PHYS 102: General Physics 2 **KOÇ UNIVERSITY** **Spring Semestre 2012**

College of Arts and Sciences

Section 1 **Quiz 7** **29 March 2012**

Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

A particle with a charge of $-1.24\times10^{-8}\,C$ is moving with instantaneous velocity $\vec{v}=(4.19\times10^{4}\,m/s)\hat{i}+(-3.85\times10^{4}\,m/s)\hat{j}$. What is the force exerted on this particle by a magnetic field

a) $\vec{B}=(1.40T)\hat{i}$ and

b) $\vec{B}=(1.40T)\hat{k}$?

Magnetic Force on a Moving Charge:

$\vec{F} = q\,\vec{v}\times\vec{B}$

a) $\vec{F} = (-1.24\times10^{-8}\,C)\,[4.19\times10^{4}\,m/s\,\hat{i} - 3.85\times10^{4}\,m/s\,\hat{j}]\times(1.40T\,\hat{i})$

since $\hat{i}\times\hat{i}=0$ & $-\hat{j}\times\hat{i}=\hat{k}$

$= -1.24\times3.85\times1.40\times10^{4}\ N\ \hat{k}$

b) $\vec{F} = (-1.24\times10^{-8}c)[4.19\times10^{4}\,m/s\,\hat{i} - 3.85\times10^{4}\,m/s\,\hat{j}]\times(1.40T\,\hat{k})$

$\hat{i}\times\hat{k} = -\hat{j}$

$-\hat{j}\times\hat{k} = -\hat{i}$

$= +[1.24\times4.19\times1.40\times10^{4}\,N\,\hat{j} + 1.24\times3.85\times1.40\ N\ \hat{i}]$

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Section 2 Quiz 7 29 March 2012

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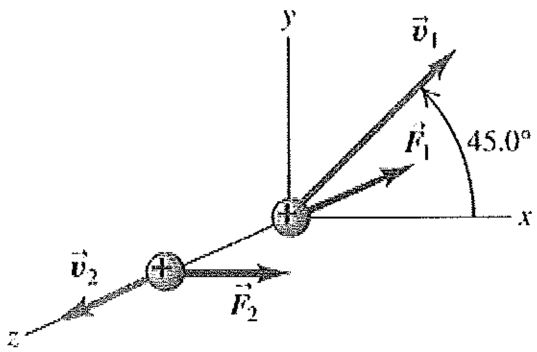
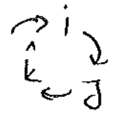
Quiz duration: 15 minutes

Name: Student ID: Signature:

When a particle of charge q>0 moves with a velocity of $\vec{v}_1$ at 45^0 from the x axis in the xy-plane, a uniform magnetic field exerts a force $\vec{F}_1$ along the –z-axis as shown in the figure. When the same particle moves with a velocity $\vec{v}_2$ with the same magnitude as $\vec{v}_1$ but along the +z-axis, a force $\vec{F}_2$ of magnitude F_2 is exerted along the +x-axis.

a) What are the magnitude (in terms of q, v, and F_2) and direction of the magnetic field?
b) What is the magnitude of $\vec{F}_1$ in terms of F_2?





let $|\vec{v}_1| = v$, so $\vec{v}_1 = v\cos(45°)\,\hat{i} + v\sin(45°)\,\hat{j}$

$\vec{v}_1 = \frac{v\sqrt{2}}{2}(\hat{i} + \hat{j})$

$\vec{F}_1 = q\,\vec{v}_1 \times \vec{B}$ let $\vec{B}$ be a generic field s.t. $\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$

$\vec{F}_1 = q\frac{\sqrt{2}}{2}v(\hat{i}+\hat{j}) \times (B_x\hat{i} + B_y\hat{j} + B_z\hat{k})$

$= \frac{q\sqrt{2}}{2}v\,(B_y\hat{k} - B_z\hat{j} - B_x\hat{k} + B_z\hat{i})$ (1)

Since $\vec{F}_1$ lies along the -z-axis ; $\vec{F}_1 = |\vec{F}_1|\,\hat{k}$

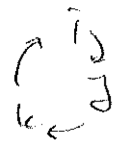
Thus, in the RHS of eqn.(1) only terms w/ $\hat{k}$ lives.

$B_z = 0 \Rightarrow (\vec{B} = B_x\hat{i} + B_y\hat{j})$

$\vec{F}_1 = vq\frac{\sqrt{2}}{2}(B_y - B_x)\hat{k}$, $(B_y < B_x)$

When the particle moves with

$$\vec{v}_2 = v\,\hat{k}$$



$$\vec{F}_2 = q\,\vec{v}_2 \times \vec{B}$$

$$= q\,v\hat{k} \times [B_x\,\hat{i} + B_y\,\hat{j}]$$

$$= qv\,[B_x\,\hat{j} - B_y\,\hat{i}]$$

But $\vec{F}_2 = |\vec{F}_2|\,\hat{i}$ $\Big\}$ $\Rightarrow B_x = 0 \Rightarrow \vec{B} = B_y\,\hat{j}$

And $|\vec{F}_2| = qv(-B_y) \Rightarrow B_y = -\dfrac{|\vec{F}_2|}{qv}$

$$\vec{B} = -\frac{|\vec{F}_2|}{qv}\,\hat{j} \quad \text{: towards } -y \text{ axis}$$

with $B_x = 0$

$$\frac{|\vec{F}_1| = +qv\frac{\sqrt{2}}{2}B_y}{|\vec{F}_2| = qv\,B_y} \Bigg\} \Rightarrow \frac{|\vec{F}_1|}{|\vec{F}_2|} = \frac{\sqrt{2}}{2}$$

$$|\vec{F}_1| = \frac{\sqrt{2}}{2}|\vec{F}_2|$$

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Section 3 **Quiz 7** **29 March 2012**

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Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

A particle with charge q is moving with speed v in the –y-direction. It is moving in a uniform magnetic field $\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$.

a) What are the components of the force $\vec{F}$ exerted on the particle by the magnetic field?
b) If q>0, what must the signs of the components of $\vec{B}$ if the components of $\vec{F}$ are all nonnegative?
c) If q<0, and $B_x = B_y = B_z > 0$, find the direction of $\vec{F}$ and find the magnitude of $\vec{F}$ in terms of $|q|$, v, B_x

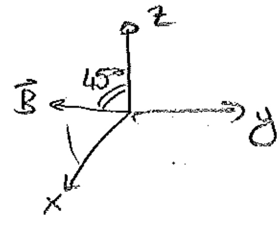
$\vec{v} = -v\hat{j}$, $v>0$

a) $\vec{F} = q\vec{v}\times\vec{B} = -qv\hat{j}\times[B_x\hat{i}+B_y\hat{j}+B_z\hat{k}]$
$= -qv(-B_x\hat{k} + B_z\hat{i})$
$= -qvB_z\hat{i} + qvB_x\hat{k}$

On the other hand,
$\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$
So $F_x = -qvB_z$, $F_y = 0$ and $F_z = qvB_x$

b) If $q>0$ and $F_x, F_y, F_z \geq 0$
Then $-qvB_z \geq 0$ (+)(+) $\Rightarrow B_z \leq 0$
$qvB_x \geq 0 \Rightarrow B_x \geq 0$, sign of B_y is arbitrary

c) If $q<0$ and $B_x = B_y = B_z > 0$
$\vec{F} = -qvB_x\hat{i} + qvB_x\hat{k} = -qvB_x(+\hat{i}+\hat{k})$ ($-qvB_x > 0$)



$|\vec{F}| = qvB_x\sqrt{2}$

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Section 4 **Quiz 7** **29 March 2012**

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Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

An open plastic bottle with an opening diameter of 2.5 cm is placed on a table. A uniform 1.75 T magnetic field directed upward parallel to vertical encompasses the bottle. What is the total magnetic flux through the plastic of the bottle.

diameter, $R = 2.5 \times 10^{-2}$ m

radius, $r = \frac{R}{2} = 1.25 \times 10^{-2}$ m

Gauss law for Magnetic field:

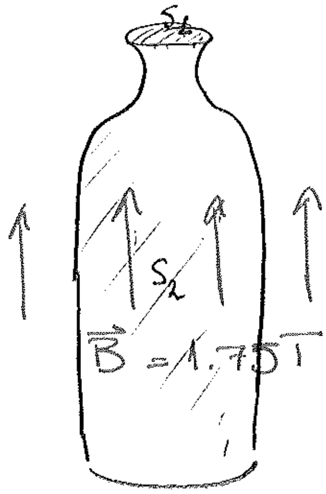
$$\oint \vec{B} \cdot d\vec{A} = 0$$

$$\int_{S_1} \vec{B} \cdot d\vec{A} + \int_{S_2} \vec{B} \cdot d\vec{A} = 0$$

$$\Rightarrow \int_{S_2} \vec{B} \cdot d\vec{A} = - \int_{S_1} \vec{B} \cdot d\vec{A}$$

$$= - B \int_{S_1} dA \quad = \pi r^2$$

$$= - 1.75\,T \times \pi (1.25 \times 10^{-2}\,m)^2$$



The total surface, $S \equiv S_1 + S_2$

S_1: opening surface

S_2: plastic surface.

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Section 5 **Quiz 7** **29 March 2012**

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Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

A particle with charge q and initial velocity $\vec{v}_0 = v_{x0}\hat{\imath} + v_{y0}\hat{\jmath}$ enters a region of uniform electric and magnetic fields. The magnetic field in the region is $\vec{B} = B_x\hat{\imath} + B_z\hat{k}$. Calculate the magnitude and direction of the electric field in the region if the particle is to pass through undeflected.

Force due to magnetic field

$$\vec{F}_M = q\vec{v}_0 \times \vec{B} = q\,(v_{x0}\hat{\imath} + v_{y0}\hat{\jmath}) \times (B_x\hat{\imath} + B_z\hat{k})$$

$$= q\begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ v_{x0} & v_{y0} & 0 \\ B_x & 0 & B_z \end{vmatrix} = q\,(v_{y0}B_z)\hat{\imath} - q\,(v_{x0}B_z)\hat{\jmath} - q\,(B_x v_{y0})\hat{k}$$

Force due to electric field,

$$\vec{F}_E = q\vec{E} = q\,(E_x\hat{\imath} + E_y\hat{\jmath} + E_z\hat{k})$$

If the particle passes through the region undeflected the net force on the particle is zero!

So $\vec{F}_E = -\vec{F}_M$

$$q(E_x\hat{\imath} + E_y\hat{\jmath} + E_z\hat{k}) = -q[-v_{y0}B_z\hat{\imath} + v_{x0}B_z\hat{\jmath} + B_x v_{y0}\hat{k}]$$

$$\Rightarrow E_x = -v_{y0}B_z, \quad E_y = v_{x0}B_z, \quad E_z = B_x v_{y0}$$

Thus,

$$\vec{E} = -v_{y0}B_z\hat{\imath} + v_{x0}B_z\hat{\jmath} + B_x v_{y0}\hat{k}$$