Homework – force on moving charge in uniform magnetic and electric field (13·7·21)

1 $\vec{F} = q\vec{v} \times \vec{B}$

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

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

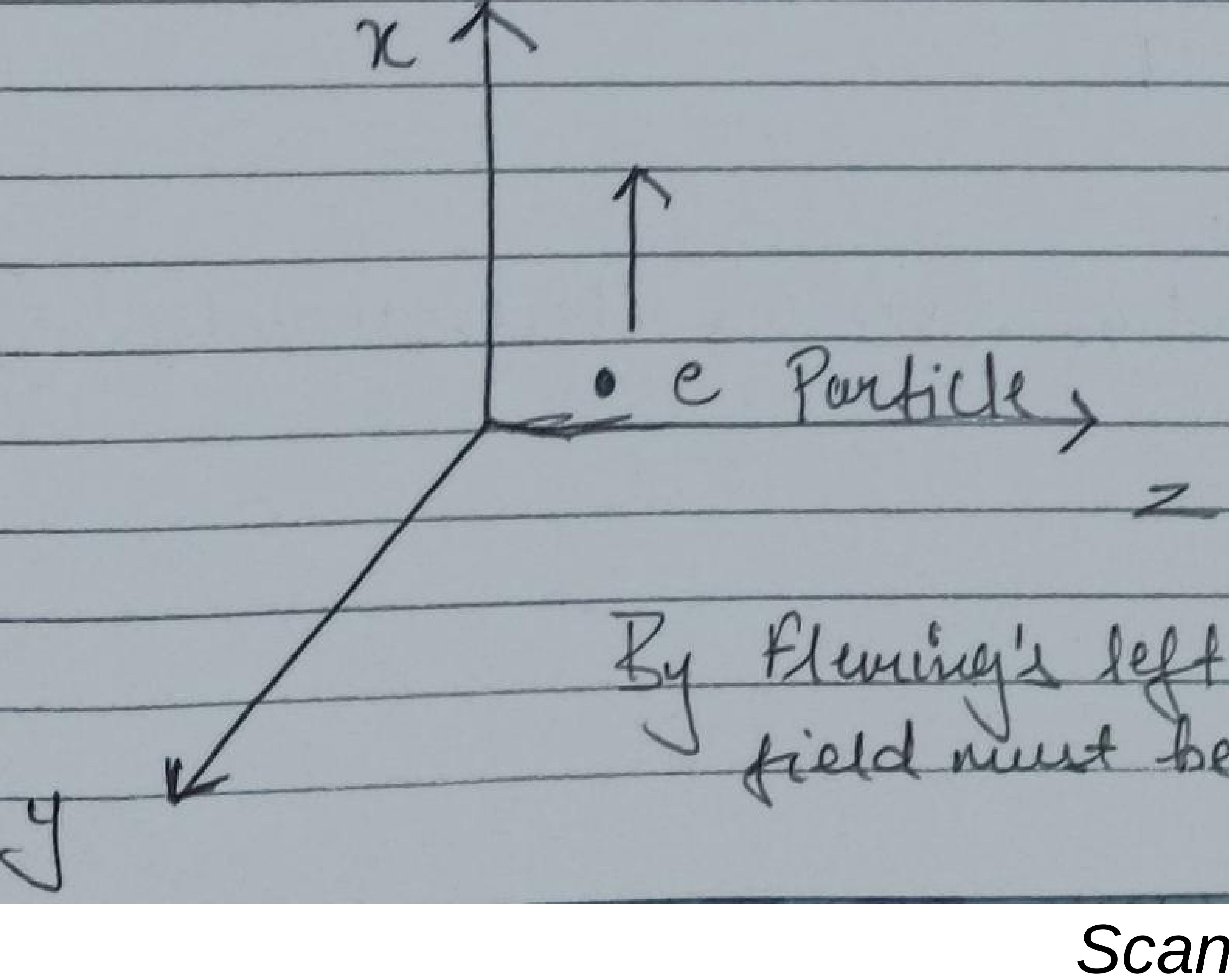
i For a Beam of charged particle to pass undeflected crossed electric and magnetic fields, the condition is that electric and magnetic forces on the beam must be equal and opposite.

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

$$v = \frac{50 \times 10^{3}}{50 \times 10^{-3}} = 1 \times 10^{6}\,ms^{-1}$$

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

2



By Fleming's left hand rule magnetic field must be along negative z-axis

3 One tesla is the magnetic field in which a charge of 1C moving with a velocity of $1 ms^{-1}$ normal to the magnetic field, experiences a force of 1N

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

If $F = 1N$, $q = 1C$, $v = 1ms^{-1}$, $\theta = 90°$

then SI unit of $B = \frac{1N}{1C \cdot 1ms^{-1} \cdot \sin 90°}$

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

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

And the time period of their motion is given by

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

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

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

Since B and q is same for electron and proton so $f \propto \frac{1}{m}$

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5 We know that when a charged particle enter a uniform magnetic field the force exert on it.

$$f = q(v \times B) = qvb \sin\theta$$

Case I when the particle enters perpendicular $\theta = 90^\circ$

In this case since $\sin\theta = 1$ is the maximum value and the direction of motion of particle hence the particle hence the particle starts moving in a circular path with radius.

$$r = mv / bq$$

Case II : the particle enter at an angle of 30°

In this case the force acting on it has two components one parallel to the motion which will cause a linear motion the other component will act perpendicular to motion which will cause circular motion.

Hence due to resultant of these two component the particle will move along a Helical Path.