

9/7/21

Home Assignment 4

1. If a particle of charge q is moving with velocity v along the x -axis and the magnetic field B is acting the x -axis, use the expression $\vec{F} = q(\vec{v} \times \vec{B})$ to find the dirⁿ of the force F acting on it.

A beam of proton passes undeflected with a horizontal velocity v , through a region of electric and magnetic field, mutually \perp to each other and normal to the direction of the beam. If the magnitudes of the electric and magnetic fields are 100 kV/m and 50 mT respectively, calculate

- i) Velocity v of the beam.
- ii) force with which it strikes a target on a screen, if proton beam current is equal to 0.80 mA .

ans

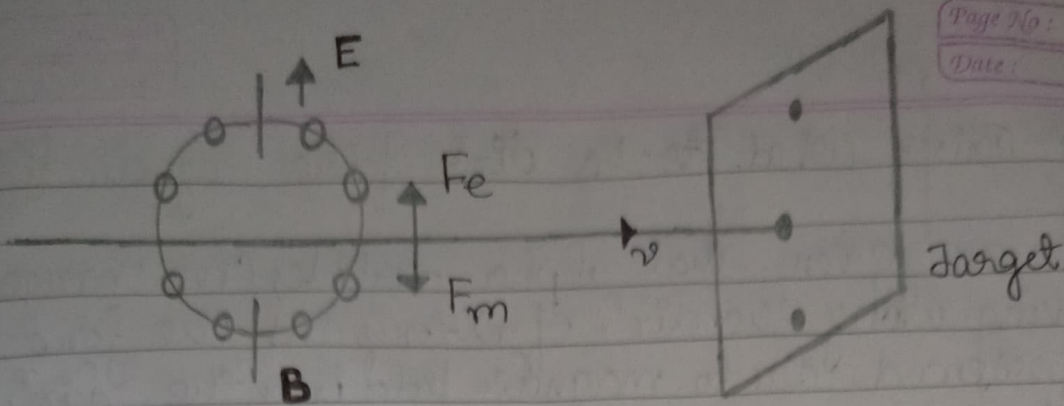
$$\vec{F} = q\vec{v} \times \vec{B}$$

Given, $\vec{v} = v\hat{k}$, $\vec{B} = B\hat{i}$

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

That is, force is acting along y -axis.

- (i) For a beam of charged particles to pass undeflected crossed electric and magnetic fields, the condition is that electric and magnetic forces on the beam must be equal and opposite i.e.,



$$eE = evB$$

$$\Rightarrow v = E/B$$

Given $\therefore E = 100 \text{ kV/m} = 100 \times 10^3 \text{ V/m}$
 $B = 50 \text{ mT} = 50 \times 10^{-3} \text{ T}$

$$v = \frac{100 \times 10^3}{50 \times 10^{-3}} = 2 \times 10^6 \text{ m/s.}$$

(ii) The beam strikes the target with a constant velocity, so force exerted on the target is zero. However, if proton beam comes to rest, it exerts a force on the target, equal to rate of change of linear momentum of the beam i.e.,

$$F = \frac{\Delta p}{\Delta t} = \frac{mv}{\Delta t} = \frac{mv}{q/i} = \frac{mvq}{q} = \frac{mvq}{ne}$$

where 'n' is the number of protons striking the target per second.

2. A beam of α -particles projected along +X-axis, experiences a force due to a magnetic field along the

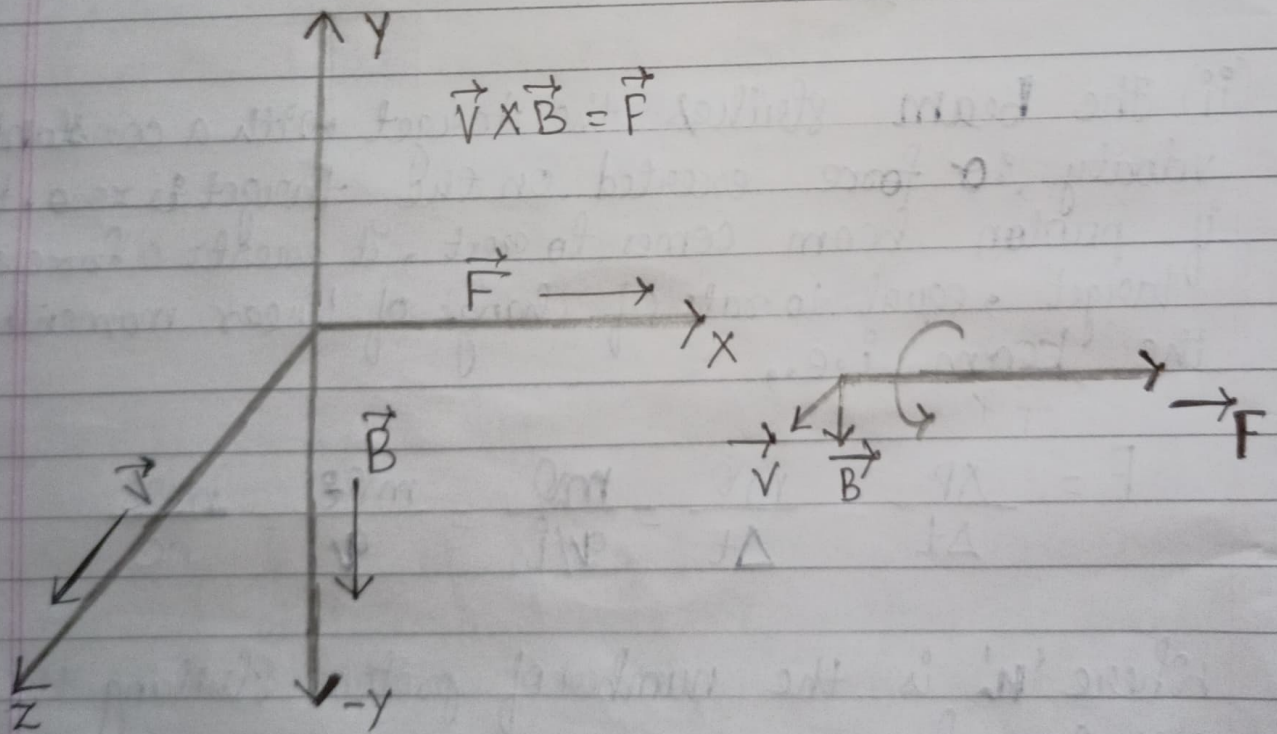
Teacher's Signature

+Y-axis. What is the dirⁿ of the magnetic field?

ans we are given - that alpha particles (+ve charge) moving along the dirⁿ of +X-axis and the force experienced due to magnetic field is in the dirⁿ of +Y-axis.

Since the force is vector product and it is given by $\vec{v} \times \vec{B} = \vec{F}$

Magnetic field should be in the direction of z-axis as shown in the figure using axis of cartesian co-ordinate system and also by right-hand screw rule for cross product of vectors.



3. Define one tesla using the expression the magnetic forces acting on a particle charge q moving with

velocity \vec{v} in a magnetic field \vec{B} .

ans One tesla is defined as the magnitude of magnetic field which produces a force of 1 newton when a charge of 1 Coulomb moves perpendicularly in the region of the magnetic field at a velocity of 1m/s .

$$F = qvB$$

$$\Rightarrow B = F/qv$$

$$\Rightarrow 1\text{T} = \frac{1\text{N}}{(1\text{C})(1\text{m/s})}$$

4. A proton and an electron travelling along parallel paths enter a region of uniform magnetic field, acting perpendicular to their paths. Which of them will move in a circular path with higher frequency?

ans Mass of electron is low as compared to proton. Hence when both enter into the uniform magnetic region, the electron will move in a circular path with higher frequency in the opposite direction to the current.

5. Two protons of equal kinetic energies enter a region of uniform magnetic field. The ^{first} proton enters normal to field dirⁿ while the second enters at 30° to the field dirⁿ. Name the trajectories followed by them.

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ans At angle of 30° , it will follow helical path.