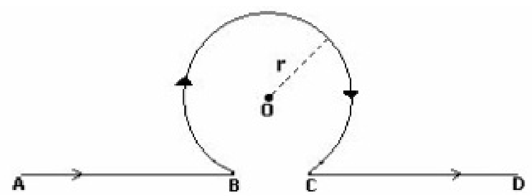
CBSE Test Paper-03

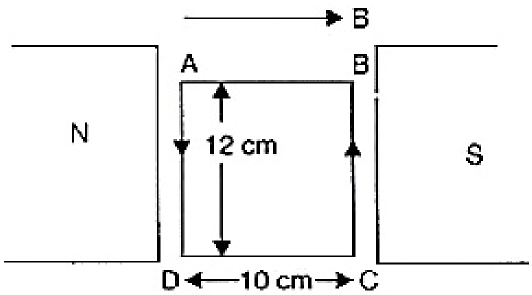
Class - 12 Physics (Moving Charges and Magnetism)

1. Which of the following is most general characteristic of Magnetic field
   a. The magnetic field exerts a force $\vec{F}$ on any other particle
   b. The magnetic field exerts a force $\vec{F}$ only on any iron filings
   c. The magnetic field exerts a force $\vec{F}$ on any other moving charge or current that is present in the field.
   d. The magnetic field exerts a force $\vec{F}$ only on any magnets present in the field.
2. The resistance of the coil of ammeter is R. The shunt resistance required to increase its range four fold should have a resistance:
   a. $\frac{R}{3}$
   b. $\frac{R}{5}$
   c. $\frac{R}{4}$
   d. 4 R
3. A wire of length L is bent to form a ring of single loop and current is flown through it. The magnetic field at its centre is B. If the same wire is bent to form 2 loops and same current is flowing, the new B' at its centre will be
   a. B
   b. $\frac{B}{2}$
   c. 4B
   d. 2B
4. An infinitely long straight conductor is bent into the shape as shown in fig. The magnetic induction at the centre of circular loop is



   a. ∞
   b. $\frac{\mu_o i}{2\pi r}\ (\pi - 1)$
   c. $\frac{\mu_o i}{2\pi r}\ (\pi + 1)$
   d. zero

5. A galvanometer of resistance 25Ω is shunted by a 2.5Ω wire. The part of total current that flows through the galvanometer is given by:
   a. $\frac{I}{I_0} = \frac{2}{11}$
   b. $\frac{I}{I_0} = \frac{4}{11}$
   c. $\frac{I}{I_0} = \frac{1}{11}$
   d. $\frac{I}{I_0} = \frac{3}{11}$
6. What is the direction of the force acting on a charged particle q, moving with a velocity $\overrightarrow{v}$ in a uniform magnetic field $\overrightarrow{B}$?
7. Using the concept of force between two infinitely long parallel current carrying conductors define one ampere of current.
8. A magnetic dipole is situated in the direction of a magnetic field. What is its potential energy? If it is rotated by 180°, then what amount of work will be done?
9. Write the SI unit of (i) magnetic pole strength (ii) magnetic dipole moment of a bar magnet.
10. A 50 turn coil as shown in the figure below carries of 2 A in a magnetic field B = 0.25 Wb m^{-2}. Find the torque acting on the coil. In what direction will it rotate?



11. What is a shunt? State its SI unit.
12. A dielectric slab of thickness 't' is kept in between the plates, each of area 'A', of a parallel plate capacitor, separated by a distance 'd'. Derive an expression for the capacitance of this capacitor for t < < d.
13. A long straight wire in the horizontal plane carries a current of 50 A in north to south direction. Give the magnitude and direction of B at a point 2.5 m east of the wire.
14. What is the toroid? Using Ampere's circuital law calculate the magnetic field inside the toroid.
15. Derive an expression for the maximum force experienced by a straight conductor of length l, carrying current I and kept in a uniform magnetic field B.

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Answers

1. c. The magnetic field exerts a force $\vec{F}$ on any other moving charge or current that is present in the field.

   Explanation: A moving charge experiences a force in a magnetic field called magnetic Lorentz force given by $\vec{F} = q\left(\vec{v} \times \vec{B}\right)$. This force acts only if the particle (i) has charge q (ii) has a non zero velocity v and (iii) does not move parallel or anti parallel to the magnetic field B. A current carrying conductor placed in a magnetic field experiences a force given by $\vec{F} = I\vec{l} \times \vec{B}$.

2. a. $\frac{R}{3}$

   Explanation: Voltage across ammetre and shunt are same. so
   $V = I \times R = 3I \times S$
   solving S= R/3

3. c. 4B

   Explanation: The radii of the coils in two cases are R_1 and R_2. Then,
   $L = 2\pi R_1 = 2 \times 2\pi R_2; R_2 = \frac{R_1}{2}$
   $B = \frac{\mu_0 I}{2R_1}$ and $B' = \frac{\mu_0 nI}{2R_2} = \frac{\mu_0 2I}{2\left(\frac{R_1}{2}\right)} = 4\frac{\mu_0 I}{2R_1} = 4B$

4. b. $\frac{\mu_o i}{2\pi r}$
   $(\pi - 1)$

   Explanation: Magnetic field directions due to straight conductor and due to circular loop are in the opposite direction
   net magnetic field is
   = $\frac{\mu_o i}{2\pi r}(\pi - 1)$

5. c. $\frac{I}{I_0} = \frac{1}{11}$

   Explanation: $S = \frac{I_g \times G}{(I - I_g)}$
   $\frac{I_g}{I} = 1/(G/S + 1)$
   $\frac{I}{I_0} = \frac{1}{11}$

6. $\because \overrightarrow{F} = q(\overrightarrow{q} \times \overrightarrow{B})$

Magnetic force is always normal to plane of $\overrightarrow{V}$ and $\overrightarrow{B}$.

7. One ampere current is the current which flows through each of two parallel uniform linear conductors of length 1m each, which are placed in free space at a distance of 1m from each other and for which they attract or repel each other with a force of 2×10^{-7}N in that space.

   The nature of the force is attractive or repulsive when the direction of currents in the two conductors are in the same or opposite directions respectively.

8. P.E. of dipole = -MB cos0^{o} = -MB

   Work done = MB(cos 0^{o} - cos 180^{o}) = M B (1 + 1) = 2 MB

9. i. The SI unit of magnetic pole strength is Am.

   ii. The SI unit of magnetic dipole strength is Am^2.

10. The sides AB and DC are along the field lines hence the force on each side is zero. The force on each vertical wire is given as

    $\tau = BINA\sin\theta$

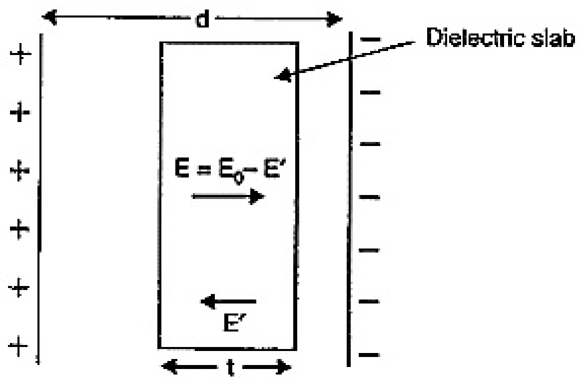
    $\tau = 0.25 \times 2 \times 50 \times 0.12 \times 0.1\sin\theta$

    = 0.3 N-m clockwise

11. A small resistance connected in parallel with a galvanometer to convert it into ammeter is called shunt. Its SI unit is ohm.

12. Let A is the area of the two plates of the parallel plate capacitor and d is the separation between them. A dielectric slab of thickness t < d and area A is kept between the two plates. The total electric field inside the dielectric slab will be:

    $E = \frac{E_0}{K} = E_0 - E'$ where E' is the opposite field developed inside the slab due to polarization of slab. Total potential difference between the plates,



    $V = E_0(d - t) + Et$

$= \frac{\sigma}{\varepsilon_0}(d-t) + \frac{\sigma}{k\varepsilon_0}t$

$= \frac{\sigma}{\varepsilon_0}\left[(d-t) + \frac{t}{k}\right]$

$V = \frac{q}{A\varepsilon_0}\left[(d-t) + \frac{t}{k}\right]$

where q is the charge on each plate.

Since, $C = \frac{q}{V}$

or $C = \frac{q}{\frac{q}{A\varepsilon_0}\left[(d-t)+\frac{t}{k}\right]}$

or $C = \frac{A\varepsilon_0}{\left[(d-t)+\frac{t}{k}\right]}$

13. Given, I = 50 A, r = 2.5 m

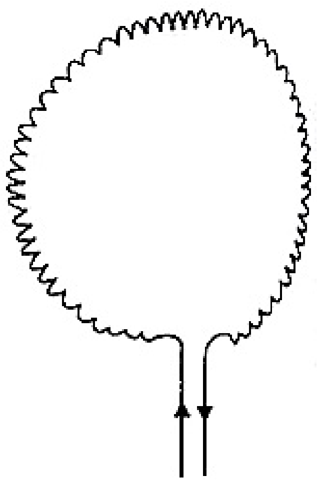
    B = ?

    As $B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\times10^{-7}\times50}{2\pi\times2.5}$

    $= 4 \times 10^{-6} T$

    Applying right hand thumb rule to find the direction of M.F. in east direction of wire it comes out upward direction.

14. When a solenoid is in the form of a ring then it is treated as toroid. Consider a toroid carrying current I and has N turns. The magnetic field is set up inside the turns of the toroid. The magnetic lines of force inside the toroid are concentric circles. By symmetry the magnitude of the field $\vec{B}$ is same at all points on the circle of radius r and is directed tangentially to the circle at any point.



$\therefore \oint \vec{B} \cdot \vec{dl} = \oint B\,dl \cos\theta^\circ$

$\oint \vec{B} \cdot \vec{dl} = \oint B\,dl \cos^\circ$

or $\oint \vec{B} \cdot \vec{dl} = B 2\pi r$

By applying Ampere's circuital law,

$\oint \vec{B} \cdot \vec{dl} = \mu_0 \times$ total current passing through circle of radius r.

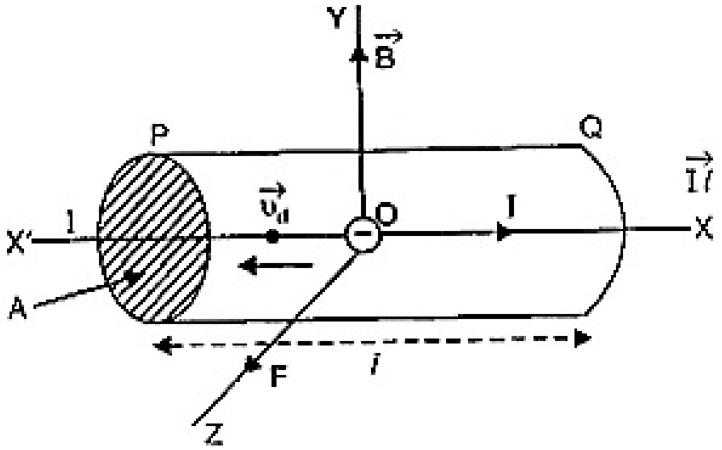
$B 2\pi r = \mu_0 \times N \times 2\pi v l$

$\therefore B = \mu_0 N I$

15. Consider a straight conductor PQ of length l, area of cross-section A carrying current I placed in a uniform magnetic field $\vec{B}$. Suppose the conductor is placed along x-axis and magnetic field acts along y-axis. Current I flows from end P to Q and electrons drift from Q to P.

Let $\vec{v_d}$ = drift velocity of electron

-e = charge on each electron



Magnetic Lorentz force on an electron is given by

$\vec{f} = -e\left(\vec{v} d \times \vec{B}\right) \left[\because F = q(\vec{v} \times \vec{B})\right]$

If n is the number of free electrons per unit volume of the conductor then total number of free electrons in the conductor will be

N = n (Al) = n A l

$\therefore$ Total force on the conductor is

$\vec{F} = N \vec{f} = nAl\left[-e(\vec{v} d \times \vec{B})\right]$

$= -nAle(\vec{v} d \times \vec{B})$ ...(i)

But the current through a conductor is related with drift velocity be the relation.

I = nAev_d

$\therefore$ I1 = nAv_dl

We represent $I \vec{1}$ as current element vector. It acts in the direction of flow of current i.e.

along OX. Then have $I\overrightarrow{1}$ and $\overrightarrow{v}d$ opposite directions. So,

$I\overrightarrow{1} = -uAle\overrightarrow{v}d$ ....(ii)

From (i) and (ii), we have

$\overrightarrow{F} I(\overrightarrow{l} \times \overrightarrow{B})$

Magnitude of

$F = I1\ B\ \sin\theta$

When $\pi = 90^{\circ}$, F_{max} = I1 B

Fleming's left hand rule: This rule gives the direction of force on current carrying conductor placed in magnetic field perpendicularly. If we stretch the fore finger, central finger and the thumb of our left hand mutually perpendicular to each other such that the fore finger points in the direction of magnetic field, central finger in the direction of current, then the thumb gives the direction of force experienced by the conductor.