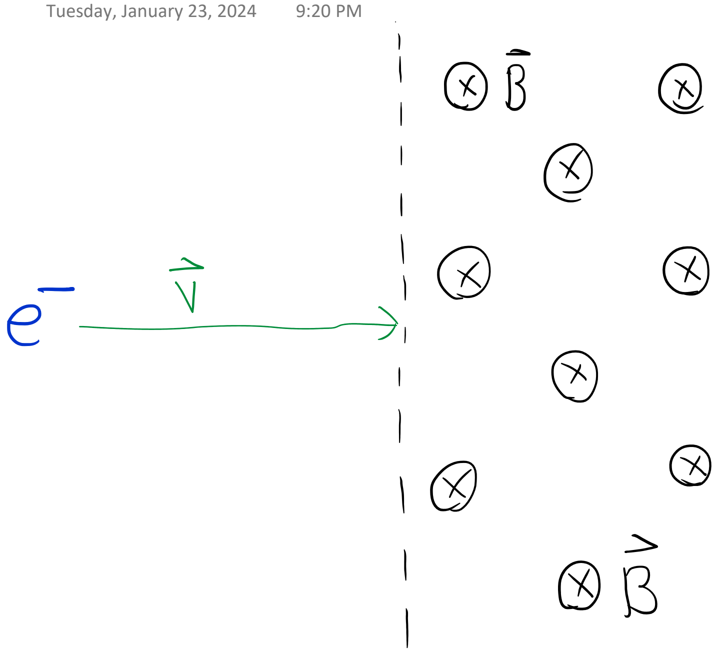
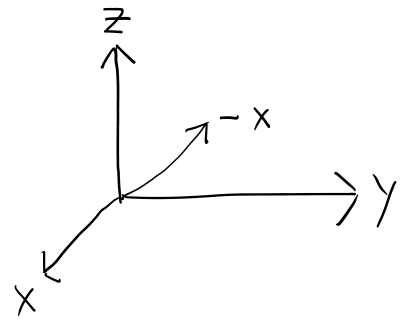
B1-1 and B1-2: B-Field Force

Tuesday, January 23, 2024 9:20 PM



An electron that is moving to the right enters a region with a uniform magnetic field that is into the screen. What is the electric force?



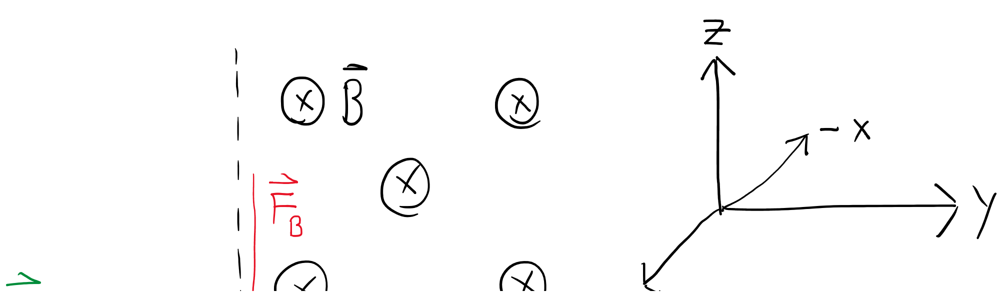
$$\vec{v} = \langle 0, v, 0 \rangle \qquad \vec{B} = \langle -B, 0, 0 \rangle$$

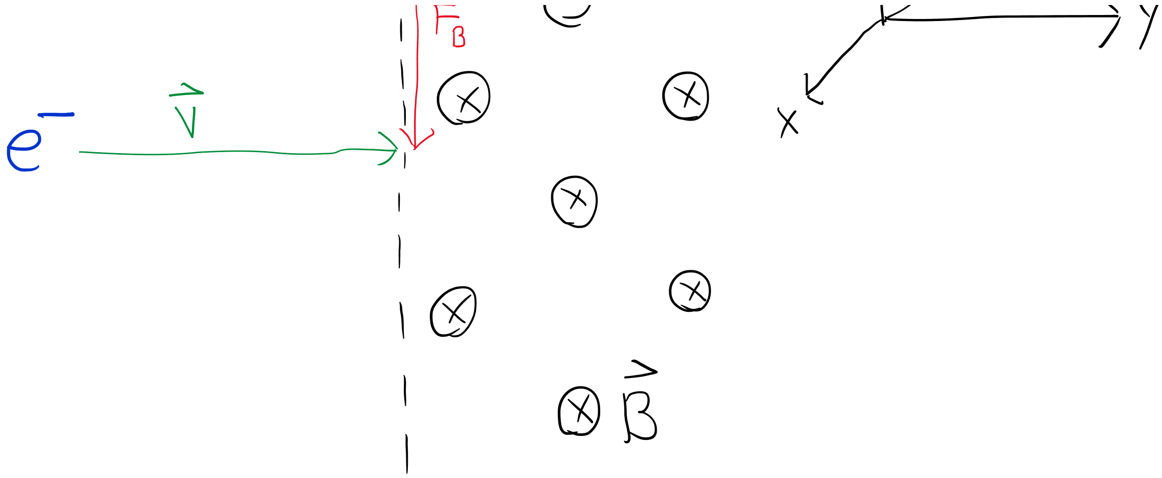
$$\vec{F}_B = q\vec{v} \times \vec{B} = q(\vec{v} \times \vec{B}) = -e\langle 0, v, 0 \rangle \times \langle -B, 0, 0 \rangle$$

$$= -e\langle 0, 0, Bv \rangle = \langle 0, 0, -evB \rangle$$

- or -

$$\vec{F}_B = -evB\hat{k}$$



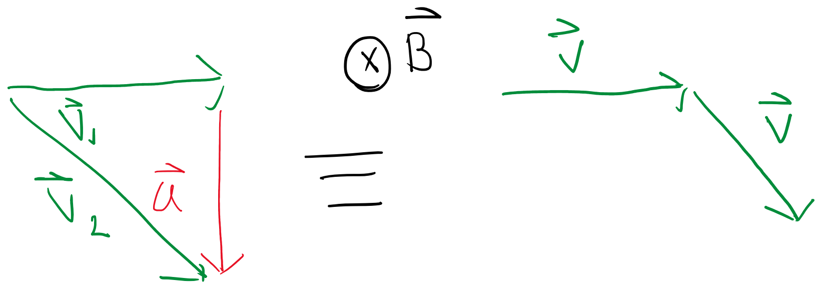


If $\vec{v} = 1500\ m/s$ & $\vec{B} = 0.3\ T$

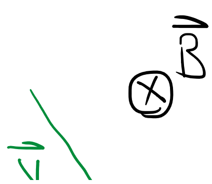
$$\vec{F}_B = -(1.602 \times 10^{-19} C)(1500\ m/s)(0.3\ T)\hat{k}$$

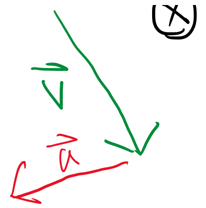
$$F_B = -7.21 \times 10^{-17}\ N\ \hat{k}$$

We already know that the magnetic field generates a force directly downwards in the negative z direction at the moment the electron enters the magnetic field. This means we also have an acceleration pointing directly downwards. Additionally, we know the acceleration is the change in velocity, so if we add the initial velocity and acceleration, we can get a new velocity.

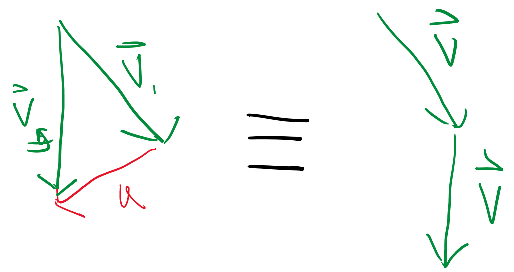


We can then use the right hand rule with the new velocity to see the direction of the acceleration for a negatively charged particle. Doing that we get the following.

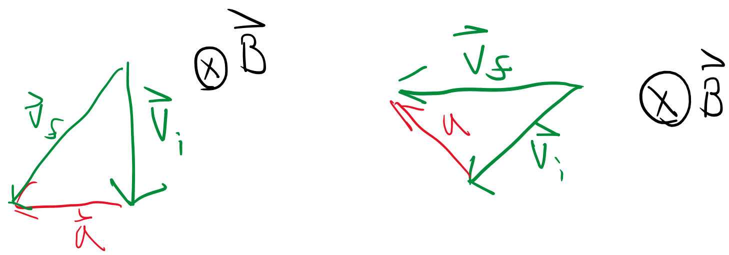




Then using vector addition to find a new velocity sometime in the future, we get



Continuing on with the same technique.



Putting all the velocity vectors together we can see that that the electron travels in a half circle till it reverses direction and exits the region with a magnetic field.