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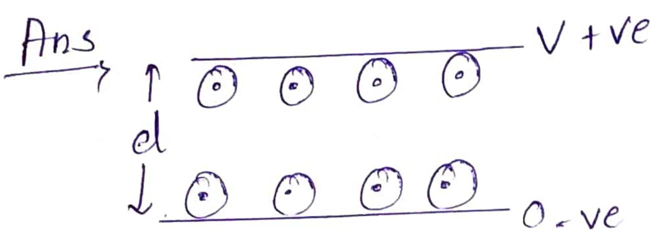
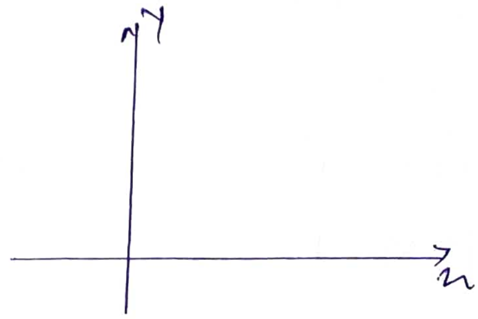
Batch -6

Q. An electron is emitted with negligible speed from the negative plate of parallel plate capacitor with large plates, charged to potential difference V. The plate is d & magnetic field B exists in the space in one direction parallel to plate. Show that the electron will fail to strike upper plate if $B^2 > \frac{2mev}{ed^2}$

Ans

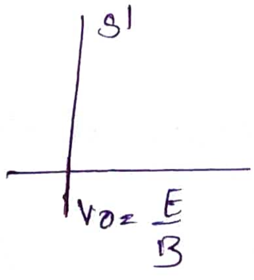



$\therefore \vec{E} = E(-\hat{j})$ $\quad$ Force $= q(\vec{E} + \vec{V} \times \vec{B})$

$\vec{B} = B(\hat{k})$

so, if we take s' frame,




We know that, in Galilion Transformation Forces do not change

$\therefore$ s' frame $\rightarrow \vec{F}$ (on charge particle)

$= q(E + \vec{V} \times \vec{B})$

$= q(\vec{E} + (\vec{V_1} + \vec{V_0}) \times \vec{B})$

$= q[(\vec{E} + \vec{V_0} \times \vec{B}) + \vec{V'} \times \vec{B}]$

This $E$ is $= E(-\hat{j})$

$\because E = E_0(-\hat{j}) \quad \vec{B} = B\hat{k}$

$\therefore \vec{V_0} = \frac{E}{B}(\hat{i})$

so,

$$E_0(-\hat{j}) - \frac{E}{B}\hat{i} \times B\hat{k}$$

$$= E(-\hat{j}) + E(-\hat{j}) \quad = E(-\hat{j}) - E(-\hat{j})$$

$$\Rightarrow E(-\hat{j}) + E(\hat{j}) = 0$$

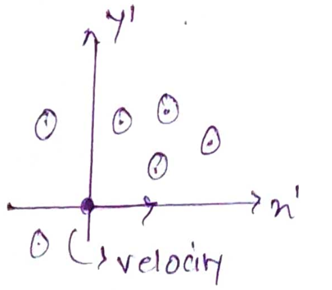
So, in particular vector i.e, $s'$,

$\vec{F} = q\vec{v_1} \times \vec{B}$

that tells me since the force is only depending on magnetic field for whatever velocity or charge.

$\therefore \vec{E} = 0$ if we only have $\vec{B}$ i.e. in $\hat{k}$ direction

in $s'$ frame

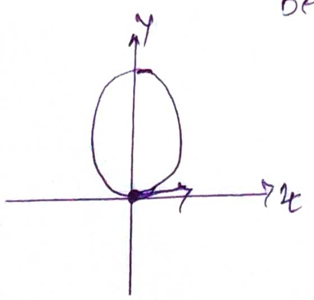



$V = V_0\hat{i}, \ \vec{B} = B\hat{k}$

$\therefore \vec{F} = -ev_0 B\hat{i} + \hat{k}$

$= ev_0 B\hat{j}$

so it means in +ve direction will bend in circle.

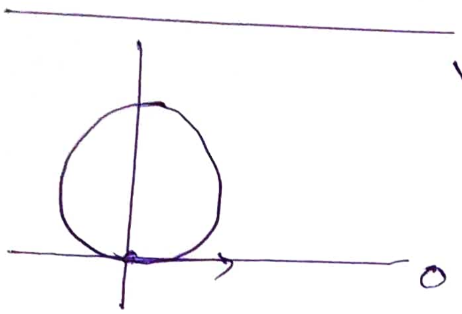



Now, what is radius of circle,

$$R = \frac{mv}{qB} \Rightarrow \frac{me\frac{E}{B}}{eB} = \frac{mev}{edB^2}$$

$\therefore$ Diameter $= \dfrac{2mev}{edB^2}$

so, if diameter of circle fail to strike upper plate




$$\therefore \frac{2mev}{edB^2} < d$$

$$\boxed{\frac{2mev}{ed^2} < B^2}$$

if this is condition $\vec{B}$ is so strong then it will bend it bellow upper plate.

Hence, we can say or prove it as $B^2 > \frac{2mev}{ed^2}$