09/07/21

HOME ASSIGNMENT-3

(1) Given

v along x-axis $\vec{v} = v\hat{i}$

B along y-axis $\vec{B} = B\hat{j}$

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

That is force is acting along z-axis

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

(a) $eE = evB$

$$\text{or } v = \frac{E}{B} = \frac{50 \times 10^3}{100 \times 10^{-3}} = 5 \times 10^5 \text{ m/s}.$$

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.

(b) $$F = \frac{\Delta p}{\Delta t} = \frac{mv}{q/i} = \frac{mvi}{q}$$

$$= \frac{1.67 \times 10^{-27} \times 5 \times 10^5 \times 0.80 \times 10^{-3}}{1.6 \times 10^{-19}}$$

$$= 4.175 \times 10^{-6} \text{ N}$$

② According to Right-hand Rule, the direction of force on positively charged particle will be perpendicular to the plane of paper upward and on negatively charged particles will be perpendicular to the plane of paper downwards.

As, $\vec{F} = q(\vec{V} \times \vec{B})$

$|\vec{F}| = q|\vec{V} \times \vec{B}| = qVB\sin\theta$

If $V = 1$, $q = 1$ and $\sin\theta = 1$ then $\theta = 90^\circ$

So $F = 1 \times 1 \times B \times 1 = B$.

Thus, the magnetic field induction at a point in the field is equal to the force experienced by a unit charge moving with a unit velocity perpendicular to the direction of magnetic field at that point.

The direction of $\vec{F}$ is the direction of cross-product of velocity $\vec{V}$ and magnetic field $\vec{B}$, which is perpendicular to the plane containing $\vec{V}$ and $\vec{B}$. Thus, from the cross product rule and Right-hand rules the direction of magnetic field is along $+Z$-axis.

③ When a charge of 1C, moving with velocity 1 m/s, normal to the magnetic field experiences a force 1N, the magnetic field is said to be 1 Tesla.

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

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

But, $f = \frac{1}{T}$

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

Since B and q is same for electron and proton.

So $f \propto \frac{1}{m}$

Since mass of electron is smaller than that of proton, hence it will have higher frequency.

(5) • when an electron enters normal to the field direction of the trajectory is circular.

• When an electron enters 30° to the field direction the trajectory is helical.