O P JINDAL SCHOOL, SAVITRINAGAR

CLASS TEST & PRACTICE

ANSWER KEY

CLASS XII PHYSICS TOPIC : MOVING CHARGES AND MAGNETISM

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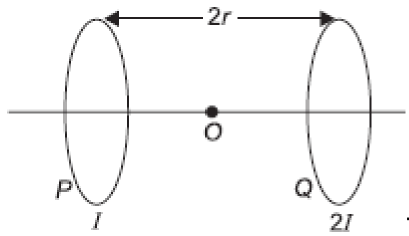
1 Two identical circular loops, P and Q, each of radius r and carrying currents I and 2I respectively are lying in parallel planes such that they have a common axis.



2

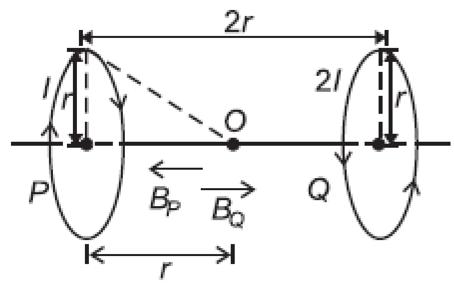
The direction of current in both the loops is clockwise as seen from O which is equidistant from both loops. Find the magnitude of the net magnetic field at point O.

Magnetic field at O due to current in loop P is given by

$$B_P = \frac{\mu_0 r^2 I}{2(r^2+r^2)^{3/2}} = \frac{\mu_0 I}{4\sqrt{2}r}$$

(pointing towards P)

Magnetic field at O due to current in loop Q is given by $B_Q = \dfrac{2\mu_0 I}{4\sqrt{2}r}$ (pointing towards) Q



Net magnetic field at O is calculated as

$$\vec{B} = \overrightarrow{B_Q} + \overrightarrow{B_P} = \frac{\mu_0 I}{4\sqrt{2}r}\hat{i}$$

ANS:

2 A circular coil of N turns and radius R carries a current I. It is unwound and rewound to make another coil of radius R/2, current I remaining the same. Calculate the ratio of the magnetic moments of the new coil and the original coil. 2

ANS: Magnetic moment of the coil having N turns and radius R carrying current I is

$$M_o = NI\pi R^2$$

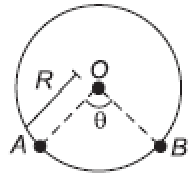
As the length of the wire making the coil remains same on reducing the radius to R/2, the number of turns increases to 2 N.

On passing the same amount of current, magnetic moment is

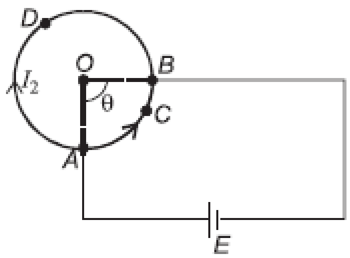
$$M_n = 2NI\pi\frac{R^2}{4} = \frac{NI\pi R^2}{2} \qquad \ldots(ii)$$

Thus, $$\frac{M_n}{M_o} = \frac{1}{2}$$

3 A wire of uniform cross-section is bent into a circular loop of radius R. Consider two points A and B on the loop, such that ∠ AOB = θ as shown. If now a battery is connected between A and B, show that the magnetic field at the centre of the loop will be zero irrespective of angle θ. 2



Let $ADB = l_2$, $ACB = l_1$, $R_{ADB} = R_2$, $R_{ACB} = R_1$



then $$\frac{R_2}{R_1} = \frac{l_2}{l_1} \qquad \ldots(i)$$

Further $$E_1 = E_2 \Rightarrow I_1R_1 = I_2R_2$$

$$\Rightarrow \frac{I_1}{I_2} = \frac{R_2}{R_1} = \frac{l_2}{l_1}$$

$$\Rightarrow I_1l_1 = I_2l_2 \qquad \ldots(ii)$$

Now, the magnetic field at O due to $ADB = \frac{\mu_0 I_2 l_2}{4\pi R^2}$ (inward)

and the magnetic field at O due to $ACB = \frac{\mu_0 I_1 l_1}{4\pi R^2}$ (outward)

$\therefore$ Magnetic field at O, $$B = \frac{\mu_0}{4\pi R^2}(I_1l_1 - I_2l_2) = 0 \qquad \text{[using (ii)]}$$

ANS: Hence proved

4 How is a moving coil galvanometer converted into a voltmeter? Explain, giving the necessary circuit diagram and the required mathematical relation used. 2

ANS: A galvanometer is a low resistance device and is very sensitive. It gives a large deflection even when a very weak current is passed through it. To measure large potential, a suitable high resistance R is connected in series with it. The value of this resistance R depends upon the voltage to be measured.

Let I_g – maximum safe current,

V_g = Range of conversion, G = Resistance of galvanometer and R = Required resistance.

$$\text{Total resistance} = R + G$$

$\therefore$ $$\text{Current} = \frac{V}{R+G}$$

This current must be equal to I_g.

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

or $$R = \frac{V}{I_g} - G$$

which is the required resistance.

5 Define the current sensitivity of a moving coil galvanometer. “Increasing the current sensitivity may not necessarily increase the voltage sensitivity.” Justify this statement. 2

ANS: Current Sensitivity: It is defined as the deflection produced in a coil per unit current passed

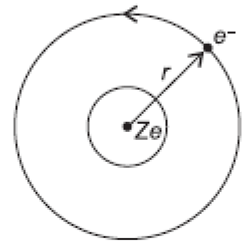
$$I_s = \frac{\alpha}{I} = \frac{NBA}{k}$$

$\because$ If $N \to 2N$, then $l \to 2l$ and $R \to 2R \Rightarrow I_s' = \frac{BA(2N)}{k} = 2I_s$

But voltage sensitivity $= V_s' = \frac{BA(2N)}{k(2R)} = \frac{BAN}{kR} = V_s$

through it. i.e. if the current sensitivity is doubled, say by doubling the number of turns, then the voltage sensitivity may not be increased because it will increase the resistance of the galvanometer and the voltage sensitivity may remain the same.

6 Deduce the expression for the magnetic dipole moment of an electron orbiting around the central nucleus. 2



Consider an electron revolving around the nucleus of an atom. The electron is in a uniform circular motion around the nucleus of charge $+Ze$. This constitutes a current.

$\therefore$ $$I = \frac{e}{T} \quad \ldots (i)$$

If r is the orbital radius of the electron and 'v' is the orbital speed, then the time period is given as

$$T = \frac{2\pi r}{v} \quad \ldots (ii)$$

From equations (i) and (ii), we get

$$I = \frac{ev}{2\pi r} \quad \ldots (iii)$$

As the magnetic moment is given by

$$\mu_l = I\pi r^2$$

We have $$\mu_l = \left(\frac{ev}{2\pi r}\right)\pi r^2 = \frac{evr}{2}$$

Multiplying and dividing by m_e in above equation, we get

$$\mu_l = \frac{evm_e r}{2m_e} = \frac{e}{2m_e} l$$

where l is the angular momentum of the electron. According to the Bohr hypothesis, the angular momentum can have discrete values only.

i.e. $$l = \frac{nh}{2\pi}$$

So, $$\mu_l = \frac{enh}{2\pi(2m)} = \frac{neh}{4\pi m}$$

ANS: In this case it is directed into the plane of the paper.

7 A charged particle of mass *m* and charge q moving at uniform velocity *v*, enters a uniform magnetic field *B* acting normal to the plane of the paper. Deduce expression for the (*i*) radius of the circular path in which it travels and (*ii*) kinetic energy of the particle. 2

(*i*) Centripetal force is provided by the magnetic force.

$$\therefore \frac{mv^2}{r} = qvB \sin 90^\circ \Rightarrow \text{Radius, } r = \frac{mv}{Bq}$$

ANS: (*ii*) $\because v = \frac{qBr}{m} \quad \therefore K.E. = \frac{1}{2}mv^2 = \frac{B^2q^2r^2}{2m}$

8 A charge q moving in a straight line is accelerated by a potential difference V. It enters into a uniform magnetic field B perpendicular to its path. Deduce, in terms of V, an expression for the radius of the circular path in which it travels. 2

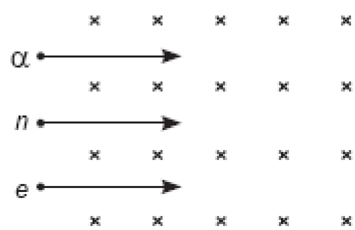
ANS: Gain in K.E. = Work done on the charge particle

$$\frac{1}{2}mv^2 = qV \quad \Rightarrow \quad v^2 = \frac{2qV}{m} \Rightarrow v = \sqrt{\frac{2qV}{m}}$$

$$\because \quad F_m = F_c$$

$$qvB \sin 90° = \frac{mv^2}{r} \quad \Rightarrow \quad r = \frac{mv}{qB} = \frac{m}{qB}\sqrt{\frac{2qV}{m}} \; ; \; r = \sqrt{\frac{2mV}{qB^2}}$$

9 (a) Write the expression for the magnetic force acting on a charged particle moving with velocity v in the presence of magnetic field B.
(b) A neuron, an electron and an alpha particle moving with equal velocities, enter a uniform magnetic field going into the plane of the paper as shown. Trace their paths in the field and justify your answer. 2



ANS:

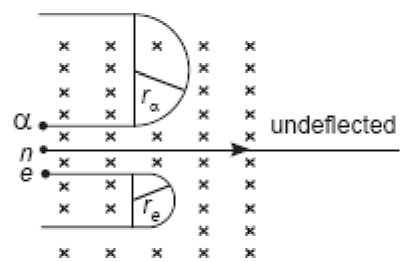
(a) $\vec{F} = q(\vec{v} \times \vec{B})$

(b) $r = \frac{mv}{Bq} \propto \frac{m}{q}, \; \because \; q_\alpha = 2e$

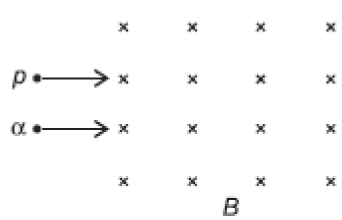
$$\therefore \; \frac{r_\alpha}{r_e} = \frac{4m_\alpha}{2e} \times \frac{e}{m_e} = \frac{2m_\alpha}{1m_e},$$

$\because \; m_\alpha >>> m_e \; \therefore \; r_\alpha >>> r_e$

Neutron being neutral will go undeflected.

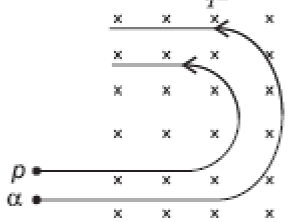


10 An α-particle and a proton moving with the same speed enter the same magnetic field region at right angles to the direction of the field. Show the trajectories followed by the two particles in the region of the magnetic field. Find the ratio of the radii of the circular paths which the two particles may describe. 2



ANS: As, $\vec{F} = q(\vec{v} \times \vec{B})$, we find an α-particle and a proton are moving anticlockwise. The radius of circular path of a charged particle in the magnetic field is

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



The ratio of radii of circular paths for an α-particle and a proton is

$$\frac{r_\alpha}{r_p} = \frac{m_\alpha}{m_p} \times \frac{q_p}{q_\alpha}$$

As $m_\alpha = 4m_p$

$$q_\alpha = 2q_p$$

$$\frac{r_\alpha}{r_p} = \frac{4}{2} \Rightarrow \frac{r_\alpha}{r_p} = \frac{2}{1}$$