Q- An electron is moving northward at $5*10^5$ m/s in a uniform electric field 20N/C directed vertically downward. Due to presence of a magnetic field as well the electron moves in a straight line andeviated.
(a) Find the magnitude and direction of the force on the electron due to electric field.
(b) Find the minimum magnitude and direction of the magnetic field present for the electron to remain andeviated.

a) The electric field strength E at a point is the force acting per unit charge at that point and hence the force on the charge q is given by

$$\vec{F}_E = q\vec{E}$$

Thus the force acting on the electron will be

$$\vec{F}_E = e\,\vec{E} = (-1.6 * 10^{-19}) * 20\,\hat{u}$$

Thus the magnitude of the field is $1.6*10^{-19}*20 = 3.2*10^{-18}$ N.

The negative sing shows that the direction of the force is opposite to that of the electric field (as electron is negatively charged) and hence the direction of the force on electron will be vertically upward.

b) The force on a charge q moving in a magnetic field B with velocity v is given by Lorentz formula as

$$\vec{F}_M = q\left(\vec{v} \times \vec{B}\right)$$

Thus the force on the electron in magnetic field will be

$$\vec{F}_M = Be\,v \sin\theta\ \hat{n}$$

Here θ is the angle between B and v and $\hat{n}$ is the unit vector in the direction normal to the plane of B and v.

For the electron to go straight without deflection the resultant of the two forces must be equal to zero and thus the magnetic force must be equal to the magnitude of electric force an in downward direction (neglecting weight of electron) thus

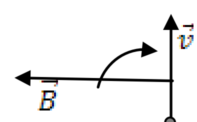
$$F_M = F_E$$

Or $$Be\,v\sin\theta = eE$$

Or $$B = \frac{E}{v\sin\theta}$$

Now for B to be minimum sin θ should be maximum i.e. 1, thus the minimum magnitude of the magnetic field required is given by

$$B = \frac{E}{v} = \frac{20}{5*10^5} = 4 * 10^{-5}\,T$$



Now the direction of B field should be such that the force on the electron is opposite to that due to electric field i. e. downward. The force F_M is in the direction of $\left(\vec{v} \times \vec{B}\right)$ but as the charge on the electron is negative the force will be in the direction of negative of $\left(\vec{v} \times \vec{B}\right)$ or $\left(\vec{B} \times \vec{v}\right)$. This product to be downward with v to the north according to right hand rule of vector product, the direction of B must be west direction.

Thus the magnetic field will be $4*10^{-5}$ T towards the west.

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