current I_1 carrying wire in the same plane as shown in figure. The net force on the loop due to the wire will be: **[9 April 2019 I]**



(a) Repulsive and equal to $\frac{\mu_o I_1 I_2}{2\pi}$

(b) Attractive and equal to $\frac{\mu_o I_1 I_2}{3\pi}$

(c) Repulsive and equal to $\frac{\mu_o I_1 I_2}{4\pi}$

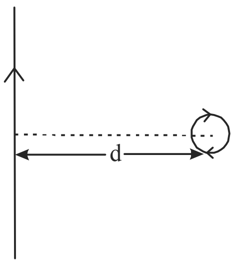
(d) Zero

78. A circular coil having N turns and radius r carries a current I. It is held in the XZ plane in a magnetic field B. The torque on the coil due to the magnetic field is : **[8 April 2019 I]**

(a) $\frac{Br^2I}{\pi N}$ (b) $B\pi r^2 IN$

(c) $\frac{B\pi r^2 I}{N}$ (d) Zero

79. An infinitely long current carrying wire and a small current carrying loop are in the plane of the paper as shown. The redius of the loop is a and distance of its centre from the wire is d (d>>a). If the loop applies a force F on the wire then: **[9 Jan. 2019 I]**



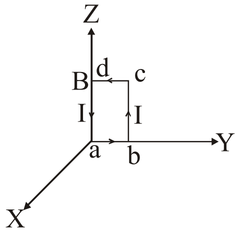
(a) F = 0 (b) $F \propto \left(\frac{a}{d}\right)$

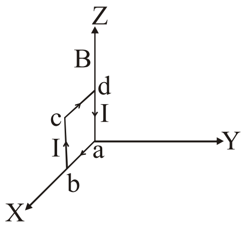
(c) $F \propto \left(\frac{a^2}{d^3}\right)$ (d) $F \propto \left(\frac{a}{d}\right)^2$

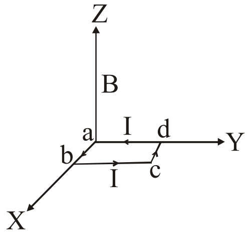
80. A charge q is spread uniformly over an insulated loop of radius r . If it is rotated with an angular velocity ω with respect to normal axis then the magnetic moment of the loop is **[Online April 16, 2018]**

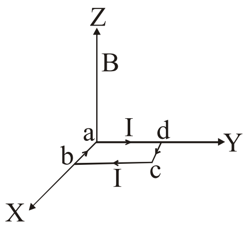
(a) $\frac{1}{2}q\omega r^2$ (b) $\frac{4}{3}q\omega r^2$ (c) $\frac{3}{2}q\omega r^2$ (d) $q\omega r^2$

81. 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 1 of 12 A. Out of the following different orientations which one corresponds to stable equilibrium? **[Online April 9, 2017]**

(a) 

(b) 

(c) 

(d) 

82. Two coaxial solenoids of different radius carry current I in the same direction. $\vec{F_1}$ be the magnetic force on the inner solenoid due to the outer one and $\vec{F_2}$ be the magnetic force on the outer solenoid due to the inner one. Then : **[2015]**

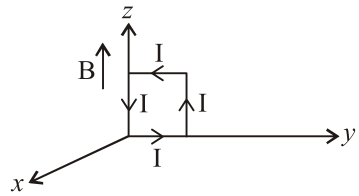
(a) $\vec{F_1}$ is radially inwards and $\vec{F_2} = 0$

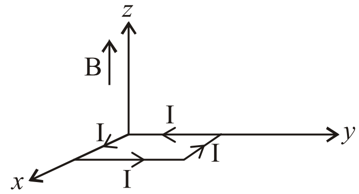
(b) $\vec{F_1}$ is radially outwards and $\vec{F_2} = 0$

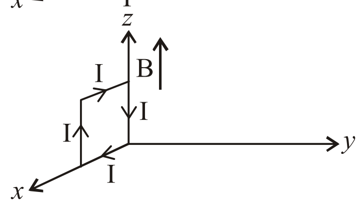
(c) $\vec{F_1} = \vec{F_2} = 0$

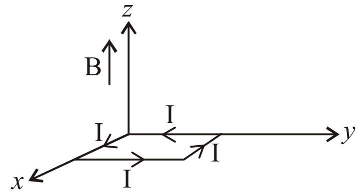
(d) $\vec{F_1}$ is radially inwards and $\vec{F_2}$ is radially outwards

83. A rectangular loop of sides 10 cm and 5 cm carrying a current 1 of 12 A is placed in different orientations as shown in the figures below :

(A) 

(B) 

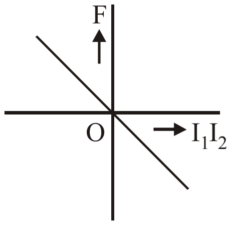
(C) 

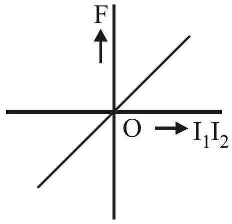
(D) 

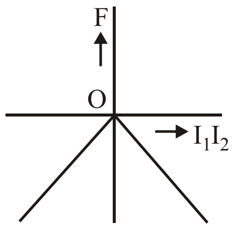
If there is a uniform magnetic field of 0.3 T in the positive z direction, in which orientations the loop would be in (i) stable equilibrium and (ii) unstable equilibrium ? **[2015]**

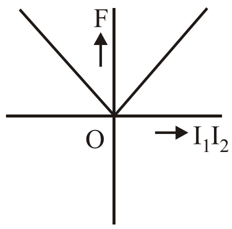
(a) (B) and (D), respectively
(b) (B) and (C), respectively
(c) (A) and (B), respectively
(d) (A) and (C), respectively

84. Two long straight parallel wires, carrying (adjustable) current 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 $I_1 I_2$, would be : **[Online April 11, 2015]**

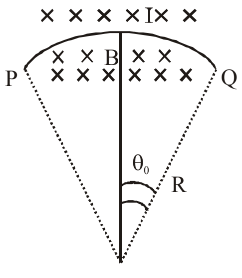
(a)


(b)


(c)


(d)


85. A wire carrying current I is tied between points P and Q and is in the shape of a circular arc of radius R due to a uniform magnetic field B (perpendicular to the plane of the paper, shown by xxx) 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 arc) then the tension in the wire is : **[Online April 11, 2015]**



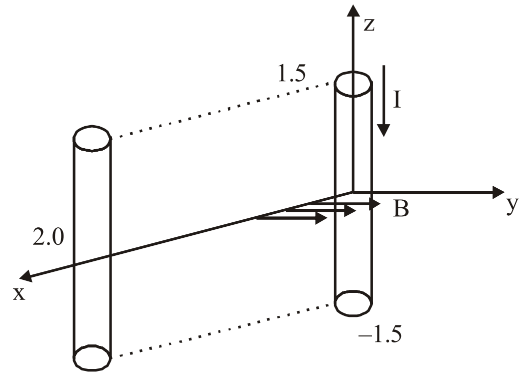
(a) $\dfrac{IBR}{2\sin\theta_0}$

(b) $\dfrac{IBR\theta_0}{\sin\theta_0}$

(c) IBR

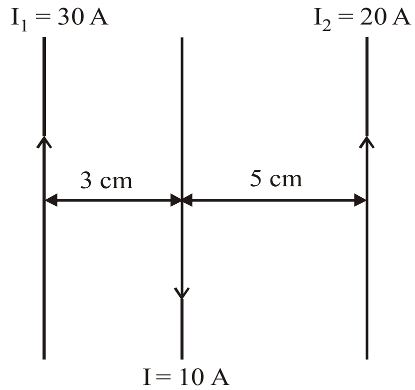
(d) $\dfrac{IBR}{\sin\theta_0}$

86. 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 $\vec{B} = 3.0\times10^{-4} e^{-0.2x}\ \hat{a}_y$ 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. **[2014]**



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

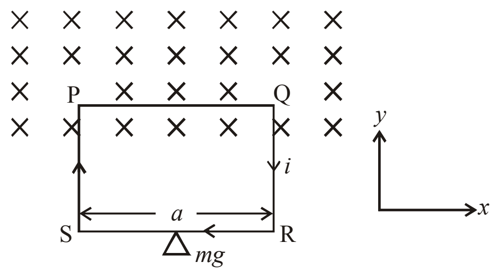
87. Three straight parallel current carrying conductors are shown in the figure. The force experienced by the middle conductor of length 25 cm is: **[Online April 11, 2014]**



(a) 3×10^{-4} N toward right
(b) 6×10^{-4} N toward right
(c) 9×10^{-4} N toward right
(d) Zero

88. A rectangular loop of wire, supporting a mass *m*, hangs with one end in a uniform magnetic field $\vec{B}$ pointing out of the plane of the paper. A clockwise current is set up such that $i > mg/Ba$, where *a* is the width of the loop. Then :

[Online April 23, 2013]



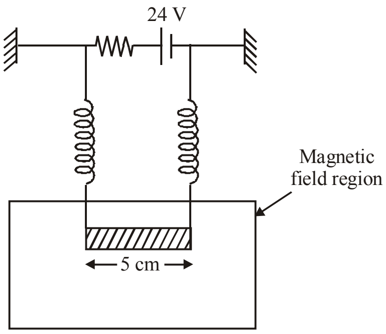
(a) The weight rises due to a vertical force caused by the magnetic field and work is done on the system.
(b) The weight do not rise due to vertical for caused by the magnetic field and work is done on the system.

(c) The weight rises due to a vertical force caused by the magnetic field but no work is done on the system.
(d) The weight rises due to a vertical force caused by the magnetic field and work is extracted from the magnetic field.

89. Currents of a 10 ampere and 2 ampere are passed through two parallel thin wires *A* and *B* respectively in opposite directions. Wire *A* is infinitely long and the length of the wire *B* is 2 m. The force acting on the conductor *B*, which is situated at 10 cm distance from *A* will be **[Online May 26, 2012]**

(a) 8×10^{-5} N (b) 5×10^{-5} N
(c) $8\pi \times 10^{-7}$ N (d) $4\pi \times 10^{-7}$ N

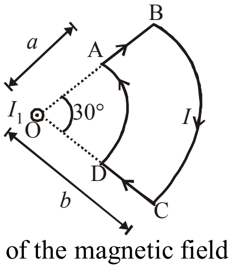
90. The circuit in figure consists of wires at the top and bottom and identical springs as the left and right sides. The wire at the bottom has a mass of 10 g and is 5 cm long. The wire is hanging as shown in the figure. The springs stretch 0.5 cm under the weight of the wire and the circuit has a total resistance of 12 Ω. When the lower wire is subjected to a static magnetic field, the springs, stretch an additional 0.3 cm. The magnetic field is **[Online May 12, 2012]**



(a) 0.6 T and directed out of page
(b) 1.2 T and directed into the plane of page
(c) 0.6 T and directed into the plane of page
(d) 1.2 T and directed out of page

Directions : *Question numbers 91 and 92 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. **[2009]**



91. The magnitude of the magnetic field (*B*) due to the loop *ABCD* at the origin (*O*) is :

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

(b) $\dfrac{\mu_o I}{4\pi}\left[\dfrac{b-a}{ab}\right]$

(c) $\dfrac{m_o I}{4p}[2(b- a)+p/3(a+b)]$

(d) zero

92. Due to the presence of the current I_1 at the origin:

(a) The forces on *AD* and *BC* are zero.
(b) The magnitude of the net force on the loop is given by $\dfrac{I_1 I}{4p} m_o[2(b- a)+p/3(a+b]$.
(c) The magnitude of the net force on the loop is given by $\dfrac{\mu_o I I_1}{24ab}(b-a)$.
(d) The forces on *AB* and *DC* are zero.

93. 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 3*d*. The new value of the force between them is **[2004]**

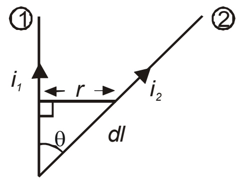
(a) $-\dfrac{2F}{3}$ (b) $\dfrac{F}{3}$ (c) $-2F$ (d) $-\dfrac{F}{3}$

94. If a current is passed through a spring then the spring will **[2002]**

(a) expand (b) compress
(c) remains same (d) none of these

95. Wires 1 and 2 carrying currents i_1 and i_2 respectively are inclined at an angle θ to each other. What is the force on a small element *dl* of wire 2 at a distance of *r* from wire 1 (as shown in figure) due to the magnetic field of wire 1? **[2002]**

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



TOPIC 4 Galvanometer and its Conversion into Ammeter and Voltmeter

96. A galvanometer of resistance G is converted into a voltmeter of ragne 0 – 1V by connecting a resistance R_1 in series with it. The additional resistance R_1 in series with it. The additional resistance that should be connected in series with R_1 to increase the range of the voltmeter to 0 – 2V will be : **[Sep. 05, 2020 (I)]**

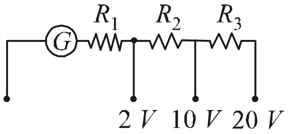
(a) G (b) R_1
(c) $R_1 - G$ (d) $R_1 + G$

97. A galvanometer is used in laboratory for detecting the null point in electrical experiments. If, on passing a current of 6 mA it produces a deflection of 2°, its figure of merit is close to : **[Sep. 05, 2020 (II)]**

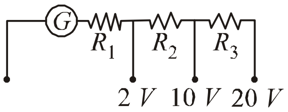
(a) 333° A/div. (b) 6×10^{-3} A/div.
(c) 666° A/div. (d) 3×10^{-3} A/div.

98. A galvanometer coil has 500 turns and each turn has an average area of 3×10^{-4} m^2. If a torque of 1.5 Nm is required to keep this coil parallel to a magnetic field when a current of 0.5 A is flowing through it, the strength of the field (in T) is __________. **[NA Sep. 03, 2020 (II)]**

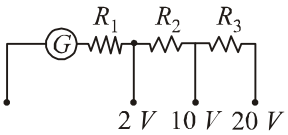
99. A galvanometer of resistance 100 Ω has 50 divisions on its scale and has sensitivity of 20 μA/division. It is to be converted to a voltmeter with three ranges, of 0–2V, 0–10 V and 0–20 V. The appropriate circuit to do so is : **[12 April 2019, I]**

(a) 

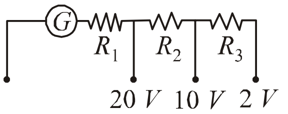
$R_1 = 2000\ \Omega$
$R_2 = 8000\ \Omega$
$R_3 = 10000\ \Omega$

(b) 

$R_1 = 1900\ \Omega$
$R_2 = 9900\ \Omega$
$R_3 = 19900\ \Omega$

(c) 

$R_1 = 1900\ \Omega$
$R_2 = 8000\ \Omega$
$R_3 = 10000\ \Omega$

(d) 

$R_1 = 19900\ \Omega$
$R_2 = 9900\ \Omega$
$R_3 = 1900\ \Omega$

100. A moving coil galvanometer, having a resistance G, produces full scale deflection when a current I_g flows through it. This galvanometer can be converted into (i) an ammeter of range 0 to I_0 ($I_0 > I_g$) by connecting a shunt resistance R_A to it and (ii) into a voltmeter of range 0 to V ($V = GI_0$) by connecting a series resistance R_v to it. Then, **[12 April 2019, II]**

(a) $R_A R_V = G^2\left(\dfrac{I_0 - I_g}{I_g}\right)$ and $\dfrac{R_A}{R_V} = \left(\dfrac{I_g}{I_0 - I_g}\right)^2$

(b) $R_A R_V = G^2$ and $\dfrac{R_A}{R_V} = \left(\dfrac{I_g}{I_0 - I_g}\right)^2$

(c) $R_A R_V = G^2\left(\dfrac{I_g}{I_0 - I_g}\right)$ and $\dfrac{R_A}{R_V} = \left(\dfrac{I_0 - I_g}{I_g}\right)^2$

(d) $R_A R_V = G^2$ and $\dfrac{R_A}{R_V} = \dfrac{I_g}{(I_0 - I_g)}$

101. A moving coil galvanometer allows a full scale current of 10^{-4} A. A series resistance of 2 MΩ is required to convert the above galvanometer into a voltmeter of range 0 – 5 V. Therefore the value of shunt resistance required to convert the above galvanometer into an ammeter of range 0 – 10 mA is : **[10 April 2019, I]**

(a) 500 Ω (b) 100 Ω (c) 200 Ω (d) 10 Ω

102. A moving coil galvanometer has resistance 50 Ω and it indicates full deflection at 4 mA current. A voltmeter is made using this galvanometer and a 5 k Ω resistance. The maximum voltage, that can be measured using this voltmeter, will be close to: **[9 April 2019 I]**

(a) 40 V (b) 15 V (c) 20 V (d) 10 V

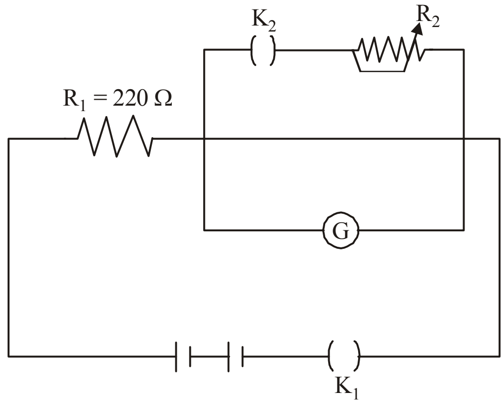
103. A moving coil galvanometer has a coil with 175 turns and area 1 cm^2. It uses a torsion band of torsion constant 10^{-6} N-m/rad. The coil is placed in a magnetic field B parallel to its plane. The coil deflects by 1° for a current of 1 mA. The value of B (in Tesla) is approximately: **[9 April 2019, II]**

(a) 10^{-4} (b) 10^{-2} (c) 10^{-1} (c) 10^{-3}

104. The resistance of a galvanometer is 50 ohm and the maximum current which can be passed through it is 0.002 A. What resistance must be connected to it order to convert it into an ammeter of range 0 – 0.5 A? **[9 April 2019, II]**

(a) 0.5 ohm (b) 0.002 ohm
(c) 0.02 ohm (d) 0.2 ohm

105. The galvanometer deflection, when key K_1 is closed but K_2 is open, equals θ_0 (see figure). On closing K_2 also and adjusting R_2 to 5Ω, the deflection in galvanometer becomes $\dfrac{\theta_0}{5}$. The resistance of the galvanometer is, then, given by [Neglect the internal resistance of battery]: **[12 Jan 2019, I]**



(a) 5Ω (b) 22Ω
(c) 25Ω (d) 12Ω

106. A galvanometer, whose resistance is 50 ohm, has 25 divisions in it. When a current of 4×10^{-4} A passes through it, its needle (pointer) deflects by one division. To use this galvanometer as a voltmeter of range 2.5 V, it should be connected to a resistance of : **[12 Jan 2019, II]**

(a) 250 ohm (b) 200 ohm
(c) 6200 ohm (d) 6250 ohm

107. A galvanometer having a resistance of 20 Ω and 30 division on both sides has figure of merit 0.005 ampere/division. The resistance that should be connected in series such that it can be used as a voltmeter upto 15 volt, is: **[11 Jan 2019, II]**

(a) 100 Ω (b) 120 Ω (c) 80 Ω (d) 125 Ω

108. A galvanometer having a coil resistance 100 Ω gives a full scale deflection when a current of 1 mA is passed through it. What is the value of the resistance which can convert this galvanometer into a voltmeter giving full scale deflection for a potential difference of 10 V? **[8 Jan 2019, II]**

(a) 10 kΩ (b) 8.9 kΩ
(c) 7.9 kΩ (d) 9.9 kΩ

109. In a circuit for finding the resistance of a galvanometer by half deflection method, a 6 V battery and a high resistance of 11kΩ are used. The figure of merit of the galvanometer 60μA/division. In the absence of shunt resistance, the galvanometer produces a deflection of $\theta = 9$ divisions when current flows in the circuit. The value of the shunt resistance that can cause the deflection of $\theta/2$, is closest to **[Online April 16, 2018]**

(a) 55Ω (b) 110Ω (c) 220Ω (d) 550Ω

110. A galvanometer with its coil resistance 25Ω requires a current of 1mA for its full deflection. In order to construct an ammeter to read up to a current of 2A, the approximate value of the shunt resistance should be **[Online April 16, 2018]**

(a) $2.5 \times 10^{-2}\Omega$ (b) $1.25 \times 10^{-3}\Omega$
(c) $2.5 \times 10^{-3}\Omega$ (d) $1.25 \times 10^{-2}\Omega$

111. 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 to voltmeter of range 0 – 10 V is **[2017]**

(a) $2.535\times10^{3}\Omega$ (b) $4.005\times10^{3}\Omega$
(c) $1.985\times10^{3}\Omega$ (d) $2.045\times10^{3}\Omega$

112. A galvanometer having a coil resistance of 100 Ω gives a full scale deflection, when a currect 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 : **[2016]**

(a) 0.1 Ω (b) 3Ω (c) 0.01Ω (d) 2Ω

113. A 50 Ω resistance is connected to a battery of 5V. 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? **[Online April 9, 2016]**

(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 galvanometer
(d) $r_s = 0.5\ \Omega$ in parallel with the galvanometer.

114. 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 related by the equation: **[Online April 9, 2016]**

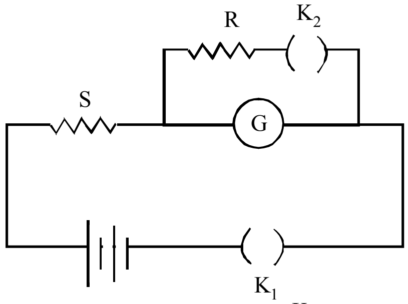
(a) $S(R+G)=RG$ (b) $2S(R+G)=RG$
(c) $2G=S$ (d) $2S=G$

115. The AC voltage across a resistance can be measured using a : **[Online April 11, 2015]**

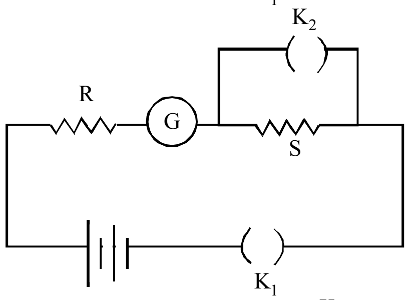
(a) hot wire voltmeter
(b) moving coil galvanometer
(c) potential coil galvanometer
(d) moving magnet galvanometer

116. In the circuit diagrams (A, B, C and D) shown below, R is a high resistance and S is a resistance of the order of galvanometer resistance G. The correct circuit, corresponding to the half deflection method for finding the resistance and figure of merit of the galvanometer, is the circuit labelled as: **[Online April 11, 2014]**

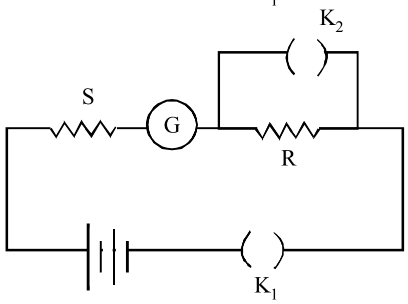
(A)



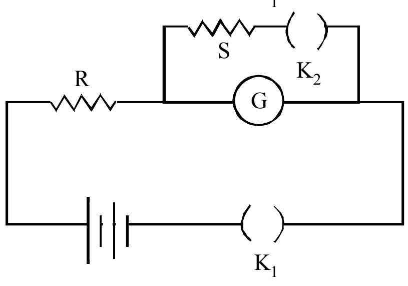
(B)



(C)



(D)



(a) Circuit A with $G = \frac{RS}{(R-S)}$

(b) Circuit B with G = S

(c) Circuit C with G = S

(d) Circuit D with $G = \frac{RS}{(R-S)}$

117. This questions has Statement I and Statement II. Of the four choices given after the Statements, choose the one that best describes into 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. **[2013]**

(a) Statement-I is true, Statement-II is true, Statement-II is the correct explanation of Statement-I.

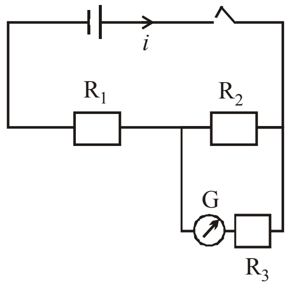
(b) Statement-I is true, Statement-II is true, Statement-II is not the correct explanation of Statement-I.

(c) Statement-I is true, Statement-II is false.

(d) Statement-I is false, Statement-II is true.

118. To find the resistance of a galvanometer by the half deflection method the following circuit is used with resistances R_1= 9970 W, R_2 = 30 W and R_3 = 0. The deflection in the galvanometer is d. With R_3 = 107 W the deflection changed to $\frac{d}{2}$. The galvanometer resistance is approximately:

[Online April 22, 2013]



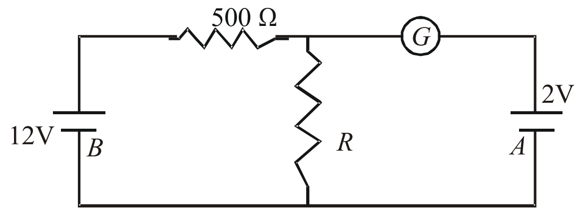
(a) 107 Ω (b) 137 Ω (c) 107/2 Ω (d) 77 Ω

119. A shunt of resistance 1 Ω is connected across a galvanometer of 120 Ω resistance. A current of 5.5 ampere gives full scale deflection in the galvanometer. The current that will give full scale deflection in the absence of the shunt is nearly : **[Online April 9, 2013]**

(a) 5.5 ampere (b) 0.5 ampere

(c) 0.004 ampere (d) 0.045 ampere

120. In the circuit , the galvanometer G shows zero deflection. If the batteries A and B have negligible internal resistance, the value of the resistor R will be - **[2005]**



(a) 100Ω (b) 200Ω (c) 1000Ω (d) 500Ω

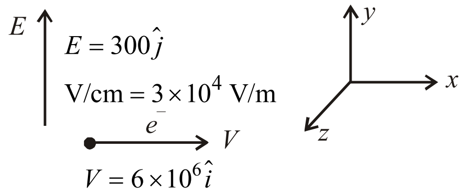
121. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10-divisions per milliampere and voltage sensitivity is 2 divisions per millivolt. In order that each division reads 1 volt, the resistance in ohms needed to be connected in series with the coil will be - **[2005]**

(a) 10^5 (b) 10^3 (c) 9995 (d) 99995

Hints & Solutions

1. (c) $\vec{E} = 300\hat{j}$ V/cm $= 3\times10^4$ V/m

$\vec{V} = 6\times10^6\hat{i}$



$\vec{B}$ must be in $+z$ axis.

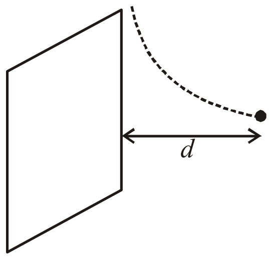
$q\vec{E} + q\vec{V}\times\vec{B} = 0$

$E = VB$

$\therefore\ B = \dfrac{E}{V} = \dfrac{3\times10^4}{6\times10^6} = 5\times10^{-3}T$

Hence, magnetic field $B = 5\times10^{-3}$ T along $+z$ direction.

2. (c) In uniform magnetic field particle moves in a circular path, if the radius of the circular path is 'r', particle will not hit the screen.



$r = \dfrac{mv}{qB_0}$ $\quad\left[\because \dfrac{mv^2}{r} = qvB_0\right]$

Hence, minimum value of v for which the particle will not hit the screen.

$v = \dfrac{qB_0 d}{m}$

3. (a) [Given: $q = 1\mu C = 1\times10^{-6}C$;

$\vec{V} = (2\hat{i}+3\hat{j}+4\hat{k})$ m/s and

$\vec{B} = (5\hat{i}+3\hat{j}-6\hat{k})\times10^{-3}$ T]

$$\vec{F} = q(\vec{V}\times\vec{B}) = 10^{-6}\times10^{-3}\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 2 & 3 & 4\\ 5 & 3 & -6\end{vmatrix}$$

$= (-30\hat{i}+32\hat{j}-9\hat{k})\times10^{-9}$ N

$\therefore \vec{F} = (-30\hat{i}+32\hat{j}-9\hat{k})$

4. (d) Pitch $= (v\cos\theta)T$ and $T = \dfrac{2\pi m}{qB}$

$\therefore$ Pitch $= (V\cos\theta)\dfrac{2\pi m}{qB}$

$= (4\times10^5\cos60°)\dfrac{2\pi}{0.3}\left(\dfrac{1.67\times10^{-27}}{1.69\times10^{-19}}\right) = 4$ cm

5. (c) Time period of one revolution of proton, $T = \dfrac{2\pi m}{qB}$

Here, m = mass of proton

q = charge of proton

B = magnetic field.

Linear distance travelled in one revolution,

$p = T(v\cos\theta)$ (Here, v = velocity of proton)

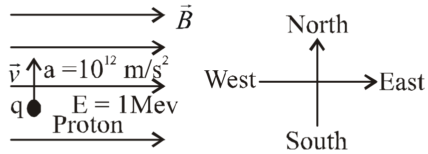
$\therefore$ Length of region, $l = 10\times(v\cos\theta)T$

$\Rightarrow l = 10\times v\cos60°\times\dfrac{2\pi m}{qB}$

$\Rightarrow l = \dfrac{20\pi mv}{qB} = \dfrac{20\times3.14\times1.67\times10^{-27}\times4\times10^5}{1.6\times10^{-19}\times0.3}$

$\Rightarrow l = 0.44$ m

6. (a)



As we know, magnetic force $F = qvB = ma$

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

$\therefore$ Also $v = \sqrt{\dfrac{2KE}{m}} = \sqrt{\dfrac{2\times e\times10^6}{m}}$

$\therefore\ a = \dfrac{qvB}{m} = \dfrac{eB}{m}\sqrt{\dfrac{2\times e\times10^6}{m}}$

$\therefore\ 10^{12} = \left(\dfrac{1.6\times10^{-19}}{1.67\times10^{-27}}\right)^{\frac{3}{2}}.\sqrt{2}\times10^3 B$

$\therefore\ B \simeq \dfrac{1}{\sqrt{2}}\times10^{-3}T = 0.71$ mT (approx)

7. **(d)** As particle is moving along a circular path

$\therefore R = \frac{mv}{qB}$ ...(i)

Path is straight line, then
$qE = qvB$

$E = vB \Rightarrow v = \frac{E}{B}$ ....(ii)

From equation (i) and (ii)

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

$\therefore m = 2.0\times10^{-24}$ kg

8. **(b)**

9. **(b)** As $mvr = qvB \Rightarrow r = \frac{mv}{qB} = \frac{\sqrt{2mK.E.}}{qB}$

$[\text{As}: \frac{1}{2}mv^2 = K.E.$

$\Rightarrow m^2v^2 = 2m K.E.$

$\Rightarrow mv = \sqrt{2m K.E.}]$

For proton, electron and α-particle,
$m_{He} = 4m_p$ and $m_p >> m_e$
Also $a_{He} = 2q_p$ and $q_p = q_e$
$\therefore$ As KE of all the particles is same then,

$r \,\alpha\, \frac{\sqrt{m}}{q}$

$\therefore r_{He} = r_p > r_e$

10. **(a)** Radius of the circular path will be $r = \frac{mv}{qB}$

$\Rightarrow r = \frac{\sqrt{2mKE}}{qB}$ $(\because p = mv = \sqrt{2mKE})$

$\because KE = q\Delta V$

$\therefore r = \frac{\sqrt{2mq\Delta V}}{qB} \Rightarrow r \propto \sqrt{\frac{m}{q}}$

$\therefore \frac{r_p}{r_\alpha} = \frac{1}{\sqrt{2}}$

11. **(d)** Radius of the path (r) is given by $r = \frac{mv}{qB}$

$r = \frac{\sqrt{2mk}}{eB}$ $\left(\because p = mv = \sqrt{2mk}\right)$

$= \frac{\sqrt{2meV}}{eB}$ $(\because k = eV)$

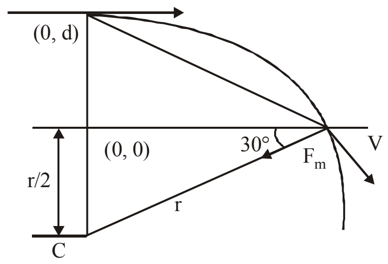
$$r = \frac{\sqrt{\frac{2m}{e}V}}{B} = \frac{\sqrt{\frac{2\times9.1\times10^{-31}}{1.6\times10^{-19}}(500)}}{100\times10^{-3}}$$

$$r = \frac{\sqrt{\frac{9.1}{0.16}\times10^{-10}}}{10^{-1}} = \frac{3}{.4}\times10^{-4}$$

$= 7.5\times10^{-4}$

12. **(BONUS)**
Assuming particle enters from (0, d)

$r = \frac{mv}{qB}$, $\quad d = \frac{r}{2}$



$a = \frac{qVB}{m}\left[\frac{-\sqrt{3}i - j}{2}\right]$

this option is not given in the all above four choices.

13. **(b)** As we know, radius of circular path in magnetic field

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

For electron, $r_e = \frac{\sqrt{2Km_e}}{eB}$ ....(i)

For proton, $r_p = \frac{\sqrt{2Km_p}}{eB}$ ....(ii)

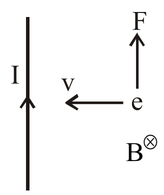
For α particle, $r_\alpha = \frac{\sqrt{2Km_a}}{q_\alpha B} = \frac{\sqrt{2K4m_p}}{2eB} = \frac{\sqrt{2Km_p}}{eB}$ ...(iii)

$\therefore r_e < r_p = r_\alpha$ $(\because m_e < m_p)$

14. **(b)** The force is parallel to the direction of current in magnetic field,

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

According to Fleming's left hand rule,



we have, the direction of motion of charge is towards the wire.

15. **(d)** According to question, as the test charge experiences no net force in that region i.e., sum of electric force $(F_e = q\vec{E})$ and magnetic forces $[F_m = q(\vec{v}\times\vec{B})]$ will be zero. Hence, $F_e + F_m = 0$

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

$$= -B_0 v_0\left[\left(3\hat{i}-\hat{j}+2\hat{k}\right)\times\left(i+2\hat{j}-4\hat{k}\right)\right]$$

$$= -B_0 v_0\left(14\hat{j}+7\hat{k}\right)$$

16. **(b)** $\because$ F = qE and F = qvB

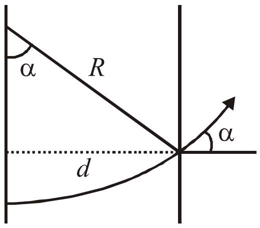
$\therefore$ E = vB

And Gauss's law in Electrostatics $E = \dfrac{\sigma}{\varepsilon_0}$

$E = \dfrac{\sigma}{\varepsilon_0} = vB \Rightarrow \sigma = \varepsilon_0 vB$

$\sigma_1 = -\sigma_2$

17. (d) From figure, $\sin\alpha = d/R$



And we know, $\dfrac{mv^2}{R} = qvB$

$\Rightarrow R = \dfrac{mv}{qB}$

$\therefore \sin\alpha = \dfrac{dqB}{mv}$

$\sin\alpha = Bd\sqrt{\dfrac{q}{2mV}}\left[\because qV = \dfrac{1}{2}mv^2\right]$

18. **(c)** The applied magnetic field provides the required centripetal force to the charge particle, so it can move in circular path of radius $\dfrac{d}{2}$

$\therefore\ Bqv = \dfrac{mv^2}{d/2}$

or, $B = \dfrac{2mv}{qd}$

Time interval for which a uniform magnetic field is applied

$\Delta t = \dfrac{\pi.\frac{d}{2}}{v}$

(particle reverses its direction after time Δt by covering semi circle).

$\Delta t = \dfrac{\pi d}{2v}$

19. **(c)** Since particle is moving undeflected

So, $q_E = qvB$

$\Rightarrow B = \dfrac{E}{V} = \dfrac{10^4}{10} = 10^3\ wb/m^2$

20. **(b)** The centripetal force is provided by the magnetic force

$\therefore\ \dfrac{mv^2}{R} = qvB \Rightarrow r = \dfrac{mv}{Bq} \quad \therefore\ r \propto \dfrac{\sqrt{m}}{q}$

$\therefore r_p : r_d : r_\alpha = \dfrac{\sqrt{m_p}}{q_p} : \dfrac{\sqrt{m_d}}{q_d} : \dfrac{\sqrt{m_\alpha}}{q_\alpha}$

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

Thus we have, $r_\alpha = r_p < r_d$

21. **(d)** When a charged particle enters the magnetic field in perpendicular direction then it experience a force in perpendicular direction.

i.e. $F = Bqv\sin\theta$

Due to which it moves in a circular path.

22. **(b)** As charge on both proton and deuteron is same i.e. '*e*'

Energy acquired by both, $E = eV$

For Deuteron.

Kinetic energy, $\dfrac{1}{2}mV^2 = eV$

[V is the potential difference]

$v = \sqrt{\dfrac{2eV}{m_d}}$

But $m_d = 2m$

Therefore, $v = \sqrt{\dfrac{2eV}{2m}} = \sqrt{\dfrac{eV}{m}}$

Radius of path, $R = \dfrac{mv}{eB}$

Substituting value of '*v*' we get

$R = \dfrac{2m\sqrt{\frac{ev}{m}}}{eB}$

$\dfrac{R}{2} = \dfrac{m\sqrt{\frac{ev}{m}}}{eB}$ ...(i)

For proton :

$\dfrac{1}{2}mV^2 = eV$

$V = \sqrt{\dfrac{2eV}{m}}$

Radius of path, $R' = \dfrac{mV}{eB} = \dfrac{m\sqrt{\frac{2eV}{m}}}{eB}$

$R' = \sqrt{2}\times\dfrac{R}{2}$ [From eq. (i)]

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

23. **(a)** $\vec{F} = q\left(\vec{V}\times\vec{B}\right)$

$= 2\times10^{-6}\left[(2\hat{i}+3\hat{j})\times10^6\times2\hat{j}\right]$

$= 2\times4\hat{k} = 8N$ in Z-direction.

24. **(c)** As velocity $v = \frac{E}{B} = \frac{7.7 \times 10^3}{0.14} = 55$ km/s

25. **(a)** The charge experiences both electric and magnetic force.

Electric force, $F_e = qE$

Magnetic force, $F_m = q(\vec{v} \times \vec{B})$

$\therefore$ Net force, $\vec{F} = q\left[\vec{E} + \vec{v} \times \vec{B}\right]$

$$= q\left[3\hat{i} + \hat{j} + 2\hat{k} + \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 4 & 1 \\ 1 & 1 & -3 \end{vmatrix}\right]$$

$$= q\left[3\hat{i} + \hat{j} + 2\hat{k} + \hat{i}(-12-1) - \hat{j}(-9-1) + k(3-4)\right]$$

$$= q\left[3\hat{i} + \hat{j} + 2\hat{k} - 13\hat{i} + 10\hat{j} - \hat{k}\right]$$

$$= q\left[-10\hat{i} + 11\hat{j} + \hat{k}\right]$$

$$F_y = 11q\hat{j}$$

Thus, the y component of the force.

26. **(b)** As velocity is not changing, charge particle must go undeflected, then

$qE = qvB$

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

Also,

$$\left|\frac{\vec{E} \times \vec{B}}{B^2}\right| = \frac{E\ B \sin\theta}{B^2}$$

$$= \frac{E\ B\ \sin 90°}{B^2} = \frac{E}{B} = |\vec{v}| = v$$

27. **(b)** When a charged particle enters a magnetic field at a direction perpendicular to the direction of motion, the path of the motion is circular. In circular motion the direction of velocity changes at every point (the magnitude remains constant).

Therefore, the tangential momentum will change at every point. But kinetic energy will remain constant as it is given by $\frac{1}{2}mv^2$ and v^2 is the square of the magnitude of velocity which does not change.

28. **(b)** The charged particle will move along the lines of electric field (and magnetic field). Magnetic field will exert no force. The force by electric field will be along the lines of uniform electric field. Hence the particle will move in a straight line.

29. **(c)** Equating magnetic force to centripetal force,

$$\frac{mv^2}{r} = qvB \sin 90°$$

$$\Rightarrow \frac{mv}{r} = Bq \quad \Rightarrow \quad v = \frac{Bqr}{m}$$

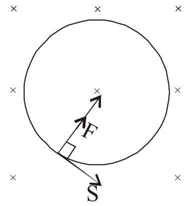
Time to complete one revolution,

$$T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}$$

30. **(b)** Due to electric field, it experiences force and accelerates i.e. its velocity decreases.

31. **(b)** The workdone, $dW = Fds \cos\theta$

The angle between force and displacement is 90°. Therefore work done is zero.



32. **(a)** When a moving charged particle is subjected to a perpendicular magnetic field, then it describes a circular path of radius.

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

where q = Charge of the particle

p = Momentum of the particle

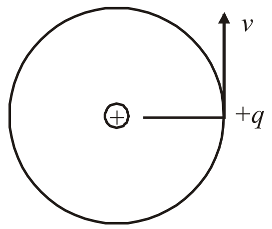
B = Magnetic field

Here p, q and B are constant for electron and proton, therefore the radius will be same.

33. **(a)** The time period of a charged particle of charge q and mass m moving in a magnetic field (B) is $T = \frac{2\pi m}{qB}$

Clearly time period is independent of speed of the particle.

34. **(d)**



Length of the circular path, $l = 2\pi r$

Current, $i = \frac{q}{T} = \frac{qv}{2\pi r}$

Magnetic moment M = Current × Area

$$= i \times \pi r^2 = \frac{qv}{2\pi r} \times \pi r^2$$

$$M = \frac{1}{2} q \cdot v \cdot r$$

Radius of circular path in magnetic field, $r = \frac{mv}{qB}$

$$\therefore M = \frac{1}{2} qv \times \frac{mv}{qB} \Rightarrow M = \frac{mv^2}{2B}$$

Direction of $\vec{M}$ is opposite of $\vec{B}$ therefore

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

(By multiplying both numerator and denominator by B).

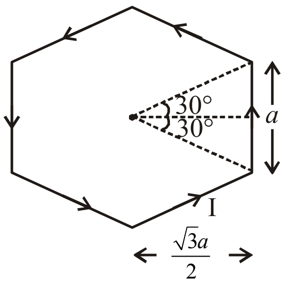
35. **(d)** Given : $I_A = 2\,\text{A}, R_A = 2\,\text{cm},\ \theta_A = 2\pi - \frac{\pi}{2} = \frac{3\pi}{2}$

$I_B = 3\,\text{A}, R_B = 4\,\text{cm},\ \theta_B = 2\pi - \frac{\pi}{3} = \frac{5\pi}{3}$

Using, magnetic field, $B = \frac{\mu_0 I\theta}{4\pi R}$

$$\frac{B_A}{B_B} = \frac{I_A}{I_B} \times \frac{\theta_A R_B}{\theta_B R_A} = \frac{2 \times \frac{3\pi}{2} \times 4}{3 \times \frac{5\pi}{3} \times 2} = \frac{6}{5}$$

36. **(c)**



Magnetic field due to one side of hexagon

$$B = \frac{\mu_0 I}{4\pi \frac{\sqrt{3}a}{2}}(\sin 30° + \sin 30°)$$

$$\Rightarrow B = \frac{\mu_0 I}{2\sqrt{3}a}\left(\frac{1}{2} + \frac{1}{2}\right) = \frac{\mu_0 I}{2\sqrt{3}a\pi}$$

Now, magnetic field due to one hexagon coil

$$B = 6 \times \frac{\mu_0 I}{2\sqrt{3}a\pi}$$

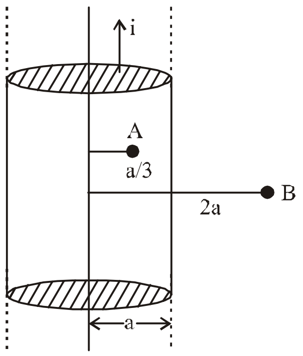
Again magnetic field at the centre of hexagonal shape coil of 50 turns,

$$B = 50 \times 6 \times \frac{\mu_0 I}{2\sqrt{3}a\pi} \qquad \left[\because a = \frac{10}{100} = 0.1\text{ m}\right]$$

or, $B = \frac{150\mu_0 I}{\sqrt{3} \times 0.1 \times \pi} = 500\sqrt{3}\frac{\mu_0 I}{\pi}$

37. **(a)** Let a be the radius of the wire
Magnetic field at point A (inside)

$$B_A = \frac{\mu_0 ir}{2\pi a^2} = \frac{\mu_0 i \frac{a}{3}}{2\pi a^2} = \frac{\mu_0 i}{\pi a^2}\frac{a}{6} = \frac{\mu_0 i}{6\pi a}$$

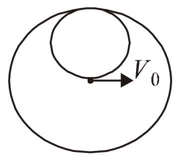


Magnetic field at point B (outside)

$$B_B = \frac{\mu_0 i}{2\pi(2a)}$$

$$\therefore \frac{B_A}{B_B} = \frac{\frac{\mu_0 i}{6\pi a}}{\frac{\mu_0 i}{2\pi(2a)}} = \frac{4}{6} = \frac{2}{3}$$

38. **(b)** Magnetic field inside the solenoid is given by
$B = \mu_0 nI$ .... (i)
Here, n = number of turns per unit length

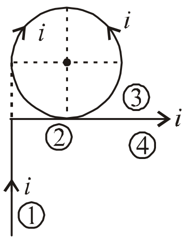


The path of charge particle is circular. The maximum possible radius of electron $= \frac{R}{2}$

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

$$\Rightarrow V_{\max} = \frac{qBR}{2m} = \frac{eR\mu_0 nI}{2m} \qquad \text{(using (i))}$$

39. **(a)**



$B_0 = B_1 + B_2 + B_3 + B_4$

$$= \frac{\mu_0 I}{4\pi R}[\sin 90° - \sin 45°] + \frac{\mu_0 I}{2R} + \frac{\mu_0 I}{4\pi R}[\sin 45° + \sin 90°]$$

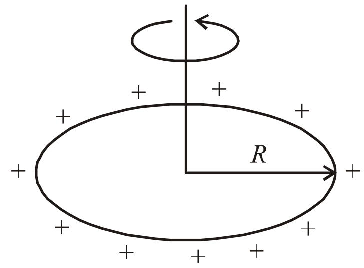
$$= -\frac{\mu_0 \text{I}}{4\pi \text{R}}\left(1 - \frac{1}{\sqrt{2}}\right) + \frac{\mu_0 \text{I}}{2\text{R}} + \frac{\mu_0 \text{I}}{4\pi \text{R}}\left(1 + \frac{1}{\sqrt{2}}\right)$$

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

40. **(a)** $\vec{B} = \vec{B}_1 + \vec{B}_2$

$$= \frac{\mu_0}{2\pi}\cdot\left(\frac{i^{\text{o}}}{d}.\hat{k} + \frac{i^{\text{o}}}{d}\left(-\hat{k}\right)\right) = 0$$

41. **(b)** If q is the charge on the ring, then



$i = \frac{q}{T} = \frac{q\omega}{2\pi}$

Magnetic field,

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

$$= \frac{\mu_0\left(\frac{q\omega}{2\pi}\right)}{2R}$$

or $3.8 \times 10^{-9} = \left(\frac{\mu_0}{4\pi}\right)\frac{q\omega}{R} = \left(10^{-7}\right)\frac{q \times 40\pi}{0.10}$

$\therefore \quad q = 3 \times 10^{-5}$ C.

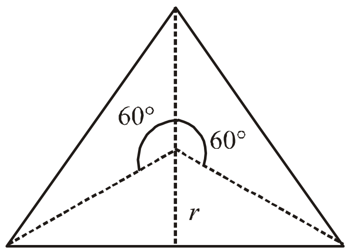
42. **(b)** $B = \frac{\mu_0}{4\pi}, \frac{i}{r}(\sin\alpha + \sin\beta)$

Here $r = \sqrt{5^2 - 3^2} = 4$ cm

$\alpha = \beta = 37°$

$\therefore \quad B = 10^{-7} \times \frac{5}{4} 2\sin 37° = 1.5 \times 10^{-5}$ T

43. **(a)**



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

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

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

$$= \frac{3\mu_0 l}{4\pi\left(\frac{a}{2\sqrt{3}}\right)} \times (2)\left(\frac{\sqrt{3}}{2}\right) = \frac{9}{2}\left(\frac{\mu_0 l}{\pi a}\right)$$

$$= \frac{9 \times 2 \times 10^{-7} \times 10}{1} = 18\ \mu\text{T}$$

44. **(d)** Let a be the area of the square and r be the radius of circular loop.

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

For square

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

For circular loop

$M_1 = (I)\pi r^2$

$$M_1 = (I)(\pi)\left(\frac{4a^2}{\pi^2}\right)$$

$$M_1 = \frac{4Ia^2}{\pi}$$

$$M_1 = \frac{4M}{\pi} \quad (\because M = Ia^2)$$

45. **(c)** Let I be the current in each wire. (directed inwards) Magnetic field at 'O' due to LP and QM will be zero.

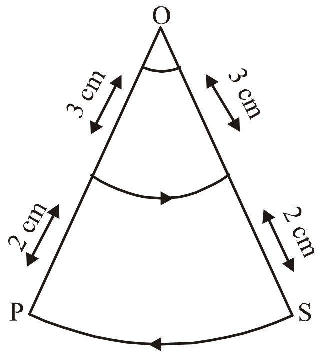
i.e., $B_0 = B_{PS} + B_{QN}$

$\therefore$ Net magnetic field $B_0 = \frac{\mu_0 i}{4\pi d} + \frac{\mu_0 i}{4\pi d}$

or $10^{-4} = \frac{\mu_0 i}{2\pi d} + \frac{2 \times 10^{-7} \times i}{4 \times 10^{-2}}$

$\therefore$ i = 20 A and the direction of magnetic field is perpendicular into the plane

46. **(d)**



i = 10 A

There will be no magnetic field at O due to wire PQ and RS

Magnetic field at 'O' due to arc QR

$$= \frac{\mu_0}{4\pi}\frac{\left(\frac{\pi}{4}\right).I}{r_1}$$

Magnetic field at 'O' due to are PS

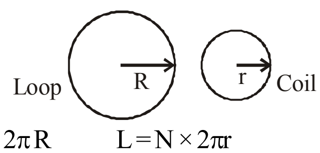
$$= \frac{\mu_0}{4\pi}\frac{\left(\frac{\pi}{4}\right).I}{r_2}$$

$\therefore$ Net magnetic field at 'O'

$$B = \frac{\mu_0}{4\pi}(\pi/4) \times 10\left[\frac{1}{\left(3 \times 10^{-2}\right)} - \frac{1}{\left(5 \times 10^{-2}\right)}\right]$$

$$\Rightarrow |\vec{B}| = \frac{\pi}{3} \times 10^{-5}\,\text{T} \approx 1 \times 10^{-5}\,\text{T}$$

47. **(d)**



$L = 2\pi R \qquad L = N \times 2\pi r$

$R = Nr \Rightarrow r = \frac{R}{N}$

$B_{Loop} = \frac{\mu_0 i}{2R}$ $B_{coil} = \frac{\mu_0 Ni}{2r} = \frac{\mu_0 Ni}{2\left(\frac{R}{N}\right)} = \frac{\mu_0 N^2 i}{2R}$

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

48. **(c)** Magnetic field at the centre of loop, $B_1 = \frac{\mu_0 I}{2R}$

Dipole moment of circular loop is $m = IA$

$m_1 = I.A = I.\pi R^2$ {R = Radius of the loop}

If moment is doubled (keeping current constant) R becomes $\sqrt{2}R$

$$m_2 = I.\pi\left(\sqrt{2}R\right)^2 = 2.I\pi R^2 = 2m_1$$

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

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

49. **(b)** Point P is situated at the mid-point of the line joining the centres of the circular wires which have same radii (R).

The magnetic fields ($\vec{B}$) at P due to the currents in the wires are in same direction.

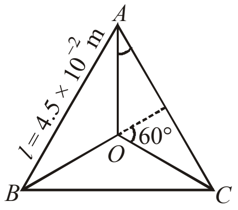
Magnitude of magnetic field at point, P

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

50. **(a)** Here, side of the triangle, $l = 4.5 \times 10^{-2}$ m, current, I = 1A magnetic field at the centre of the triangle 'O' $B = ?$

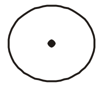
From figure, $\tan 60° = \sqrt{3} = \frac{1}{2d}$

$$\Rightarrow d = \frac{l}{2\sqrt{3}} = \left(\frac{4.5 \times 10^{-2}}{2\sqrt{3}}\right) \text{m}$$



Magnetic field, $B = \frac{\mu_0 i}{4\pi d}(\cos\theta_1 + \cos\theta_2)$

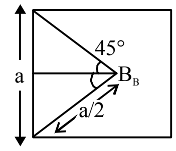
Putting value of $\mu = 4\pi \times 10^{-7}$ and θ_1 and θ_2 we will get $B = 4 \times 10^{-5}$ Wb/m^2

51. **(b)** Case (a) : 

$$B_A = \frac{\mu_0}{4\pi}\frac{I}{R} \times 2\pi = \frac{\mu_0}{4\pi}\frac{I}{\ell / 2\pi} \times 2\pi \ (\because 2\pi R = \ell)$$

$$= \frac{\mu_0}{4\pi}\frac{I}{\ell} \times (2\pi)^2$$

Case (b) :



$$B_B = 4 \times \frac{\mu_0}{4\pi}\frac{I}{a/2}[\sin 45° + \sin 45°]$$

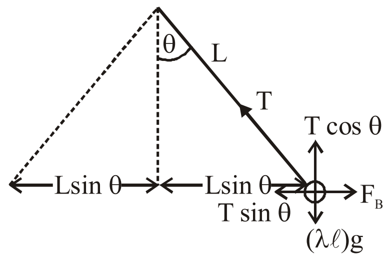
$$= 4 \times \frac{\mu_0}{4\pi} \times \frac{I}{\ell/8} \times \frac{2}{\sqrt{2}} = \frac{\mu_0}{4\pi}\frac{I}{\ell} \times \frac{64}{\sqrt{2}} = \frac{\mu_0 I}{4\pi\ell}32\sqrt{2} \quad [4a = l]$$

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

52. **(d)** Let us consider 'ℓ' length of current carrying wire.

At equilibrium

$T \cos\theta = \lambda g \ell$



and $T \sin\theta = \frac{m_0}{2p}\frac{I' \, Il}{2L\sin q}$ $\left[\because \frac{F_B}{\ell} = \frac{\mu_0}{4\pi}\frac{2I \times I}{2\ell\sin\theta}\right]$

Therefore, $I = 2\sin q\sqrt{\frac{pl \, gL}{u_0 \cos q}}$

53. **(b)** For loop $B = \frac{\mu_0 nI}{2a}$

where, a is the radius of loop.

Then, $B_1 = \frac{\mu_0 I}{2a}$

Now, for coil $B = \frac{\mu_0 I}{4\pi}.\frac{2nA}{x^3}$

at the centre x = radius of loop

$$B_2 = \frac{\mu_0}{4\pi}.\frac{2 \times 3 \times (I/3) \times \pi(a/3)^2}{(a/3)^3} = \frac{\mu_0.3I}{2a}$$

$$\therefore \frac{B_1}{B_2} = \frac{\mu_0 I / 2a}{\mu_0.3I / 2a}$$

$B_1 : B_2 = 1 : 3$

54. **(d)** Magnetic field between the plates in this case is zero.

55. **(a)** Magnetic field at any point lies on axial position of current carrying conductor B = 0

56. **(a)** If magnetic field is perpendicular and into the plane of the paper, it is represented by cross $\otimes$ and if the direction of the magnetic field is perpendicular out of the plane of the paper it is represented by dot $\odot$.

57. **(b)** Given : Radius = R

Distance $x = 2\sqrt{2}R$

$$\frac{B_{centre}}{B_{axis}} = \left(1+\frac{x^2}{R^2}\right)^{3/2} = \left(1+\frac{(2\sqrt{2}R)^2}{R^2}\right)^{3/2}$$

$$= (9)^{3/2} = 27$$

58. **(a)** The magnetic field due to a disc is given as

$$B = \frac{\mu_0 \omega Q}{2\pi R} \quad \text{i.e.,} \quad B \propto \frac{1}{R}$$

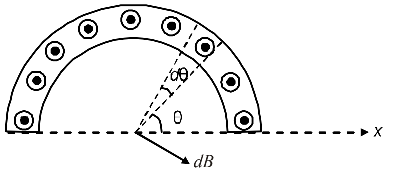
59. **(d)** Let R be the radius of semicircular ring. Let an elementary length dl is cut for finding magnetic field. So, $dl = Rd\theta$. Current in a small element, $dI = \frac{d\theta}{\pi} I$

Magnetic field due to the element

$$dB = \frac{\mu_0}{4\pi}\frac{2dI}{R} = \frac{\mu_0 I}{2\pi^2 R}$$

The component $dB\cos\theta$, of the field is cancelled by another opposite component.

Therefore,



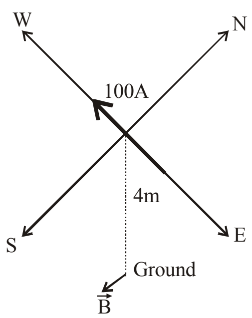
$$B_{net} = \int dB\sin\theta = \frac{\mu_0 I}{2\pi^2 R}\int_0^{\pi}\sin\theta d\theta = \frac{\mu_0 I}{\pi^2 R}$$

60. **(a)** The magnetic field varies inversely with the distance for a long conductor. That is, $B \propto \frac{1}{d}$

so, graph in option (a) is the correct one.

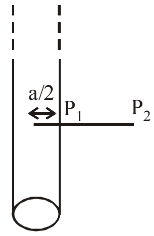
61. **(c)** The magnetic field is

$$B = \frac{\mu_0}{4\pi}\frac{2I}{r} = 10^{-7} \times \frac{2\times 100}{4} = 5\times 10^{-6}\ T$$



Current flows from east to west. Point is below the power line, using right hand thumb rule, the magnetic field is directed towards south.

62. **(d)** Since uniform current is flowing through a straight wire, current enclosed in the amperean path formed at a distance $r_1 \left(= \frac{a}{2}\right)$ is



$$i = \left(\frac{\pi r_1^2}{\pi a^2}\right) \times I,$$

where I is total current

Using Ampere circuital law,

$$\oint B\cdot \vec{dl} = \mu_0 i$$

$$\Rightarrow B_1 = \frac{\mu_0 \times \text{current enclosed}}{\text{Path}}$$

$$\Rightarrow B_1 = \frac{\mu_0 \times \left(\frac{\pi r_1^2}{\pi a^2}\right)\times I}{2\pi r_1} = \frac{\mu_0 \times I r_1}{2\pi a^2}$$

Now, magnetic field induction at point P_2,

$$B_2 = \frac{\mu_0}{2\pi}\cdot\frac{I}{(2a)} = \frac{\mu_0 I}{4\pi a}.$$

$$\therefore \frac{B_1}{B_2} = \frac{\mu_0 I r_1}{2\pi a^2}\times\frac{4\pi a}{\mu_0 I}$$

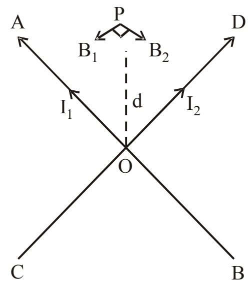
$$\Rightarrow \frac{B_1}{B_2} = \frac{2r_1}{a} = \frac{2\times\frac{a}{2}}{a} = 1.$$

63. **(d)** There is no current inside the pipe. From Ampere's circuital law $\oint \vec{B}\cdot\vec{dl} = \mu_0 I$

$\because I = 0$

$\therefore B = 0$

64. **(c)** The direction of magnetic field induction due to current through AB and CD at P are indicated as B_1 and B_2. The magnetic fields at a point P, equidistant from AOB and COD will have directions perpendicular to each other, as they are placed normal to each other.



Magnetic field at P due to current through AB,

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

Magnetic field at P due to current through CD,

$$B_2 = \frac{\mu_0 I_2}{2\pi d}$$

$\therefore$ Resultant field, $B = \sqrt{B_1^2 + B_2^2}$

$$\therefore B = \sqrt{\left(\frac{\mu_0}{2\pi d}\right)^2\left(I_1^2 + I_2^2\right)}$$

or, $B = \frac{\mu_0}{2\pi d}\left(I_1^2 + I_2^2\right)^{1/2}$

65. **(a)** Magnetic field due to long solenoid is given by $B = \mu_0 nI$

In first case $B_1 = \mu_0 n_1 I_1$

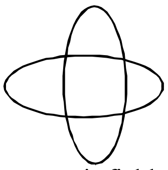
In second case, $B_2 = \mu_0 n_2 I_2$

$\therefore \frac{B_2}{B_1} = \frac{\mu_0 n_2 i_2}{\mu_0 n_1 i_1}$

$\Rightarrow \frac{B_2}{6.28 \times 10^{-2}} = \frac{100 \times \frac{i}{3}}{200 \times i}$

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

66. **(d)**



The magnetic field due to circular coil (1) is

$B_1 = \frac{\mu_0 i_1}{2r} = \frac{\mu_0 i_1}{2(2\pi \times 10^{-2})} = \frac{\mu_0 \times 3 \times 10^2}{4\pi}$

Magnetic field due to coil (2)

Total magnetic field

$B_2 = \frac{\mu_0 i_2}{2(2\pi \times 10^{-2})} = \frac{\mu_0 \times 4 \times 10^2}{4\pi}$

Total magnetic field, $B = \sqrt{B_1^2 + B_2^2}$

$= \frac{\mu_0}{4\pi} \cdot 5 \times 10^2$

$\Rightarrow B = 10^{-7} \times 5 \times 10^2$

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

67. **(b)** From Ampere's circuital law

$\int \vec{B} \cdot \vec{dl} = \mu_0 i$

$\Rightarrow B \times 2\pi r = \mu_0 i$

Here i is zero, for $r < R$, whereas R is the radius

$\therefore B = 0$

68. **(b)** Magentic field at the centre of a circular coil of radius R carrying current i is $B = \frac{\mu_0 i}{2R}$

The circumference of the first loop $= 2\pi R$. If it is bent into n circular coil of radius r'.

$n \times (2\pi r') = 2\pi R$

$\Rightarrow nr' = R$ ...(1)

New magnetic field, $B' = \frac{n \cdot \mu_0 i}{2r'}$ ...(2)

From (1) and (2),

$B' = \frac{n\mu_0 i \cdot n}{2\pi R} = n^2 B$

69. **(c)** The magnetic field at a point on the axis of a circular loop at a distance x from centre is,

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

Magnetic field at the centre of loop is

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

$\therefore B' = \frac{B \cdot (x^2 + a^2)^{3/2}}{a^3}$

Put $x = 4$ & $a = 3$

$\Rightarrow B' = \frac{54(5^3)}{3 \times 3 \times 3} = 250\ \mu T$

70. **(a)** Magnetic field induction at the centre of current carrying circular coil of radius r is

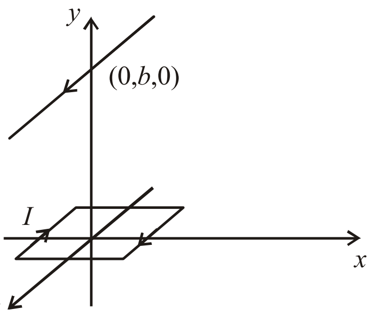
$B = \frac{\mu_0}{4\pi}\frac{I}{R} \times 2\pi$

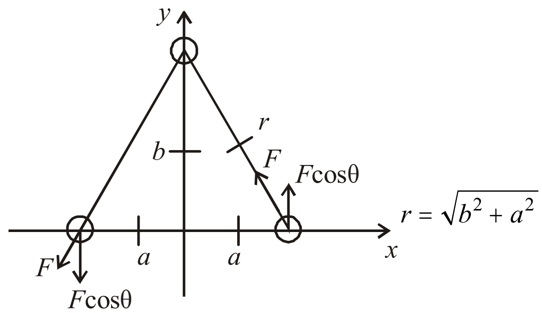
Here $B_A = \frac{\mu_0}{4\pi}\frac{I}{R} \times 2\pi$

and $B_B = \frac{\mu_0}{4\pi}\frac{2I}{2R} \times 2\pi$

$\Rightarrow \frac{B_A}{B_B} = \frac{I/R}{2I/2R} = 1$

71. **(b)**





Force, $F = BI2a = \frac{\mu_0 I}{2\pi r} I \times 2a$

Force, $F = \frac{\mu_0 I^2 a}{\pi\sqrt{b^2 + a^2}}$

Torque, $\tau = F_1 \times$ Perpendicular distance $= F\cos\theta \times 2a$

$= \frac{\mu_0 I^2 a}{\pi\sqrt{b^2 + a^2}} \times \frac{b}{\sqrt{b^2 + a^2}} \times 2a$

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

If $b >> a$ then $\tau = \dfrac{2\mu_0 I^2 a^2}{\pi b}$

72. **(c)** Torque on the loop,

$\bar{\tau} = \bar{M} \times \bar{B} = MB\sin\theta = MB\sin 90°$

Magnetic field, $B = \dfrac{\mu_0 I}{2\pi d}$

$$\therefore \tau = I_1(2a)^2\left(\frac{\mu_0 I_2}{2\pi d}\right)\sin 90°$$

$$= \frac{2\mu_0 I_1 I_2}{\pi d} \times a^2 = \frac{2\mu_0 I^2 a^2}{\pi d}$$

73. **(b)** Magnetic moment of loop $ABCD$,

M_1 = area of loop × current

$\vec{M}_1 = (abI)(\hat{j})$ (Here, ab = area of rectangle)

Magnetic moment of loop $DEFA$,

$\vec{M}_2 = (abI)(\hat{i})$

Net magnetic moment,

$$\vec{M} = \vec{M}_1 + \vec{M}_2 \Rightarrow \vec{M} = abI(\hat{i} + \hat{j})$$

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

74. **(c)** Torque on circular loop, $\tau = MB\sin\theta$

where, M = magnetic moment

B = magnetic field

Now, using $\tau = I\alpha$

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

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

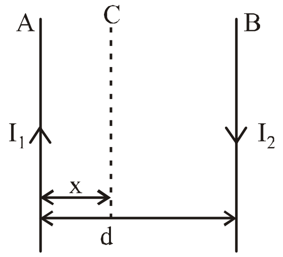
($\because m = IA$ and moment of inertia of circular loop, $I = \dfrac{mR^2}{2}$)

$$\Rightarrow \pi R^2 IB\,\theta = \frac{mR^2}{2}\omega\theta$$

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

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

75. **(d)**



As net force on the third wire C is zero.

$$\Rightarrow \vec{F} = \frac{\mu_0 I_1}{2\pi x} + \frac{\mu_0 I_2}{2\pi(d-x)} = 0$$

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

$I_1 x - I_1 d = I_2 x$

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

Two cases may be possible if $I_1 > I_2$ or $I_2 > I_1$

76. **(d)** $\tau = MB\sin 45° = N(iA)B\sin 45°$

$$= 100 \times 3(5 \times 2.5) \times 10^{-4} \times 1 \times \frac{1}{\sqrt{2}}$$

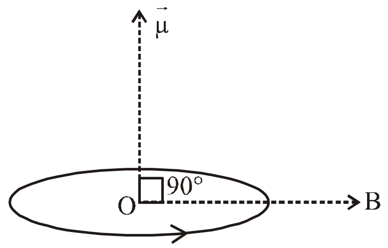
$= 0.27$ N-m

77. **(c)** $F = \dfrac{\mu_0}{2\pi}\left(\dfrac{i_i i_2}{a} - \dfrac{i_1 i_2}{2a}\right) \times a = \dfrac{\mu_0 i_1 i_2}{4\pi}$

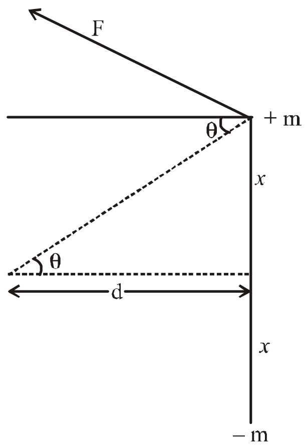
78. **(b)** $|\vec{\tau}| = |\vec{\mu} \times \vec{B}|$ [$\mu = NIA$]

$= NIA \times B\sin 90°$ [$A = \pi r^2$]

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



79. **(d)**



Force on one pole,

$$F = m \times \frac{\mu_0 I}{2\pi\sqrt{d^2 + x^2}}$$

Total force, $F_{total} = 2F\sin\theta$

$$= 2 \times \frac{\mu_0 Im}{2\pi\sqrt{d^2 + a^2}} \times \frac{x}{\sqrt{d^2 + a^2}}$$

$$= \frac{\mu_0 Im\,x}{\pi(d^2 + a^2)}$$

Magnetic moment, $M = I\pi a^2 = m \times 2$

or, Total force, $F_{total} = \dfrac{\mu_0 I a^2}{2(d^2 + a^2)}$

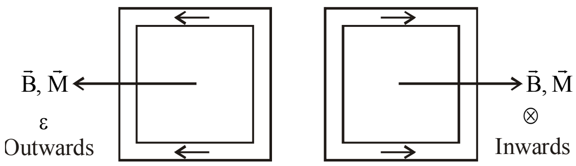
$= \dfrac{\mu_0 I a^2}{2d^2} \quad [\because d >> a]$

Clearly $F_{total} \propto \dfrac{a^2}{d^2}$

80. **(a)** Magnetic moment, $\mu = IA = \dfrac{qv}{2\pi r}(\pi r^2)$

or, $\mu = \dfrac{qr\omega}{2\pi r}(\pi r^2) = \dfrac{1}{2} qr^2\omega$

81. **(c)** Magnetic moment of current carrying rectangular loop of area A is given by M = NIA
magnetic moment of current carrying coil is a vector and its direction is given by right hand thumb rule, for rectangular loop, $\vec{B}$ at centre due to current in loop and $\vec{M}$ are always parallel.



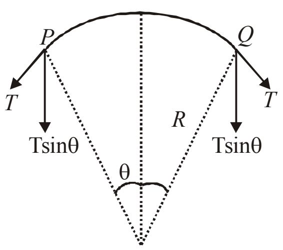
Hence, (c) corresponds to stable equilibrium.

82. **(c)** $\vec{F}_1 = \vec{F}_2 = 0$
because of action and reaction pair

83. **(a)** For stable equilibrium $\vec{M} \parallel \vec{B}$
For unstable equilibrium $\vec{M} \parallel (-\vec{B})$

84. (a) $I_1 I_2$ = Positive
(attract) F = Negative
$I_1 I_2$ = Negative
(repell) F = Positive
Hence, option (a) is the correct answer.

85. (c) For small arc length
$2T \sin\theta = BIR\, 2\theta$ (As $F = BIL$ and $L = RZ\theta$)
$T = BIR$

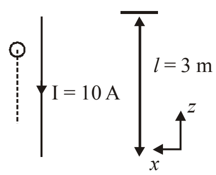


86. **(b)** Work done in moving the conductor is,

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

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

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



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

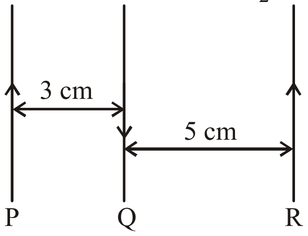
$= \dfrac{9 \times 10^{-3} \times (0.33)}{2} = \dfrac{2.97 \times 10^{-3}}{2}$

Power required to move the conductor is,

$P = \dfrac{W}{t}$

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

87. **(a)** $I_1 = 30$ A $\quad I = 10$ A $\quad I_2 = 20$ A



Also given; length of wire Q
= 25 cm = 0.25 m
Force on wire Q due to wire R

$F_{QR} = 10^{-7} \times \dfrac{2 \times 20 \times 10}{0.05} \times 0.25$

$= 20 \times 10^{-5}$ N (Towards left)
Force on wire Q due to wire P

$F_{QP} = 10^{-7} \times \dfrac{2 \times 30 \times 10}{0.03} \times 0.25$

$= 50 \times 10^{-5}$ N (Towards right)
Hence, $F_{net} = F_{QP} - F_{QR}$
$= 50 \times 10^{-5}$ N $- 20 \times 10^{-5}$ N
$= 3 \times 10^{-4}$ N towards right

88. **(c)**

89. **(a)** Force acting on conductor B due to conductor A is given by relation

$F = \dfrac{\mu_0 I_1 I_2 l}{2\pi r}$

l-length of conductor B
r-distance between two conductors

$\therefore F = \dfrac{4\pi \times 10^{-7} \times 10 \times 2 \times 2}{2 \times \pi \times 0.1} = 8 \times 10^{-5}$ N

90. **(a)**

91. **(a)** The magnetic field at O due to current in DA is

$B_1 = \dfrac{\mu_o}{4\pi}\dfrac{I}{a} \times \dfrac{\pi}{6}$ (directed vertically upwards)

The magnetic field at O due to current in BC is

$B_2 = \dfrac{\mu_o}{4\pi}\dfrac{I}{b} \times \dfrac{\pi}{6}$ (directed vertically downwards)

The magnetic field due to current AB and CD at O is zero.
Therefore the net magnetic field is

$B = B_1 - B_2$ (directed vertically upwards)

$$= \frac{\mu_o}{4\pi}\frac{I}{a}\frac{\pi}{6} - \frac{\mu_o}{4\pi}\frac{I}{b}\times\frac{\pi}{6}$$

$$= \frac{\mu_o I}{24}\left(\frac{1}{a} - \frac{1}{b}\right) = \frac{\mu_o I}{24ab}(b-a)$$

92. **(d)** $\vec{F} = I(\vec{\ell}\times\vec{B})$

The force on AD and BC due to current I_1 is zero. This is because the directions of current element $I\,\overrightarrow{d\ell}$ and magnetic field $\vec{B}$ are parallel.

93. **(a)** Force acting between two long conductor carrying current,

$$F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d}\times\ell \qquad ...(i)$$

Where d = distance between the conductors

ℓ = length of conductor

In second case, $F' = -\frac{\mu_0}{4\pi}\frac{2(2I_1)I_2}{3d}\ell \qquad ..(ii)$

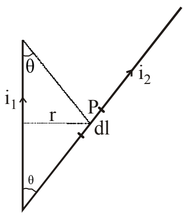
From equation (i) and (ii), we have

$$\therefore \frac{F'}{F} = \frac{-2}{3}$$

94. **(b)** When current is passed through a spring then current flows parallel in the adjacent turns in the same direction. As a result the various turn attract each other and spring get compress.

95. **(c)** Magnetic field due to current in wire 1 at point P distant r from the wire is

$$B = \frac{\mu_0}{4\pi}\frac{i_1}{r}[\cos\theta + \cos\theta]$$



$$B = \frac{\mu_0}{2\pi}\frac{i_1\cos\theta}{r}$$

This magnetic field is directed perpendicular to the plane of paper, inwards.

The force exerted due to this magnetic field on current element $i_2\,dl$ is

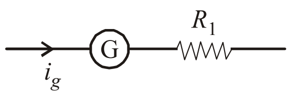
$dF = i_2\,dl\,B\sin 90°$

$\therefore\ dF = i_2\,dlB$

$$\Rightarrow dF = i_2\,dl\left(\frac{\mu_0}{4\pi}\frac{i_1\cos\theta}{r}\right)$$

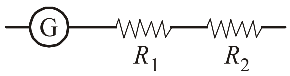
$$= \frac{\mu_0}{2\pi r}i_1 i_2\,dl\cos\theta$$

96. **(d)** Galvanometer of resistance (G) converted into a voltmeter of range 0-1 V.



$$V = 1 = i_g(G + R_1) \qquad ...(i)$$

To increase the range of voltmeter 0-2 V



$$2 = i_g(R_1 + R_2 + G) \qquad ...(ii)$$

Dividing eq. (i) by (ii),

$$\Rightarrow \frac{1}{2} = \frac{G + R_1}{G + R_1 + R_2}$$

$$\Rightarrow G + R_1 + R_2 = 2G + 2R_1$$

$$\therefore R_2 = G + R_1$$

97. **(d)** Given,

Current passing through galvanometer, $I = 6$ mA

Deflection, $\theta = 2°$

Figure of merit of galvanometer

$$= \frac{I}{\theta} = \frac{6\times10^{-3}}{2} = 3\times10^{-3}\ \text{A/div}$$

98. **(20)**

Given,

Area of galvanometer coil, $A = 3\times10^{-4}\ \text{m}^2$

Number of turns in the coil, $N = 500$

Current in the coil, $I = 0.5$ A

Torque $\tau = |\vec{M}\times\vec{B}| = NiAB\sin(90°) = NiAB$

$$\Rightarrow B = \frac{\tau}{NiA} = \frac{1.5}{500\times0.5\times3\times10^{-4}} = 20\,T$$

99. **(c)** $i_g = 20\times50 = 1000\ \mu A = 1$ mA

Using, $V = i_g(G + R)$, we have

$2 = 10^{-3}(100 + R_1)$

$R_1 = 1900\ \Omega$

when, $V = 10$ volt

$10 = 10^{-3}(100 + R_2 + R_1)$

$10000 = (100 + R_2 + 1900)$

$\therefore\ R_2 = 8000\ \Omega$

100. **(b)** In an ammeter,

$$i_g = i_0\frac{R_A}{R_A + G}$$

and for voltmeter,

$V = i_g(G + R_V) = Gi_0$

On solving above equations, we get

$R_A R_V = G^2$

and $\frac{R_A}{R_V} = \left(\frac{i_g}{i_0 - i_g}\right)^2$

101. **(Bonus)** $v = i_g(R + G)$

$\Rightarrow 5 = 10^{-4}(2\times10^6 + x)$

$x = -195\times10^4\Omega$

102. (c) $V = i_g(G+R) = 4\times10^{-3}(50+5000) = 20V$

103. (d) $C\theta = NBiA \sin 90°$

or $10^{-6}\left(\frac{\pi}{180}\right) = 175B(10^{-3})\times10^{-4}$

$\therefore B = 10^{-3}T$

104. (d) Using, $i_g = i\frac{S}{S+G}$

$0.002 = 0.5\frac{S}{S+50}$

On solving, we get

$S = \frac{100}{498} \simeq 0.2\,\Omega$

105. (b) When key K_1 is closed and key K_2 is open

$$i_g = \frac{E}{220+R_g} = C\theta_0 \quad \text{... (i)}$$

When both the keys are closed

$$i_g = \left(\frac{E}{220+\frac{5R_g}{5+R_g}}\right)\times\frac{5}{(R_g+5)} = \frac{C\theta_0}{5}$$

$$\Rightarrow \frac{5E}{225R_g+1100} = \frac{C\theta_0}{5} \quad \text{... (ii)}$$

$$\frac{E}{220+R_g} = C\theta_0 \quad \text{... (i)}$$

Dividing (i) by (ii), we get

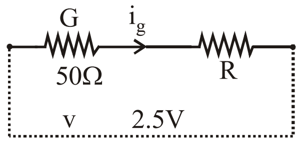
$\Rightarrow \frac{225R_g+1100}{1100+5R_g} = 5$

$\Rightarrow 5500+25R_g = 225R_g+1100$

$200R_g = 4400$

$R_g = 22\Omega$

106. (b) Galvanometer has 25 divisions $I_g = 4\times10^{-4}\times25 = 10^{-2}A$



$V = I_g R_{net}$

$v = I_g(G+R)$

$2.5 = (50+R)\,10^{-2} \therefore R = 200\Omega$

107. (c) Deflection current

$= Ig_{max} = nxk = 0.005\times30$

Where, n = Number of divisions = 30 and k = 0.005 amp/division

$= 15\times10^{-2} = 0.15$

$v = I_g[20+R]$

$15 = 0.15\,[20+R]$

$100 = 20+R$

$R = 80\,\Omega$

108. (d) Given,

Resistance of galvanometer, $G = 100\Omega$

Current, $i_g = 1\ mA$

A galvanometer can be converted into voltmeter by connecting a large resistance R in series with it.

Total resistance of the combination = $G+R$

According to Ohm's law, $V = i_g(G+R)$

$\therefore 10 = 1\times10^{-3}(100+R_0)$

$\Rightarrow 10000-100 = 9900\,\Omega = R_0$

$\Rightarrow R_0 = 9.9\,k\Omega$

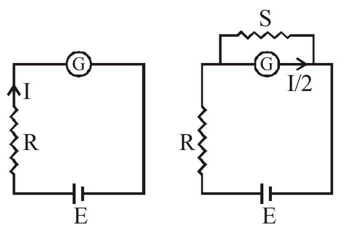
109. (b) Figure of merit of a galvanometer is the correct required to produce a deflection of one division in the galvanometer

i.e., figure of merit = $\frac{I}{\theta}$

$I = \frac{\varepsilon}{R+G} \qquad G = \frac{1}{9}K\Omega$

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

$$S = \frac{RG\times\frac{1}{2}}{\varepsilon-\frac{(R+G)I}{2}}$$



$$S = \frac{11\times10^3\times\frac{1}{2}\times10^2\times270\times10^{-6}}{6-\left(\frac{6}{2}\right)} = 110\Omega$$

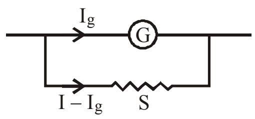
110. (d) According to question, current through galvanometer, $I_g = 1$ mA

Current through shunt $(I-I_g) = 2$ A

Galvanometer resistance $R_g = 25\Omega$

Resistance of shunt, S = ?

$I_0R_0 = (I-I_g)S$



$\Rightarrow S = \frac{10^{-3}\times25}{2}$

$S \simeq 1.25\times10^{-2}\Omega$

111. (c) Given : Current through the galvanometer,

$i_g = 5\times10^{-3}A$

Galvanometer resistance, $G = 15\Omega$

Let resistance R to be put in series with the galvanometer to convert it into a voltmeter.

$V = i_g(R+G)$

$10 = 5\times10^{-3}(R+15)$

$\therefore \quad R = 2000-15 = 1985 = 1.985\times10^3\,\Omega$

112. (c) $I_g G = (I-I_g)s$

$\therefore 10^{-3}\times100 = (10-10^{-3})\times S$

$\therefore S \approx 0.01\Omega$

113. **(d)** As we know, $I = \frac{V}{R} = \frac{5}{50} = 0.1$

$I' = 0.099$

When Galvanometer is connected

$$R_{eq} = 50 + \frac{100S}{100+S} = \frac{V}{I}$$

$$\Rightarrow \frac{100S}{100+S} = \frac{5}{0.099} - 50$$

$$\Rightarrow \frac{100S}{100+S} = 50.50 - 50 \Rightarrow \frac{100S}{100+S} = 0.5$$

$$\Rightarrow 100S = 50 + 0.55 \Rightarrow 99.5S = 50$$

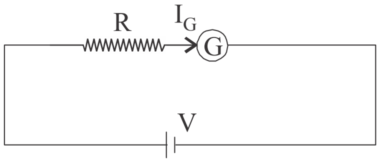
$$S = \frac{50}{99.05} = 0.5\Omega$$

So, shunt of resistance $= 0.5\Omega$ is connected in parallel with the galvanometer.

114. **(a)** According to Ohm's Law, $I = \frac{V}{R}$

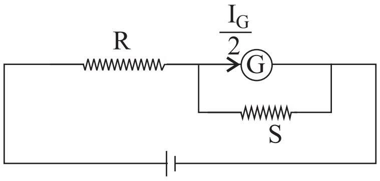
$$I_g = \frac{V}{R+G}$$

where, I_g-Galvanometer current, G-Galvonometer resistance



When shunt of resistance S is connected parallel to the Galvanometer then $G = \frac{GS}{G+S}$

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



Equal potential difference is given by

$$I'_g G = (I - I'_g)S$$

$$I'_g(G+S) = IS$$

$$\Rightarrow \frac{I_g}{2} = \frac{IS}{G+S}$$

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

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

$$\Rightarrow R(G+S) + GS = 2S(R+G)$$

$$\Rightarrow RG + RS + GS = 2S(R+G)$$

$$\Rightarrow RG = 2S(R+G) - S(R+G)$$

$$\therefore RG = S(R+G)$$

115. **(b)** To measure AC voltage across a resistance a moving coil galvanometer is used.

116. **(d)** The correct circuit diagram is *D* with galvanometer resistance

$$G = \frac{RS}{R-S}$$

117. **(d)** Statements I is false and Statement II is true

For ammeter, shunt resistance, $S = \frac{IgG}{I - Ig}$

Therefore for *I* to increase, *S* should decrease, So additional S can be connected across it.

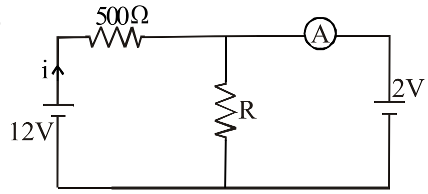
118. **(d)**

119. **(d)** The current that will given full scale deflection in the absence of the shunt is nearly equal to the current through the galvanometer when shunt is connected i.e. I_g

$$\text{As } I_g = \frac{IS}{G+S}$$

$$= \frac{5.5 \times 1}{120+1} = 0.045 \text{ ampere.}$$

120. **(a)**



$$12 - 2 = (500\Omega)i \Rightarrow i = \frac{10}{500} = \frac{1}{50}$$

$$\text{Again, } i = \frac{12}{500+R} = \frac{1}{50}$$

$$\Rightarrow 500 + R = 600$$

$$\Rightarrow R = 100\,\Omega$$

121. **(c)** Resistance of Galvanometer,

$$G = \frac{\text{Current sensitivity}}{\text{Voltage sensitivity}} \Rightarrow G = \frac{10}{2} = 5\Omega$$

Here i_g = Full scale deflection current $= \frac{150}{10} = 15$ mA

V = voltage to be measured = 150 volts

(such that each division reads 1 volt)

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