ITU PHYSICS ENGINEERING. STUDENT, **dec05, 16**
IDENTITY NUMBER :
NAME LASTNAME :
FIZ 411E QUIZ – 7 POINT :

[**Question.1**] (*80/100 Pnts*) About a moving charge in the **B**.
[**Question.1.1**] (*30/100 Pnts*) Obtain the linear momentum p expression, for the moving charge in a plane perpendicular to $\mathbf{B}_{\otimes}$[1]. Let us take the charge as q.

Hint-1: Let us assume that the motion of a charged particle in a magnetic field is **circular**. Let us take the radius R. Sketch the figure.

[**Answer.1.1**] (*30/100 Pnts*)

With the help of Hint-1,

let us sketch the figure as:

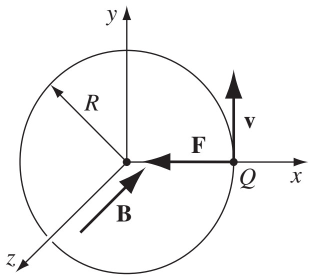

FIG. 1: cyclotron motion

Then,

$$\begin{aligned}
\mathbf{F_B} &= q\,(\mathbf{v}\times\mathbf{B})\ , \\
& \quad \text{and} \\
\mathbf{F} &= m\mathbf{a}\ , \\
&= m\,\frac{v^2}{R}\ , \\
& \quad \text{by equaling two forces to each other}\ , \\
F_B &= F \\
q\ v\ B &= m\frac{v^2}{R}\ , \\
\therefore p &= q\ B\ R\ . \qquad (1)
\end{aligned}$$

here we use $p = mv$.

[1] $\otimes$ shows that the direction of **B** is into the page.

[**Question.1.2**] (*50/100 Pnts*) A particle of charge q enters a region of uniform magnetic field $\mathbf{B}_{\otimes}$. The field deflects the particle a distance d above the original line of flight, as shown in the following Figure. Is the charge positive or negative? In terms of a, d, B and q, find the linear momentum of the particle.

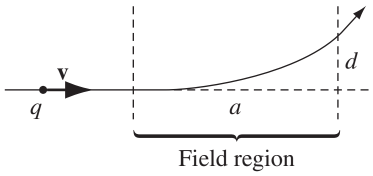

FIG. 2: trajectory of the charge q

Hint-2: Use the found expression p in your result for the [**Question.1.1**].

[**Answer.1.2**] (*50/100 Pnts*)

Due to $\boldsymbol{F}_B = q\,\boldsymbol{v} \times \boldsymbol{B}$. Let us take, $\boldsymbol{v} = \hat{\boldsymbol{i}}v$ and $\boldsymbol{B} = -\hat{\boldsymbol{k}}B$, thus the sign of $\boldsymbol{F} = \hat{\boldsymbol{j}}F$ is positive. Then q is the positive charge.

By using Hint-2, we should use the equation (), we need to find R in terms of the values a and d.

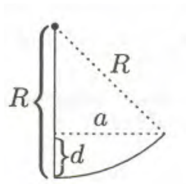

FIG. 3: trajectory radius

With the help of above figure, we obtain the $R = \frac{1}{2d}(a^2 + d^2)$ by using the pythagoras theorem.

Then we find the expression p as

$$\therefore p = q\,B\,\frac{1}{2d}(a^2 + d^2)\,. \tag{2}$$

[**Question.2**] (*20/100 Pnts*) Please derive the most general expressions of $\boldsymbol{F}_B$ for the carrying current line, and surface and volume **current** densities, $\boldsymbol{I}$, $\boldsymbol{\kappa}$ and J, respectively.

Hint-3: Use the Lorentz Force law.

Apply $\boldsymbol{I} = \lambda\, \boldsymbol{v}$, $\boldsymbol{\kappa} = \sigma\, \boldsymbol{v}$, $\boldsymbol{J} = \rho\, \boldsymbol{v}$ and $dq \sim \lambda\, dl \sim \sigma\, da \sim \rho\, d\tau$ to the Lorentz Force law.

[**Answer.2**] (*20/100 Pnts*)

With the help of Hint-3, by remembering Lorentz Force law(LFL), $\boldsymbol{F}_B \;=\; q\,(\boldsymbol{v} \times \boldsymbol{B})$.

• By applying $\boldsymbol{I} = \lambda\, \boldsymbol{v}$ and $dq \sim \lambda\, dl$ to LFL,

$$\begin{aligned} \int d\boldsymbol{F}_B &= \int dq(\boldsymbol{v} \times \boldsymbol{B})\ , \\ \boldsymbol{F}_B &= \int \lambda\, dl(\boldsymbol{v} \times \boldsymbol{B})\ , \\ \therefore \boldsymbol{F}_B &= \int dl(\boldsymbol{I} \times \boldsymbol{B})\ . \end{aligned} \tag{3}$$

Also, if $\boldsymbol{I}$ and $d\boldsymbol{l}$ both point in the same direction, we can write as

$$\therefore \boldsymbol{F}_B = I \int (d\boldsymbol{l} \times \boldsymbol{B})\ . \tag{4}$$

• By applying $\boldsymbol{\kappa} = \sigma\, \boldsymbol{v}$ and $dq \sim \sigma\, da_\perp$ to LFL,

$$\begin{aligned} \int d\boldsymbol{F}_B &= \int dq(\boldsymbol{v} \times \boldsymbol{B})\ , \\ \boldsymbol{F}_B &= \int \sigma\, da_\perp(\boldsymbol{v} \times \boldsymbol{B})\ , \\ \therefore \boldsymbol{F}_B &= \int da_\perp(\boldsymbol{\kappa} \times \boldsymbol{B})\ . \end{aligned} \tag{5}$$

• By applying $\boldsymbol{J} = \sigma\, \boldsymbol{v}$ and $dq \sim \rho\, d\tau$ to LFL,

$$\begin{aligned} \int d\boldsymbol{F}_B &= \int dq(\boldsymbol{v} \times \boldsymbol{B})\ , \\ \boldsymbol{F}_B &= \int \rho\, d\tau(\boldsymbol{v} \times \boldsymbol{B})\ , \\ \therefore \boldsymbol{F}_B &= \int d\tau(\boldsymbol{J} \times \boldsymbol{B})\ . \end{aligned} \tag{6}$$