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School no.: 9888
Home Assignment 5
Date: 8-7-2021...10-7-2021
PHYSICS

Force on moving charge in uniform magnetic and electric field

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 04
CHAPTER NAME : MOVING CHARGES AND MAGNETISM

HOME ASSIGNMENT

1. If a particle of charge q is moving with velocity v along the z-axis and the magnetic field B is acting along the x-axis, use the expression $\vec{F} = q(\vec{v} \times \vec{B})$ to find the direction of the force F acting on it. A beam of proton passes unelected with a horizontal velocity v, through a region of electric and magnetic fields, mutually perpendicular 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

(a) velocity v of the beam.

(b) the force with which it strikes a target on a screen if the proton beam cutting is equal to 0.80 mA.

Answer)

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

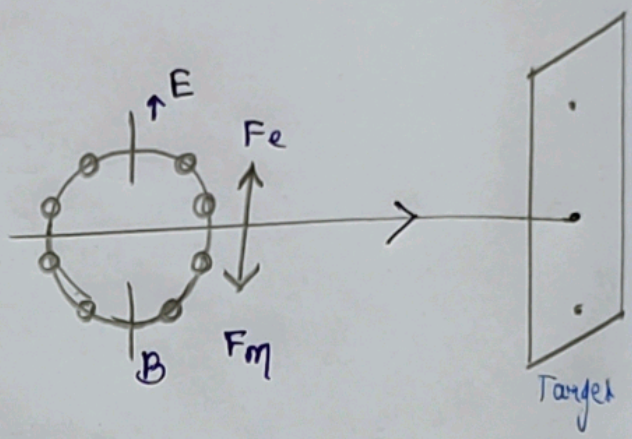
$\vec{v} = v\hat{k}$, $\vec{B} = B\hat{i}$

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

Force act along y axis.

i) velocity v of beam.

A/Q for beam of charged particles to pass undeflected crossed electric and magnetic field, the electric and magnetic force on beam must be equal and opposite.



$\Rightarrow$ $E = 50\,kV/m$

$= 50 \times 10^3\ V/m$

$B = 50mT = 50 \times 10^{-3}\ T$

$v = \dfrac{50 \times 10^3}{50 \times 10^{-3}}$

$= 1 \times 10^{3+3} = 1 \times 10^6\ m/s$

$\therefore v = 1 \times 10^6\ m/s$.

(iii) force with ..... on a screen, if proton ... 0.8 mA.

Ans: The beam strikes a target with constant velocity, force exerted on target = 0 (zero).

But if proton beam comes to rest, force exerted on target equal to rate of change of linear momentum of beam, [n: no. of protons striking the target per second]

$$\Rightarrow F = \frac{\Delta p}{\Delta t} = \frac{mv}{\Delta t} = \frac{mv}{\frac{q}{i}}$$

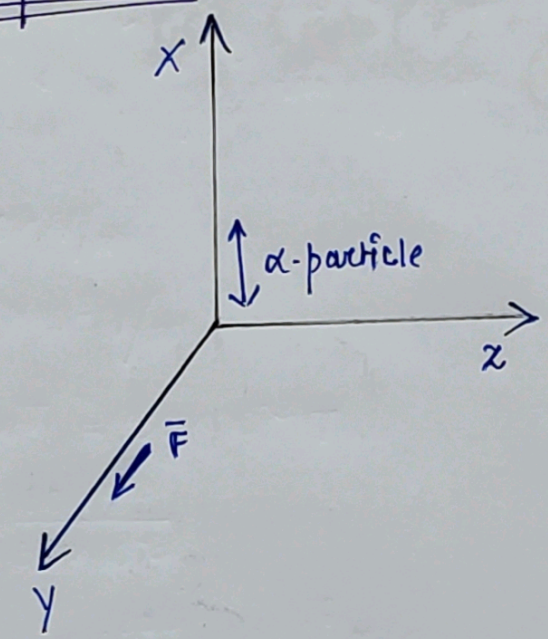
$$= \frac{mvi}{q} = \frac{mvi}{ne}.$$

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

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

Ans a A/Q

Let the graph be :-



Magnetic force on a point charge

Using Reigh Hand Rule ;

∴ B field (magnetic) direction towards Z axis.

3. Define one tesla using the expression the magnetic force acting on a particle charge q moving with velocity v in a magnetic field B.

Ans 3

One Tesla :- If is the magnetic field where a charge of 1 C moving with velocity of 1 m/s is normal to the magnetic field, experiences a force of 1N.

Now $B = \frac{F}{qv\sin\theta}$

$\Rightarrow$ $F = 1N$, $q = 1C$

$v = 1 m/s$, $\theta = 90^\circ$

So, SI unit of B

$= \frac{1N}{1C \cdot 1 m/s \cdot \sin 90^\circ}$

$= 1NA^{-1}m^{-1}$

$= 1$ Tesla. — Ans

i.e. $1 \text{ Tesla } (T) = \frac{1N}{(1C)(1m/s)}$

v in a magnetic field B.

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?

5. Two protons of equal kinetic energies enter a region of uniform magnetic field. The first proton enters normal to

Ans 4

When charge particle enters a region of uniform magnetic field, perpendicular to their their paths, they move in a circular path.

Now Time period of their motion (T)

$$= \frac{2\pi m}{qB}$$

But, $f = \frac{1}{T} = \frac{qB}{2\pi m}$

$\because$ B and q same for both e and p.

$\therefore$ so, $f \propto \frac{1}{m}$

$\because$ Mass of electron smaller and lower than proton,

$\therefore$ Electron will have higher frequency in a circular path.

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

Ans 5 :-

When charged particle enters uniform magnetic field the force exerted on it.

$$F = q(v \times B)$$

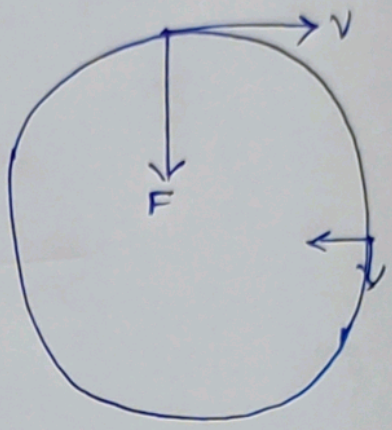
$$= qvB \sin\theta.$$

Case I When particle enters perpendicular, $\theta = 90^\circ$

Now $\sin\theta = \sin 90^\circ = 1$, maximum value and direction of force perpendicular to direction of motion of particle.

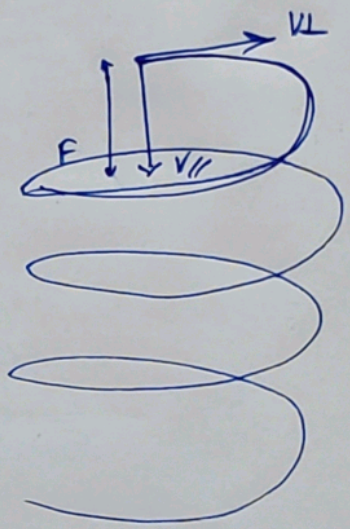
∴ Particle starts moving in a **circular** path with radius,

$r = mv/bq$. * Circular path



Case II When particle enters at an angle of 30°

Now force acting on it has two components one parallel to motion that cause linear motion, the other component acts perpendicular to motion that cause circular motion.



∴ Due to the resultant of the 2 components the particle moves along a **Helical** path

* Helical path.


THANK YOU !