Physics 3B Week 8: Magnetic Forces and Magnetic Fields

Name: Andrea Silvestri, ID#:

TA: Andrea Silvestri

Date: March 5, 2008 Day: Wednesday Hour: 8:00 - 12:50

1. Problem 1

A combination of electric $\hat{\mathbf{E}}$ and magnetic fields $\hat{\mathbf{B}} = B\hat{\mathbf{j}}$, with $B = 20.0$ mT, forms a velocity selector. Find the direction and the magnitude of $\hat{\mathbf{E}}$ such that an electron with kinetic energy $E_e = 2.0 \times 10^{-16}$ Joules moving along the x-axis remains undeflected. (mass of the electron $m_e = 9.11 \times 10^{-31}$ kg)

magnetic force: $\vec{F}_B = q\,\vec{v} \times \vec{B} = -e\left(v\hat{i} \times B\hat{j}\right)$

$= -\hat{k}\left(evB\right).$

for undeflection we impose:

$$\vec{F}_{tot} = \vec{F}_E + \vec{F}_B = 0$$

$\vec{F}_E = -\vec{F}_B \Rightarrow \vec{F}_E = +\hat{k}F_E = \hat{k}(eE)$

therefore $eE = evB \Rightarrow E = vB$

Since the kinetic energy is:

$KE = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2KE}{m_e}}$

the Electric field must be:

$$E = \sqrt{\frac{2KE}{m_e}}B \quad \left(\frac{kV}{m}\right)$$

$$E = \sqrt{\frac{2 \times 2.0 \times 10^{-16}\ J}{9.11 \times 10^{-31}\ kg}} \times (0.02\ T) = 420 \left(\frac{kV}{m}\right)$$

$$\boxed{\vec{E} = +\hat{k}(420)\ \left[\frac{kV}{m}\right]}$$

to the positive z-direction.