CLASS:XII UNIT-3. MAGNETIC EFFECT OF CURRENT AND MAGNETISM Physics Assignment03

Answer the following questions,

i. Can a magnetic field be used to speed up a charged particle? Explain why are why not?

ii. On what factors do the pole strength of a magnet depends? **Ans: Its cross section, nature and state of magnetization**

iii. Can ever there be a magnet (a) with no poles (b) with one pole (c) with two similar poles (d) with three poles ?

iv. **Ans: (a) yes (b) no (c) yes (d) yes**

v. What happens to the pole-strength and magnetic moment of a magnet if it is cut in two equal halves (a) parallel to its length (b) perpendicular to its length? **Ans: (a) The pole-strength and magnetic moment both are halved (b) the pole-strength remains same while magnetic moment halved**

vi. Magnetic field lines can be entirely confined within the core of a toroid, but not within a straight solenoid, why? [Home - www.mywebpathshala.com]

vii. What is the importance of a radial magnetic field and how is it produced in MCG?

viii. Why is that while a MCG as a voltmeter a high resistance in series is required whereas in an ammeter a shunt (low resistance) is used?

ix. "Increasing the current sensitivity may not necessarily increases the voltage sensitivity" justify this statement.

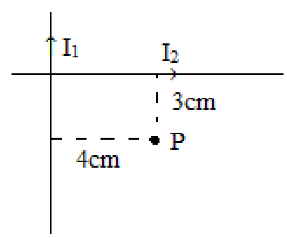
x. Why should the material used for making permanent magnets have high coercivity?

xi. Why is core of an electromagnet made of ferromagnetic materials?

xii. How does the pole strength and magnetic moment of each part of a bar magnet change if it is cut into two equal pieces (i) transverse to its length and (ii) along its length?

Problems based on Biot-Savart Law and Ampere's circuital Law:

1. An element $\overrightarrow{\Delta l} = \Delta x\, \hat{i}$ is placed at the origin and carries a large current I = 10 A. What is the magnetic field on the y-axis at a distance of 0.5 m. Δx = 1 cm. **Ans: 4x 10^{-8} $\hat{k}$T**
2. A horizontal overhead power line carries a current of 100 A in the east west direction. What is the magnitude and direction of the magnetic field due to this current 4m below the line? **Ans: 5μT, directed from N to south**
3. Two infinitely long insulated wires are kept perpendicular to each other. They carry currents I_1 = 2 A and I_2 = 1.5 A. (i) Find the magnitude and direction of the magnetic field at P. (ii) If the direction of current is reversed in one of the wires , what would be the magnitude of the field B ?
   Ans: (i) 2x 10^{-5} T, normally into the plane of paper (ii) zero



4. Compute the magnetic field at the centre of a current carrying coil if it is in the form of a square of side 'a' and caries a clockwise current I. **Ans:** $\frac{\mu_o}{4\pi} \times \frac{8\sqrt{2}I}{a}$ **inward.**
5. A long straight telephone cable contains six wires, each carrying a current of 0.5 A. The distance between the wires is negligible. What is the magnitude of magnetic field at a distance of 10 cm from the cable (i) if the currents in all the six wires are in same direction (ii) if four wires carry current in one direction and the other two in opposite direction? **Ans: 6.0 x 10^{-6} T (ii) 2.0 x 10^{-6} T**
6. Sketch the magnetic field lines for two long straight parallel wires having current in same direction.
7. A circular current carrying coil has a radius R. At what distance from the centre of the coil, on the axis of it magnetic induction is 1/8th to its value at the centre of the coil. **Ans: R√3**

8. Two similar coils of radius R and number of turns N are lying concentrically with their plane at right angles to each other. The current flowing in them are I and $\sqrt{3}$ I respectively. What will be resultant magnetic induction at the centre? **Ans:** $\frac{\mu_o NI}{R}$

9. The magnetic field inside a toroidal solenoid of radius R is B. If the current through it is doubled and the radius is also doubled keeping the number of turns per unit length the same, what will is the magnetic field produced by it. **Ans. 2B**

10. Find magnetic field at center of the arc in the **fig.01**. where $\theta = 90^o$ **Ans:** $\frac{\mu_o}{4\pi} \times \frac{2i}{r} \times [\sqrt{2} + \frac{\pi}{4}]$

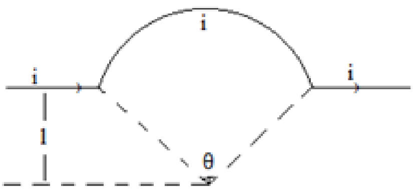


fig. 01

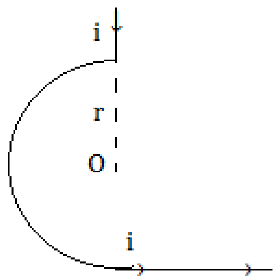


fig. 02

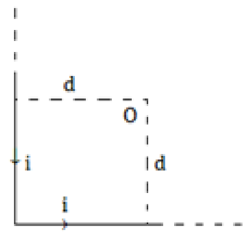


fig. 03

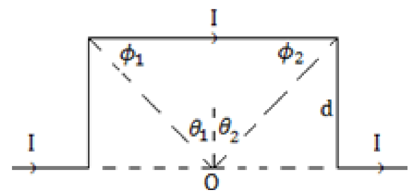


fig. 04

11. Find magnetic induction at point O, **fig.02**. **Ans:** $\frac{\mu_o i}{4r} + \frac{\mu_o i}{4\pi r}$

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12. An infinite wire bent in the form of L caries current **i, fig.03.** What is the magnetic field at the point? Ans:

13. What is the magnetic field at O due to current in the infinite wire forming a loop as shown in **fig.04.**

Ans: $\frac{\mu_o}{4\pi}\frac{I}{d} \times [\cos\Phi_1 + \cos\Phi_2]$

14. A square frame of side **l** carries a current **i** produces a field B_1 at its centre. The same current is passed through a circular coil having perimeter same as the square. The field at the center of circular wire is B_2.

Find the ratio of B_2 / B_1. **Ans:** $\frac{8\sqrt{2}}{\pi^2}$

15. A solenoid of radius R is made up of a long piece of wire of radius **r**, length L (>>R) and resistivity ρ. Find the magnetic field at the center of the solenoid if the wire is connected to a battery having emf E. **Ans:** $\frac{\mu_o E r^2}{2\rho L R}$

16. (i) A straight thick long wire of uniform cross-section of radius 'a' is carrying a steady current I . Use Ampere's circuital law to obtain a relation showing the variation of the magnetic field (B_r) inside and outside the wire with distance r, ($r \le a$) and ($r > a$) of the field point from the centre of its cross-section. Plot a graph showing the variation of the field B with distance r. (ii) Calculate the ratio of magnetic field at a point a/2 above the surface of the wire to that at a point a/2 below its surface. What is the maximum value of the field of this wire?

17. A solenoid 50cm long has 4 layers of windings of 350 turns each. The radius of the lowest layer is 1.4cm. if the current carried is 6.0 A, estimate the magnitude of B (a) near the centre of the solenoid on its axis and off its axis, (b) near its ends on its axis, (c) outside the solenoid near its centre.

Ans: (a) same 2.1 x 10^{-2} T (b) 1.05 x 10^{-2} T

18. A toroid has a core of inner radius 20cm and outer radius 22cm around which 4200 turns of a wire are wound. If the current in the wire is 10A. What is the magnetic field (i) inside the core of toroid (ii) outside the toroid and (iii) in the empty space surrounded by the toroid. **Ans: (i) 0.04 T (ii) zero (iii) zero**

19. A circular coil has 35 turns and a mean radius of 35 turns. It carries a current of 1.2 A. Find the magnetic field (i) at a point on the axis of the coil at a distance of 40 cm from its centre and (ii) at the centre of the coil.

Ans: (i) 6.5 x 10^{-7} T (b) 6.6 x 10^{-4} T

Problems based on Lorentz Force, Motion of charge particle inside magnetic field:

20. A proton is moving along +ve x-axis in the presence of uniform magnetic field along +ve y-axis. What is direction of the force acting on it? **Ans: +ve z-axis**
21. An electron of mass $\mathbf{m_e}$ kg moves under the action of magnetic field in a circle of radius $\mathbf{r_e}$ at a speed of $\mathbf{v_e}$ m/s. if a proton of mass $\mathbf{m_p}$ kg were to move in a circle of same radius in the same magnetic field, then what will be its speed. **Ans:** $\mathbf{v_p = v_e (m_e / m_p)}$
22. A proton, a deuteron and an α particle having the same kinetic energy are moving in circular trajectories in a constant magnetic field. If r_p, r_p and r_a denote respectively the radii of the trajectories of these particles, then **Ans.** $\mathbf{r_a = r_p < r_d}$
23. An electron having a kinetic energy of 100 eV circulates in a path of radius 10 cm in a magnetic field. Find the magnetic field and the number of revolutions per second made by the electron. **Ans: 3.4 x 10^{-4} T, 9.4 x 10^{6}**
24. In a hydrogen atom the electron moves in an orbit of radius 0.5 Ȧ making 10^{16} rev/s. what is the magnetic moment associated with the orbital motion of the electron? **Ans: 12.56 x 10^{-24} Am^2**
25. An alpha particle is projected vertically upward with a speed of 3.0 x 10^4 km/s in a region where a magnetic field of magnitude 1.0 T exits in the direction south to north. Find the magnetic force that acts on the α-particle.
    Ans: 9.6 x 10^{-12} N towards west
26. A magnetic field of (4.0 x 10^{-3} $\hat{k}$) T exerts a force of (4.0 $\hat{\imath}$ + 3.0 $\hat{\jmath}$) x 10^{-10} N on a particle having a charge of 1.0 x 10^{-9} C and going in the X – Y plane. Find the velocity of the particle. **Ans: (-75 $\hat{\imath}$ + 100 $\hat{\jmath}$) m/s**
27. A solenoid of length 1.5m has a radius of 1.5cm and has a total of 1500 turns wound on it. It carries a current of 3A. Calculate the magnitude of the axial magnetic field inside the solenoid. If an electron were to move with a speed 2 x 10^4 m/s along the axis of this current carrying solenoid. What would be the force experienced by this electron? **Ans: 0.38T, 0**
28. A proton of energy 3.4MeV moves vertically downwards through a horizontal magnetic field of 3T which acts from south to north. What is the force on the proton?
    Ans: 12.15 x 10^{-12} N
29. What is the trajectory of a charge particle in a magnetic field if the particle moves (a) parallel to the field (b) perpendicular to the field (c) at an angle to the field? **Ans: (a) straight line (b) circle (c) helix**
30. What is the smallest value of B that can be set up at the equator to permit a proton of speed 10^7 m/s to circulate around the earth? **Ans: 1.6 x 10^{-8} T**
31. A cyclotron has 40cm usable diameter inside the dee's. a uniform magnetic field of 1.6 T is applied to it. What is the maximum velocity of a deuteron accelerated in the cyclotron? **Ans: 1.65 x 10^7 m/s**
32. The electron in hydrogen atom moves around the proton with a speed of 2.2 x 10^6 ms^{-1} in a circular orbits of 5.3 x 10^{-11} m. Calculate (i) the equivalent current (ii) equivalent dipole moment and (iii) the Magnetic field at the site of proton. **Ans: (i) 1.057 x 10^{-3} A (b) 9.32 x 10^{-24} Am^{-2} (c) 12.5 T**
33. If a particle of charge q is moving with velocity v along the z-axis and the magnetic field B is acting along the x-axis, use the expression $\vec{F} = q\left(\vec{v} \times \vec{B}\right)$ to find direction of the force F acting on it.
    A beam of proton passes un-deflected with a horizontal velocity v, through a region of electric and magnetic fields, mutually perpendicular to each other and normal to the direction of the beam. If the magnitudes of electric and magnetic fields are 100 kV/m and 30 mT respectively. Calculate (i) velocity v of the beam, (ii) force with which it strikes a target on a screen, if the proton beam current is equal to 0.80 mA.
    Ans: (i) 2 x 10^6 m/s (b) 1.675 x 10^{-5} N

34. A beam of protons enters a uniform magnetic field of 0.3 T with a velocity of 4x 10^5 m/s at an angle of 60^o to the field. Find the radius of the helical path taken by the beam. Also find the pitch of the helix. **Ans: 1.2 cm, 4.35cm**

35. An electron beam passes through a magnetic field of 2 x 10^{-3} Wbm^{-2} and an electric field of 1.0 x10^4 V/m both acting simultaneously. If the path of the electrons remains undeviated, calculate the speed of the electrons. If the electric field is removed, what will be the radius of the circular path? **Ans: 5 x 10^6 m/s, 1.43cm**

36. A proton, a deuteron and an α-particle after being accelerated through the same potential difference, enter in a region of uniform magnetic field B, in a direction perpendicular to B. Compare their kinetic energies. If the radius of proton's circular path is 5cm, what will be the radii of the paths of the deuteron and α-particle? **Ans: 1:1:2, r_d = 7.07cm, r_α = 10cm**

37. An α-particle is accelerated in a cyclotron in which a magnetic field of 1.25T is applied perpendicular to the dees. How rapidly should the electric field between the dees be reversed? What are the velocity and kinetic energy of an α-particle when it moves in circular orbit of radius 25cm? **Ans: 9.5 x 10^6 Hz, 1.5 x 10^7 m/s, 7.5 x 10^{-13} J.**

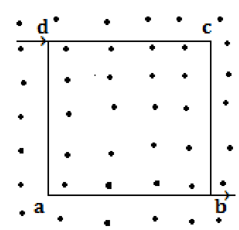
Problems based on Force/torque acting on a current carrying conductor/loop:

38. Two thin long parallel wires separated by a distance b are carrying a current I ampere each. What will be the magnitude of the force per unit length exerted by one wire on the other? **Ans:** $\frac{\mu_o I^2}{b^2}$

39. A thin straight wire of length 0.2 m whose mass is 10^4 kg floats in a magnetic induction field when a current of 10A is passed through it. To make this possible, what should be the minimum magnetic intensity? **Ans: 4.9 x 10^{-4} T**

40. A charge **q** coulomb move in a circle at **n** revolutions per second and the radius of the circle is **r** meter. Find magnetic field at the centre of the circle. **Ans:** $\frac{2\pi nq}{r} \times 10^{-7}$

41. A current of 2A enters at the corner **d** of a square frame **abcd** of side 20 cm and leaves at the opposite corner **b**. A magnetic field B = 0.1 T exists in the space in a direction perpendicular to the plane of the frame as shown in figure. **Ans: 0.02 N on each wire, on da and cb towards left and on dc and ab downwards**



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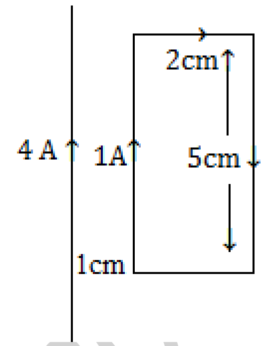
42. A semicircular wire of radius 5.0 cm carries a current of 5.0 A. A magnetic field B of magnitude 0.50 T exists along the perpendicular to the plane of the wire. Find the magnitude of the magnetic force acting on the wire. **Ans: 0.25 N**

43. On a smooth plane inclined at 30^o with the horizontal, a thin current carrying metallic rod is placed parallel to the horizontal ground. The plane located in a uniform magnetic field of 0.15T in the vertical direction. For what value of current can the rod remain stationary? The mass per unit length of the rod is 0.03kg/m. **Ans: 11.3 A**

44. A conductor of length 20cm is placed (i) parallel (ii) perpendicular (iii) inclined at an angle of 30^o, to a uniform magnetic field of 2T. if a charge of 10C passes through it in 5s, find the force experienced by the conductor. **Ans: (i) zero (ii) 0.8N (iii) 0.4N**

45. A rectangular loop of wire of size 2cm x 5cm carries a steady current of 1A. A straight long wire carrying 4A current is kept near the loop as shown in fig. if the loop and the wire are co-planar, find (i) the torque acting on the loop and (ii) magnitude and direction of the force on the loop due to the current carrying wire.

Ans: (i) τ = 0 (ii) F= 2.67μN, towards the straight wire



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46. A wire AB is carrying a steady current of 12A and is lying on the table. Another wire CD carrying 5A is held directly above AB at a height of 1mm. Find the mass per unit length of wire CD so that it remains suspended at its position when left free. Give the direction of the current flowing in CD with respect to that in AB.
Ans: 1.2×10^{-3} kg/m, in the opposite direction

47. A straight, horizontal wire of mass 10 mg and length 1.0 m carries a current of 2.0 A. what minimum magnetic field B should be applied in the region so that the magnetic force on the wire may balance its weight?
Ans: 4.9×10^{-5} T

48. A straight wire of length l can slide on two parallel plastic rails kept in a horizontal plane with a separation d. The coefficient of friction between the wire and the rails is μ. If the wire carries a current i, what minimum magnetic field should exists in the space in order to slide the wire on the rails. **Ans: $\frac{\mu mg}{il}$**

49. A 100 turns closely wound circular coil of radius 10cm carries a current of 3.2A. (i) What is the field at the center of the coil? (ii) What is the magnetic moment of this arrangement?
The coil is placed in a vertical plane and is free to rotate about a horizontal axis which coincides with its diameter. A uniform magnetic field of 2T in horizontal direction exists such that initially the axis of the coil is in the direction of the field. The coil rotates through an angle of 90^o under the influence of magnetic field. (iii) What are the magnitudes of the torques of the coil in the initial and final position? (iv) What is the angular speed acquired by the coil when it has rotated by 90^o ? The MI of the coil is 0.1kg m^2 **Ans: (i) 2×10^{-3}T (ii) 10Am^2 (iii) τ = 20Nm (iv) 20 rad/s**

50. (a) Is it possible to orient a current loop in a uniform field so that the loop does not tend to rotate? **Ans: yes**
(b) For what orientation of the loop is the equilibrium stable? **Ans: $\theta = 0^o$**

51. (a) What is the net force on a current loop in a magnetic field?
(b) What type of magnetic field is required to exert a resultant force on current loop?

52. The magnetic field existing in a region is given by $\vec{B} = B_o \{1+\frac{x}{l}\}\hat{k}$. A square loop of edge l and carrying a current i, is placed with its edges parallel to the X-Y axes. Find the magnitude of the net magnetic force experienced by the loop. **Ans: i B_ol**

53. A rectangular coil of sides 8cm and 6cm having 2000 turns and current of 200mA is placed in a uniform magnetic field of 0.2T directed along the +ve axis. (i) What is the maximum torque the coil can experience? In which orientation does it experiences maximum torque? (ii) For which orientations of the coil is the torque zero? When is this equilibrium stable and when is it unstable? **Ans: (i) 0.384Nm (ii) $\theta = 0^o$ –stable eqbm. $\theta = 180^o$ – unstable eqbm.**

54. A wire of length L metre carrying a current i ampere is bent in the form of circle. The magnitude of magnetic moment is **Ans. i $L^2/4\pi$**

Problems based on Moving Coil Galvanometer and its sensitivity:

55. A moving coil meter has the following particulars: number of turns, N= 24; area of coil A= $20x10^{-3}$ m^2; magnetic field strength, B = 0.20T; resistance of the coil, R= 14Ω (i) Indicate a simple way to increase the current sensitivity of the meter by 25% (It is not easy to change A or B) (ii) If in doing so, the resistance of the coil increases to 21Ω, is the voltage sensitivity of modified meter greater or less than the original meter? **Ans: (i) N should be increased from 24 to30 (ii) voltage sensitivity for original meter 1.7 and for modified meter 1.4**

56. A coil of a MCG twists through 45^o when a current of 1μA is passed through it. When a current of 1microAmpere is passed through it. If the area of the coil is $10^{-5}m^2$ and it has 1000 turns, find the magnetic field of the magnet of the galvanometer. The restoring torque per unit twist of the galvanometer coil is 10^{-4} Nm deg^{-1}. **Ans.45 T**

57. If the current sensitivity of a moving coil galvanometer is increased by 20%, its resistance also increases by 1.5 times. How will the voltage sensitivity of the galvanometer be affected? **Ans. Decreases by 20%**

58. A galvanometer with a coil of resistance 12.0Ω shows full scale deflection for a current 2.5mA. How will you convert the meter into: (i) An ammeter of range 0 to 7.5 A, (ii) A voltmeter of range 0 to 10.0V. **Ans. (i) 4 x 10^{-3}Ω (ii) 3988Ω**

59. An ammeter of resistance 0.80Ω can measure currents upto 1.0 A. (i) what must be the shunt resistance to enable the ammeter to measure current upto 5.0 A? (ii) What is the combined resistance of the ammeter and the shunt? **Ans. 0.20 Ω 0.16 Ω**

60. A voltmeter reads 5.0V at full scale deflection and is graded according to its resistance per volt at full scale deflection as 5000Ω V^{-1}. How will you convert it into a voltmeter that reads 20 V at full scale deflection? Will it still be graded as 5000ΩV^{-1}? Will you prefer this voltmeter to one that is graded as 2000 ΩV^{-1}?

Problems based on Magnetism: Home - www.mywebpathshala.com

61. If the horizontal and vertical components of the earth's magnetic field are equal at a certain place, what would be the angle of dip at that place? **Ans: 45^o**

62. A short bar magnet placed with its axis at 30^o to a uniform magnetic field of 0.2T experiences a torque of 0.06 Nm. (i) calculate the magnetic moment of the magnet (ii) find out what orientation of the magnet corresponds to its stable equilibrium in the magnetic field. **Ans. (i) m = 0.6 Am^2**

63. An electron moves around the nucleus in a hydrogen atom of radius 0.51Ȧ, with a velocity $2x10^6$ m/s. calculate the following: (i) the equivalent current due to the orbital motion of electron (ii) the magnetic field produced at the centre of the nucleus (iii) the magnetic moment associated with the electron. **Ans. (i) 10^{-4}A (ii) 1.23 T (iii) 8.16 x 10^{-25} Am^2**

64. A planar loop of irregular shape encloses an area of $7.5x10^{-4}$ m^2 and carries a current of 12A. The sense of flow of current appears to be clockwise to an observer. What is the magnitude and direction of the magnetic moment vector associated with the current loop? **Ans. m = 9.0 x 10^{-3} Am^2**

65. A magnetic needle free to rotate in a vertical plane parallel to the magnetic meridian has its north tip down 60^o with the horizontal. The horizontal component of the earth's magnetic field at that place is known to be 0.04G. Determine the magnitude of the earth's magnetic field at that place. **Ans. 0.8 G**

66. A magnetizing field of 1500A/m produces a magnetic flux of $2.4x10^{-5}$ weber in a bar of iron of cross-section $0.5cm^2$. Calculate permeability and susceptibility of the iron bar used. **Ans. μ = $3.2x10^{-4}$ Tm A^{-1}, χ_m= 253.77**

67. At a certain location in Africa, a compass points 12º west of the geographic north. The north tip of the magnetic needle of a dip circle placed in the plane of magnetic meridian points 60º above the horizontal. The horizontal component of the earth's field is measured to be 0.16 G. Specify the direction and magnitude of the earth's field at the location. **Ans. 0.32 G**

68. A short bar magnet has a magnetic moment of 0.48 J T^{-1}. Give the direction and magnitude of the magnetic field produced by the magnet at a distance of 10 cm from the centre of the magnet on (a) the axis, (b) the equatorial lines (normal bisector) of the magnet. **Ans. (a) 0.96 G (b) 0.48 G**

69. A short bar magnet placed in a horizontal plane has its axis aligned along the magnetic north-south direction. Null points are found on the axis of the magnet at 14 cm from the centre of the magnet. The earth's magnetic field at the place is 0.36 G and the angle of dip is zero. What is the total magnetic field on the normal bisector of the magnet at the same distance as the null–point (i.e., 14 cm) from the centre of the magnet? (At *null points*, field due to a magnet is equal and opposite to the horizontal component of earth's magnetic field.) **Ans: 0.54 G**

70. A short bar magnet of magnetic moment 5.25×10^{-2} J T^{-1} is placed with its axis perpendicular to the earth's field direction. At what distance from the centre of the magnet, the resultant field is inclined at 45º with earth's field on (a) its normal bisector and (b) its axis. Magnitude of the earth's field at the place is given to be 0.42 G. Ignore the length of the magnet in comparison to the distances involved.