O P JINDAL SCHOOL, SAVITRINAGAR

CLASS TEST & PRACTICE

ANSWER KEY

CLASS XII PHYSICS TOPIC : MOVING CHARGES AND MAGNETISM

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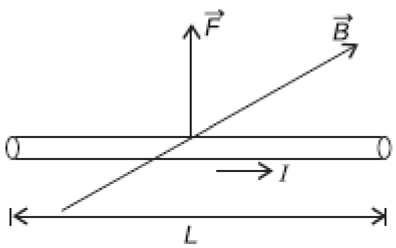
1 A straight wire of length *L*, carrying a current *I*, stays suspended horizontally in mid air in a region where there is a uniform magnetic field $\vec{B}$. The linear mass density of the wire is λ. Obtain the magnitude and direction of this magnetic field. 2

$$\lambda = \frac{\text{mass}}{\text{length}} \Rightarrow \text{mass} = m = \lambda L$$

According to the question, $ILB = \lambda L g$

ANS: $\therefore \quad B = \frac{\lambda}{I} g$



Magnetic field will act in the direction perpendicular to the direction of flow of current.

2 A particle of charge *q* and mass *m* is moving with velocity $\vec{v}$. It is subjected to a uniform magnetic field $\vec{B}$ directed perpendicular to its velocity. Show that it describe a circular path. Write the expression for its radius. 2

ANS: According to the Lorentz magnetic force, $\vec{F} = q(\vec{v} \times \vec{B})$ The magnetic force acts always perpendicular to the velocity of the charged particle and changes only the direction of motion of charged particle. As force acts always perpendicular to velocity vector, it provides a centripetal force.

Here $F = qvB \quad (\because \theta = 90°) \qquad \ldots(i)$

$$F_c = \frac{mv^2}{r} \qquad \ldots(ii)$$

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

$$\frac{mv^2}{r} = qvB \Rightarrow r = \frac{mv}{qB}$$

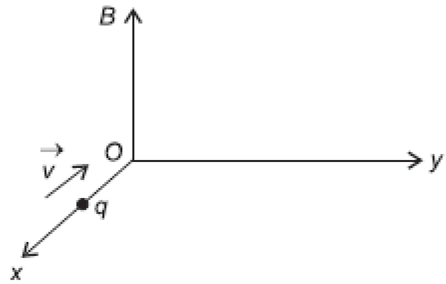
3 Write the expression for Lorentz magnetic force on a particle of charge *q* moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$. Show that no work is done by this force on the charged particle. 2

Lorentz magnetic force, $\vec{F} = q(\vec{v} \times \vec{B})$

ANS: $\because$ Work done $= \vec{F}.\vec{S}. \; (\because \vec{S} \,||\, \vec{v})$ As the force is acting in a direction normal to the velocity of a charged particle (i.e. displacement), no work is done by the force.

4 A charge q moving along the x-axis with a velocity $\vec{v}$ is subjected to a uniform magnetic field B acting 2

along the z-axis as it crosses the origin O.

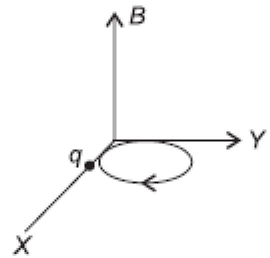


(i) Trace its trajectory.

(ii) Does the change gain kinetic energy as it enters the magnetic field? Justify your answer.

ANS:

(*i*) According to the question, the velocity is $-v\hat{i}$ and the magnetic field is $B\hat{k}$.



Since, $$\vec{F} = q(\vec{v} \times \vec{B})$$
$$\vec{F} = -q(v\hat{i} \times B\hat{k}) = qvB\hat{j}$$

At the origin, it will move along positive y-axis.

(*ii*) Kinetic energy does not change irrespective of the direction of the motion of charge as,

Power delivered $= \dfrac{\Delta W}{\Delta t} = \vec{F} \cdot \vec{v} = q(\vec{v} \times \vec{B}).\vec{v} = 0 \Rightarrow W.D. = 0$

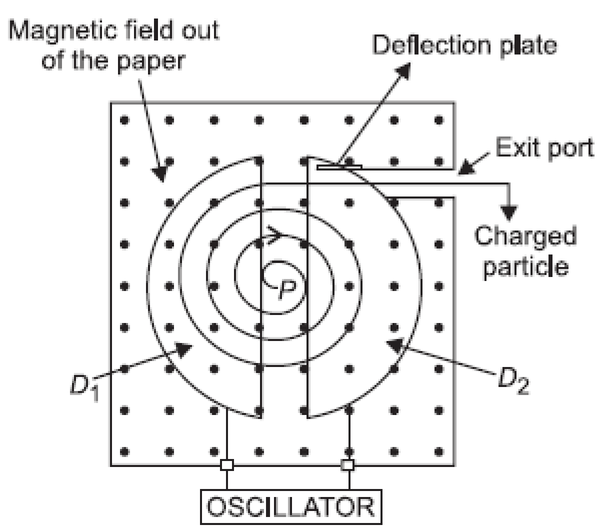
[$\because$ Scalar triple product $(\vec{v} \times \vec{B}) \cdot \vec{v} = 0$]

$\because$ $W.D. = \Delta K.E. = 0$ or kinetic energy remains constant.

5 (i) Name the machine which uses crossed electric and magnetic fields to accelerate the ions to high energies. With the help of a diagram, explain the resonance condition. 2

(ii) What will happen to the motion of charged particle if the frequency of the alternating voltage is doubled?

ANS:



(i) The machine is cyclotron. A cyclotron is in resonance, when the oscillator frequency (n) is equal to the cyclotron frequency (nc).

(ii) On doubling the frequency, the resonance condition will not be satisfied. Therefore, a charged particle will not come out in stipulated time.

6 What is velocity selector? Write its uses. 2

ANS: Velocity selector is a device consisting of perpendicular electric and magnetic fields that can be used as a velocity filter for charged particles. It is used to measure charge to mass ratio and is also used in Mass Spectrometer.

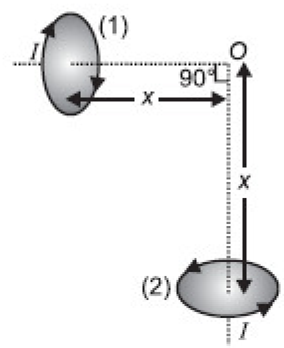
7 Both, the electric and magnetic fields can deflect a moving electron. What is the difference between these deflections? 2

ANS: In electric field; the speed of an electron may increase or decrease and, if it enters the electric field perpendicularly, then it will move along a parabolic path. Whereas, in magnetic field, an electron will move along a circular path, without any change in its speed.

8 State the underlying principle of a cyclotron. Write briefly how this machine is used to accelerate charged particles to high energies. 2

ANS: Principle: The energy of charged particles or ions can be made to increase by using the crossed electric and magnetic fields.
The magnetic field makes the charged particles move in a circular path, while moving from one dee to another, a particle is acted upon by the alternating electric field, and is accelerated by this field. As a result, the energy of particles increases.

9 Two very small identical circular loops, (1) and (2), carrying equal currents I are placed vertically (with respect to the plane of the paper) with their geometrical axes perpendicular to each other as shown in the figure. Find the magnitude and direction of the net magnetic field produced at the point O.



2

ANS:

$$\vec{B_1} = \frac{\mu_0}{4\pi}\frac{2M}{(R^2+x^2)^{3/2}} \text{ along } \overrightarrow{OA}$$

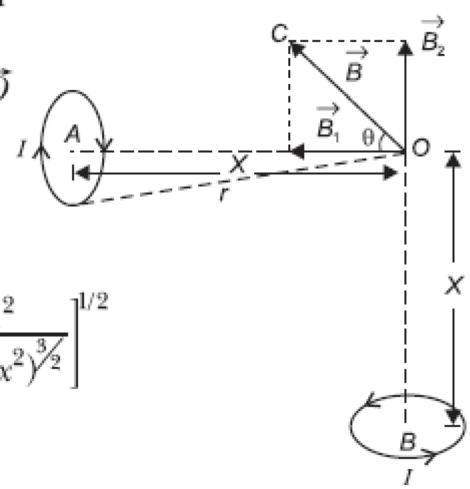
$$\vec{B_2} = \frac{\mu_0}{4\pi}\frac{2M}{(R^2+x^2)^{3/2}} \text{ along } \overrightarrow{BO}$$

$$\because \vec{B_1} \perp \vec{B_2}, \text{ and } |\vec{B_1}| = |\vec{B_2}|$$

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

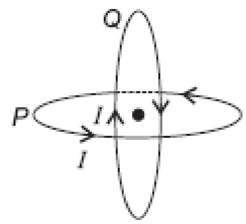
$$B = 2\sqrt{B_1} = 2\left(\frac{\mu_0}{4\pi}\cdot\frac{2I\times\pi R^2}{(R^2+x^2)^{3/2}}\right)^{1/2} = 2\left[\frac{\mu_0}{2}\frac{IR^2}{(R^2+x^2)^{3/2}}\right]^{1/2}$$

$$\theta = \tan^{-1}\left(\frac{B_2}{B_1}\right) = 45^\circ \text{ from } \overrightarrow{OA}$$



10 Two identical circular wires P and Q each of radius R and carrying current I are kept in perpendicular planes such that they have a common centre as shown in the figure. Find the magnitude and 2

direction of the net magnetic field at the common centre of the two coils.



ANS: Magnetic field at the centre of a circular loop of radius R carrying current I is given by

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

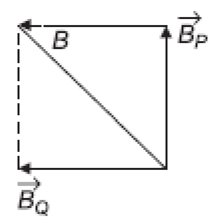
Here $B_P = \frac{\mu_0 I}{2R}$ [directed vertically upward]

$$B_Q = \frac{\mu_0 I}{2R}$$

[directed along horizontal direction say left]

Resultant magnetic field, $B = \sqrt{B_P^2 + B_Q^2} = \sqrt{2} B_P$

i.e. $B = \sqrt{2}\left(\frac{\mu_0 I}{2R}\right)$; $B = \frac{\mu_0 I}{\sqrt{2} R}$



$\because$ $\tan\beta = \frac{B_P}{B_Q} = 1$

$\therefore$ $\beta = 45°$

The resultant magnetic field is $\frac{\mu_0 I}{\sqrt{2} R}$ making an angle of 45° with the horizontal.