1) An electron with velocity \( \vec{v} = (2.9\hat{i} + 3.8\hat{j}) \times 10^6 \text{ m/s} \) moves through a uniform magnetic field \( \vec{B} = (0.029\hat{i} - 0.20\hat{j}) \text{ T} \). What is the magnitude of the magnetic force on the electron?

\[
\vec{F}_B = q(\vec{v} \times \vec{B}), \quad \vec{F}_B = F_B \hat{k}, \quad F_B = q \left( v_x B_y - v_y B_x \right), \quad q = -e = -1.602 \times 10^{-19} \text{ C}
\]

\[
V_A = 2.9 \times 10^6 \text{ m/s}, \quad v_y = 3.8 \times 10^6 \text{ m/s}, \quad B_x = 0.029 \text{ T}, \quad B_y = -0.20 \text{ T}, \quad \text{so}
\]

\[
F_B = 1.1 \times 10^{-13} \text{ N} \quad (\text{in } \hat{k} \text{ direction})
\]

An electron is moving in the positive \( x \)-direction when it enters a region with uniform electric field \( \vec{E} = -E \hat{k} \). The electron experiences no net force, and continues along a straight trajectory.

2) A magnetic field must be exerting a force on the electron. What is the direction of the magnetic field?

\[
\vec{F}_E = q \vec{E} = -e \vec{E}
\]

\[
\vec{F}_B = q(\vec{v} \times \vec{B}) = -e \vec{v} \times \vec{B}
\]

So, \(-e \vec{v} \times \vec{B}\) must point down \((-\hat{k})\), \(\vec{v} \times \vec{B}\) must point up \((+\hat{k})\)

So, \(\vec{B} = B \hat{j}\), \(\vec{B}\) points in \(y\) direction

\(\text{(into page)}\)

3) If the electric field has magnitude \( E = 1.50 \text{kV/m} \) and the magnetic field has magnitude 0.400 T, what is the electron's speed?

\[
\vec{F}_{net} = 0 \quad \Rightarrow \quad \vec{F}_E + \vec{F}_B = 0, \quad -e \vec{E} - e \vec{v} \times \vec{B} = 0
\]

\[
\vec{E} + \vec{v} \times \vec{B} = 0, \quad \vec{v} \times \vec{B} = (\vec{v} \hat{\imath})(\vec{B} \hat{j}) = vB \hat{k}
\]

\[
-E \hat{k} + vB \hat{k} = 0
\]

\[
E = vB, \quad v = \frac{E}{B} = \frac{1.5 \times 10^3 \text{ V/m}}{0.400 \text{ T}} = 3.75 \times 10^2 \text{ m/s}
\]
Mass spectrometer: An atomic ion has a net charge of magnitude \(e\) (it is either \(+e\) or \(-e\), you decide). It is accelerated across a voltage \(V = 1000\) V, then enters a region of uniform magnetic field of magnitude \(B = 8.00 \times 10^{-2}\) T. Its velocity is perpendicular to \(\vec{B}\). The diameter of the ion's circular trajectory is measured to be 1.8254 m.

4) What is the ion's kinetic energy after being accelerated?

\[
K_i + u_i = K_f + u_f, \quad \Delta K = -\Delta u, \quad K_i = 0, \quad K_f = \Delta K = -e \Delta V = -e (1000 V),
\]

\[
K_f = e (1000 V) = 1000 \text{ eV} = 1.602 \times 10^{-16} \text{ J}
\]

5) What is the mass of the ion?

\[
F_{net} = \vec{e} \times \vec{B} = m \frac{u^2}{r}, \quad \text{so} \quad e \nu B = m \frac{u^2}{r}
\]

\[
\nu B = m \frac{u^2}{r}
\]

\[
\nu B = m \frac{u^2}{2}
\]

\[
\nu B = \frac{1}{2} m v^2 = K \quad \text{where} \quad K = 1.602 \times 10^{-16} \text{ J}
\]

So, we have:

\[
(1) \quad m = \frac{e \nu B}{v}
\]

\[
(2) \quad v = 2K\nu, \quad v = \sqrt{\frac{2K}{m}},
\]

\[
m = \frac{e \nu B}{\sqrt{\frac{2K}{m}}}
\]

\[
m = \frac{(e \nu B)^2}{2K}, \quad \text{and} \quad m = \frac{(e \nu B)^2}{2K}
\]

\[
= \frac{2.04 \text{ amu}}{}
\]