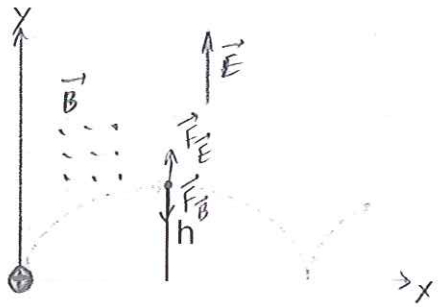
PHYS 102: General Physics - KOÇ UNIVERSITY
College of Sciences
Quiz 6 Nov 18, 2016

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes
Name: **ID #:** **Signature:**

Q. A particle with mass m and positive charge q starts from rest at the origin shown in the figure.There is a uniform electric field $\vec{E}$ in the y-direction and a uniform magnetic field $\vec{B}$ directed out of the page. The trajectory of the particle (not a circle) is shown. If the maximum height is h. calculate the speed at the point of maximum height by using energy conservation in terms of h and other given quantities. What is direction and magnitude of the total force acting on the particle at this point?



$$W = qEy = \frac{1}{2}mv^2 \longrightarrow v = \sqrt{\frac{2qEy}{m}}.$$

$$\text{At top: } F = qE - qvB = -\frac{mv^2}{R} = -\frac{m}{2y}\frac{2qEy}{m} = -qE$$

$$\Rightarrow 2qE = qvB \Rightarrow v = \frac{2E}{B}$$

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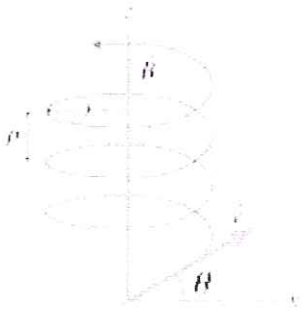
Q. A particle with charge q follows a helical path in a uniform magnetic field $\vec{B}$, if its initial velocity has components both parallel and perpendicular to $\vec{B}$. The radius r and the pitch p of the helical orbit are shown in the figure. Which of the quantities (B, v, θ) determine the ratio p/r? Calculate p/r.



$$T = \frac{2\pi r}{v_\perp} = \frac{2\pi r}{v\cos\theta}$$

$$P = v_\parallel T = T v \sin\theta = \frac{2\pi r}{v\cos\theta} v \sin\theta = 2\pi r \tan\theta$$

$$\Rightarrow \frac{P}{r} = 2\pi \tan\theta$$

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Q. Typical speed of a N_2 molecule in air at room temperature is $v = 5.0 \times 10^2$ m/s. An ionized N_2 molecule with charge $e = 1.6 \times 10^{-19}$C and mass $m = 4.6 \times 10^{-26}$kg is moving along x-direction. Earth's magnetic field is along y-direction and has magnitude 0.5G (1G $= 10^{-4}$T). Find the ratio of the particle's weight to the magnetic force acting on it. Which is dominant?

$$\vec{F} = q\vec{v} \times \vec{B} = q\left[(v\,\hat{i}) \times (B_y\,\hat{j})\right] = q\,v_x B_y\,\hat{k}$$

$$\frac{m\vec{g}}{|\vec{F}|} = \frac{mg}{qvB} = \frac{4.6 \times 10^{-26} \times 9.8}{1.6 \times 10^{-19} \times 5 \times 10^{2} \times 0.5 \times 10^{-4}} = 1.127 \times 10^{-4}$$

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Q. A particle with charge q is subject to a magnetic force $\vec{F} = F_y\,\hat{j} + F_z\,\hat{k}$ when it is travelling in a uniform magnetic field $\vec{B}$ with an instantaneous velocity $\vec{v} = v_0\,\hat{i}$. Deduce all you can about $\vec{B}$.

$$\vec{F} = q\vec{v}\times\vec{B} = qv_0\,\hat{i}\times(B_x\,\hat{i} + B_y\,\hat{j} + B_z\,\hat{k})$$

$$= qv_0\,(B_x\,\underbrace{\hat{i}\times\hat{i}}_{0} + B_y\,\underbrace{\hat{i}\times\hat{j}}_{\hat{k}} + B_z\,\underbrace{\hat{i}\times\hat{k}}_{-\hat{j}})$$

$$= -qv_0 B_z\,\hat{j} + qv_0 B_y\,\hat{k}$$

and $\vec{F} = F_y\,\hat{j} + F_z\,\hat{k}$

$$\Rightarrow\quad B_z = -\frac{F_y}{qv_0}\,,\quad B_y = \frac{F_z}{qv_0}$$

and B_x is undetermined!