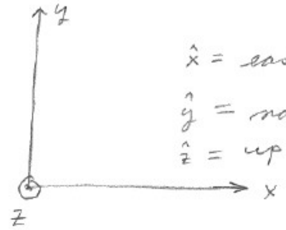
Solutions to hw1

1) $\vec{B} = B_y \hat{y}$

$\vec{E} = E_z \hat{z}$ $\quad$ ($\vec{E}$ down $\Rightarrow E_z < 0$)

$\vec{v} = v_x \hat{x}$



$\hat{x}$ = east
$\hat{y}$ = north
$\hat{z}$ = up

$\vec{F}_g = -mg\hat{z}$

$\vec{F}_E = q\vec{E} = -eE_z\hat{z}$ $\quad$ (note: $q = -e$ for electron)

$\vec{F}_B = q\vec{v} \otimes \vec{B} = -e v_x B_y \hat{z}$

my numbers: $B_y = 74\,\mu T$, $E_z = -250\ N/C$, $v_x = 6\times10^{6}\ m/s$

give: $F_g = 8.93\times10^{-30} N$ down, $F_E = 4.005\times10^{-17} N$ up, $F_B = 7.11\times10^{-17} N$ down

2) $\vec{v} = v_x\hat{x}$ $\quad \vec{a} = a_z\hat{z}$ $\quad \vec{E} = E\hat{z}$

$\vec{F} = q(\vec{E} + \vec{v}\otimes\vec{B}) = m\vec{a} \Rightarrow$

$E_x + v_y B_z - v_z B_y = 0$ $\quad$ no information

$E_y + v_z B_x - v_x B_z = 0 \Rightarrow B_z = 0$

$q(E_z + v_x B_y - v_y B_x) = ma_z \Rightarrow B_y = \dfrac{ma_z - qE_z}{q v_x}$

$\therefore$ B_x has any value, $B_y = -\dfrac{m_e a_z + eE_z}{e v_x}$, $B_z = 0$

my numbers: $v_x = 1.6$ km/s, $a_z = 2\times10^{12}\ m/s^2$, $E_z = 18\ N/C \Rightarrow B_y = -1.84\times10^{-2}\ T$

3) $I\ell B = mg$ with I to right

my numbers: $\frac{m}{\ell} = 0.04$ kg/m, $B = 3.8T \Rightarrow I = 0.103\ A$

4) $\vec{\tau} = \vec{\mu}\otimes\vec{B} \Rightarrow \tau_{max} = \mu B = IAB$

$U = -\vec{\mu}\cdot\vec{B} \Rightarrow |U| \le \mu B$

my numbers: $I = 5A$, $d = 11\ cm$, $B = 2.6\ mT \Rightarrow \mu B = 123.5\,\mu J$

5)

$$m\frac{v^2}{r} = qvB \Rightarrow r = \frac{mv}{qB}$$

$$\frac{1}{2}mv^2 = qV \Rightarrow v = \sqrt{\frac{2qV}{m}}$$

my numbers: $m = 3.20 \times 10^{-26}$ kg, $qV = 813$ eV, $B = 0.94$ T $\Rightarrow r = 1.92$ cm

6)

$$\left.\begin{array}{l} m\frac{v^2}{r} = qvB \Rightarrow r = \frac{mv}{qB} \\ K = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2K}{m}} \end{array}\right\} \quad r = \frac{\sqrt{2mK}}{qB}$$

my numbers: $m = m_p$, $K = 32$ MeV, $B = 3.4$ T $\Rightarrow r = 24.0$ cm