problem 8.1:

a) $\rightarrow$

b) $\otimes$ in

c) $\uparrow$

d) $F=0$

e) $\rightarrow$

f $\downarrow$

Forces

problem 8.2

a) $\rightarrow$

b) $\otimes$ in

c) $\downarrow$

Velocity

8.3

$$\vec{F} = q\vec{v}\times\vec{B}$$

$$= \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ V_x & V_y & V_z \\ B_x & B_y & B_z \end{vmatrix} = \left|\begin{array}{ccc|cc} x & y & z & x & y \\ 3 & 4 & 0 & 3 & 4 \\ 0.5 & 0 & 0.8 & 0.5 & 0 \end{array}\right.$$

$$F_B = q\left(4(0.8)\hat{x} - 3(0.8)\hat{y} - 4(0.5)\hat{z}\right)$$

$$F_B = \boxed{3.2\hat{x} - 2.4\hat{y} - 2.0\hat{z} \text{ [N]}}$$

problem 8.4

$V_1 = (0, 0, V_0)$

$V_2 = (V_0, 0, 0)$

$V_3 = (0, V_0, 0)$

$V_4 = \left(\frac{V_0}{2}, \frac{\sqrt{3}}{2}V_0, 0\right)$

$\vec{v} \times \vec{B} \Rightarrow$

Right Hand Rule:

F_1 = zero

F_2 = $-y$ direction

F_3 = $+x$ direction

F_4 = $(+x, -y)$ direction

$$F_1 = q(\vec{V}_1 \times \vec{B}) = q\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ 0 & 0 & V_0 \\ 0 & 0 & B_0 \end{vmatrix} = \boxed{0}$$

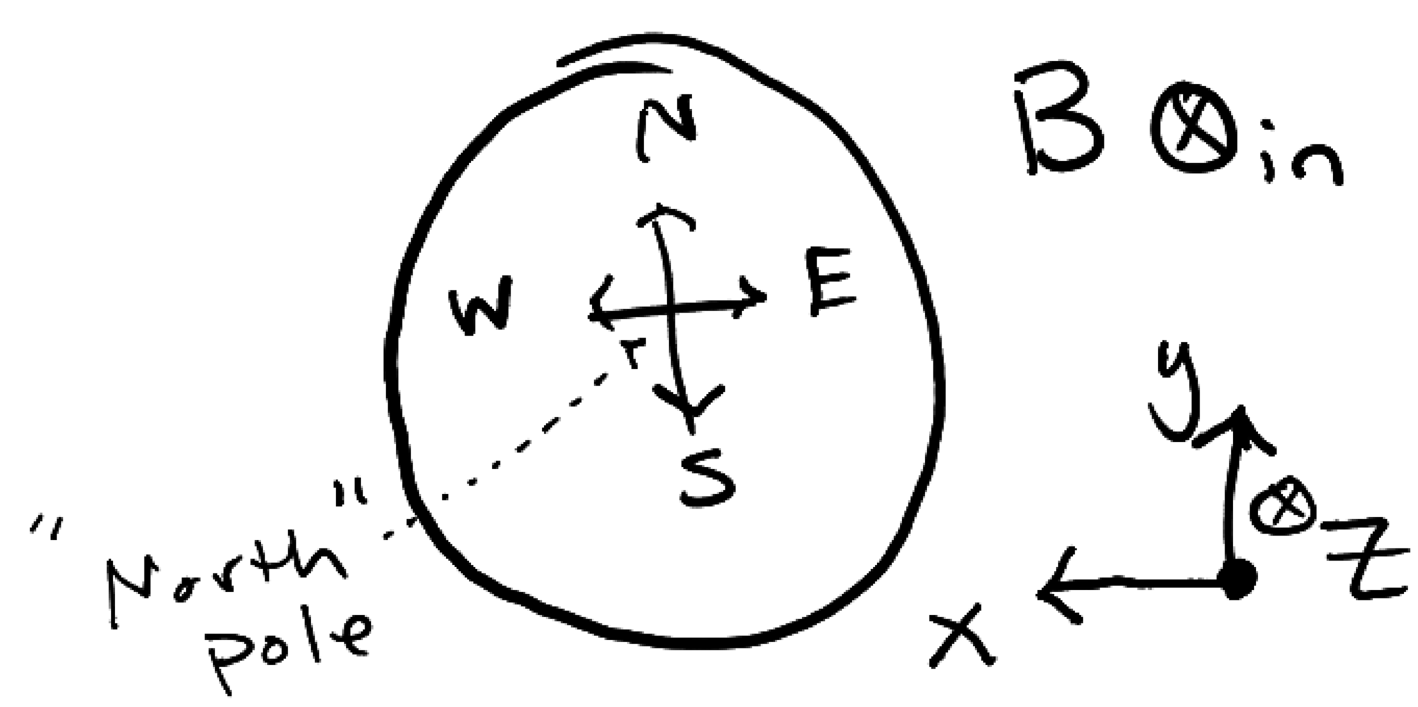
$$F_2 = q\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ V_0 & 0 & 0 \\ 0 & 0 & B_0 \end{vmatrix} = \boxed{-qV_0B_0\hat{y}}$$

$$F_3 = q\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ 0 & V_0 & 0 \\ 0 & 0 & B_0 \end{vmatrix} = \boxed{+qV_0B_0\hat{x}}$$

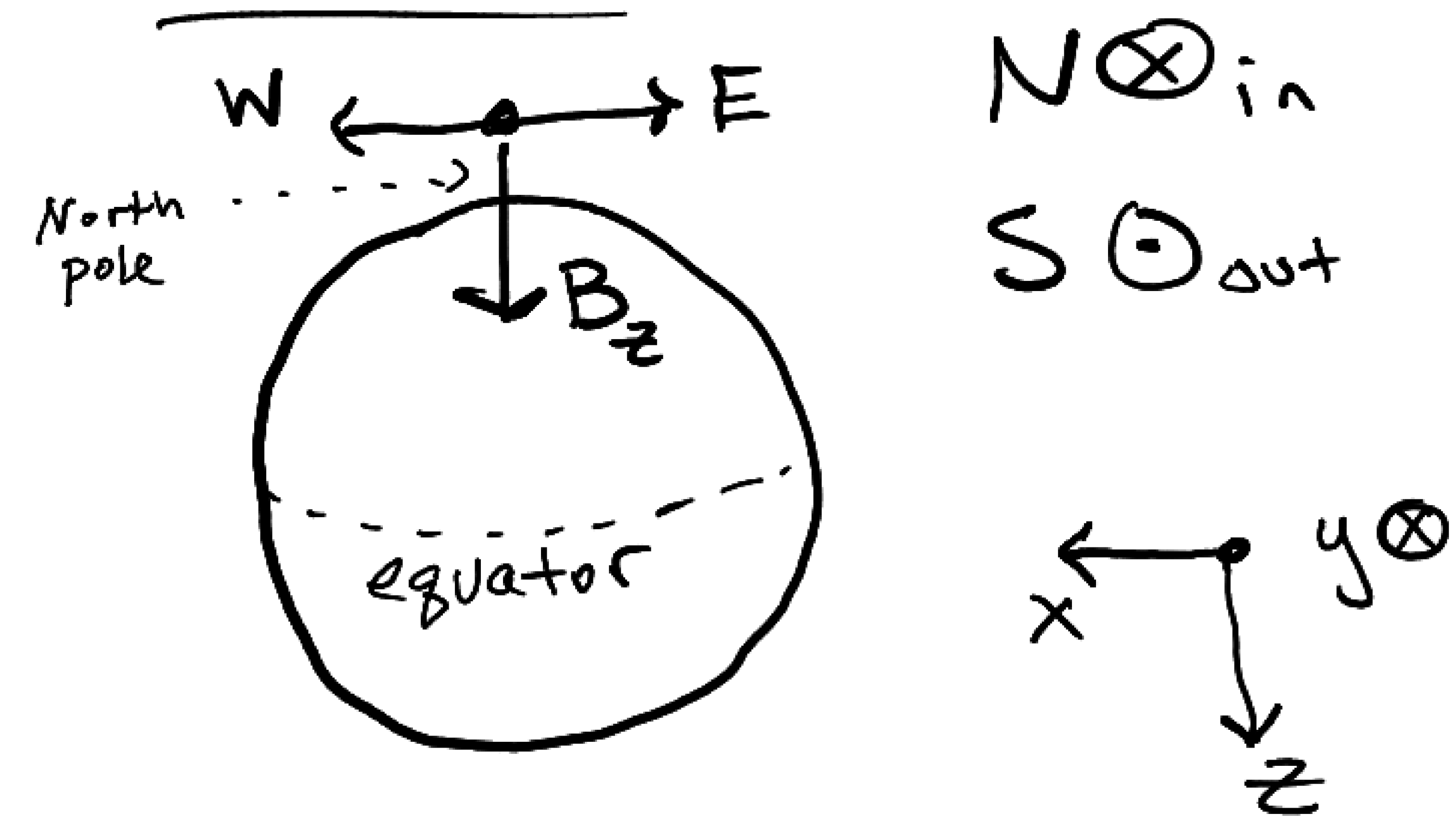
$$F_4 = q\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ V_0/2 & \frac{\sqrt{3}V_0}{2} & 0 \\ 0 & 0 & B_0 \end{vmatrix}\begin{matrix} \hat{x} & \hat{y} \\ V_0/2 & \frac{\sqrt{3}V_0}{2} \\ 0 & 0 \end{matrix} = \boxed{\frac{\sqrt{3}V_0B_0}{2}\hat{x} - \frac{V_0B_0}{2}\hat{y}}$$

problem 8.5:

Top view of Earth



Side view

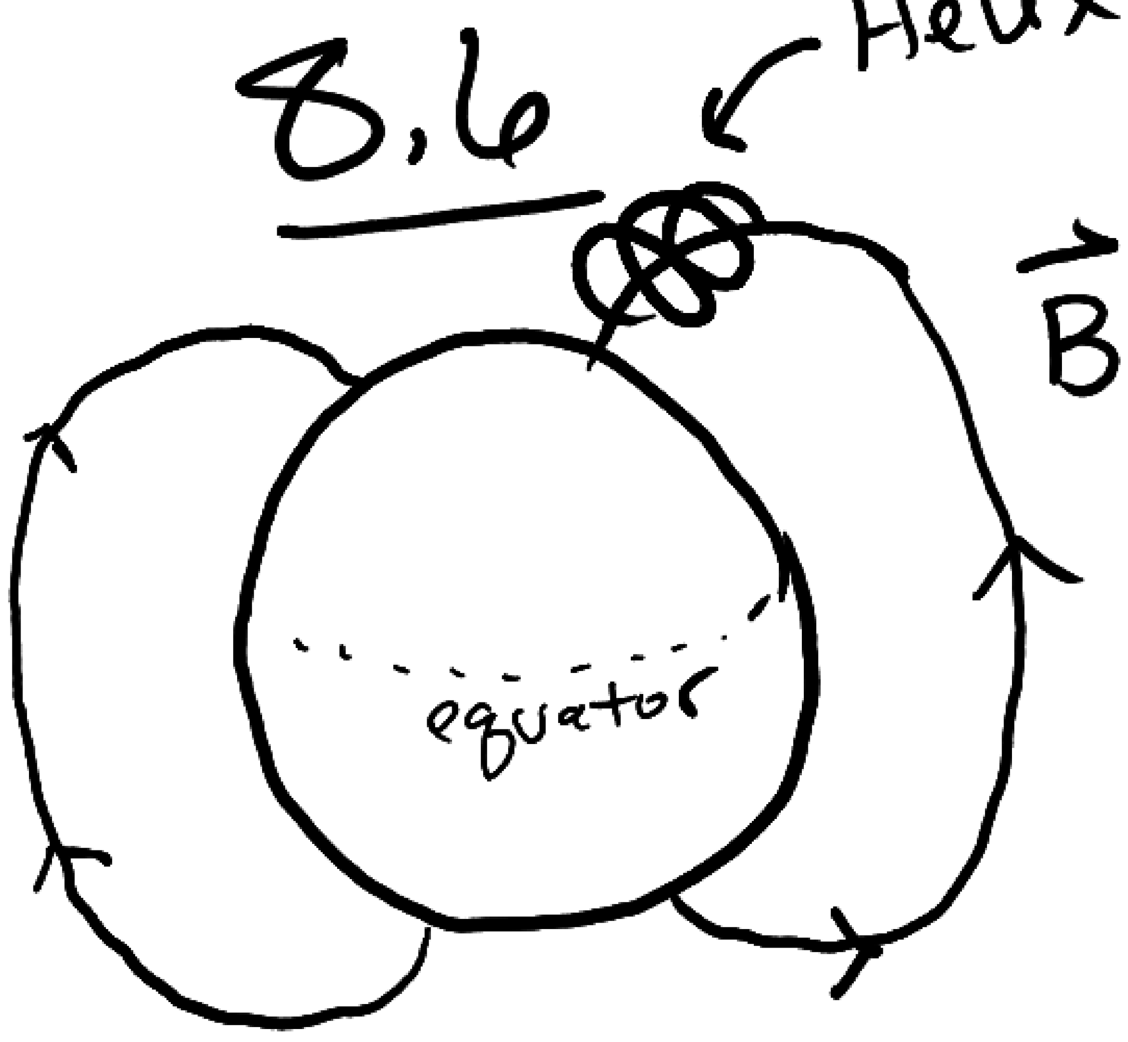


plane flying from right to left

$$\vec{F} = q\vec{v} \times \vec{B} \qquad \vec{v} = V_0 \hat{x}, \quad \vec{B} = B_0 \hat{z}$$

$$F = -qVB\hat{y} = \boxed{2.6E-7 \text{ [N] cardinal south}}$$

8.6



$m_e = 9.01 \times 10^{-31}$ kg

$V = 7.5E6$ m/s

$q = e = -1.6 \times 10^{-19}$ C

$B = 1.0E-5$ T

circular Motion $\Rightarrow$ $\Sigma F = ma_c$

$$qVB = \frac{mv^2}{r}$$

$$r = \frac{mV}{qB} = \boxed{4.22 \text{ m}}$$

8.7 : α-particle => doubly ionized Helium4

a) $F = qvB = \frac{mv^2}{r}$ $\qquad v = \frac{rqB}{m} = \boxed{\qquad \frac{m}{s}}$

b) $K = \frac{1}{2}mv^2 = \boxed{\qquad J}$

c) Conserve energy

$$\cancel{W_{nc}}^{\,0} = \Delta K + \Delta U_E$$

Voltage

$$\frac{1}{2}mv_f^2 = q\Delta V$$

Velocity

$$\Delta V = \frac{mv^2}{2q} = \boxed{\qquad \text{Volts}}$$

8.8 Forces

a) $\leftarrow$

b) $\otimes$ in

c) $\uparrow$

d) $F = 0$

e) $\rightarrow$

f) $\downarrow$

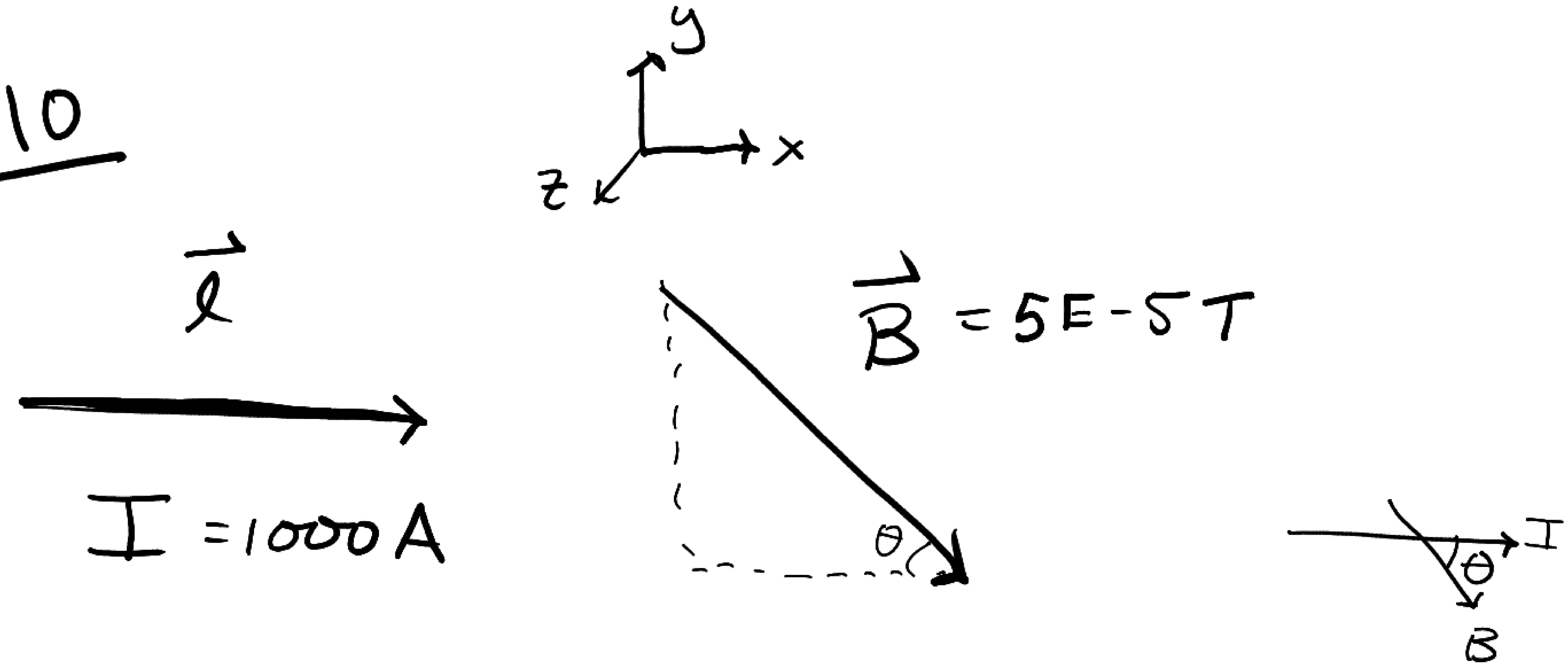
8.9

a) $\otimes$ in

b) $\leftarrow$

c) $\odot$ out

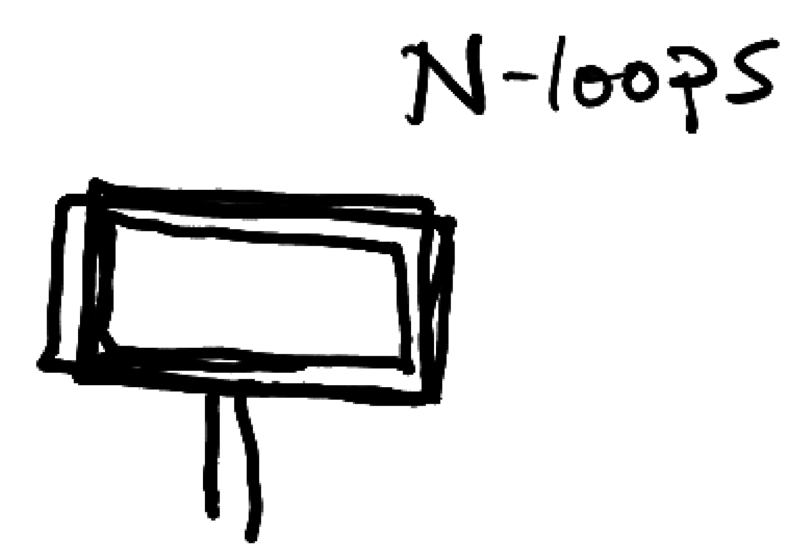
8.10



$$\vec{F} = I\vec{l} \times \vec{B} = lIB\sin\theta = \boxed{\qquad\qquad N}$$

$$\vec{F} = I\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ l & 0 & 0 \\ B\cos\theta & B\sin\theta & 0 \end{vmatrix} = IlB\sin\theta\,\hat{z}$$

8.11

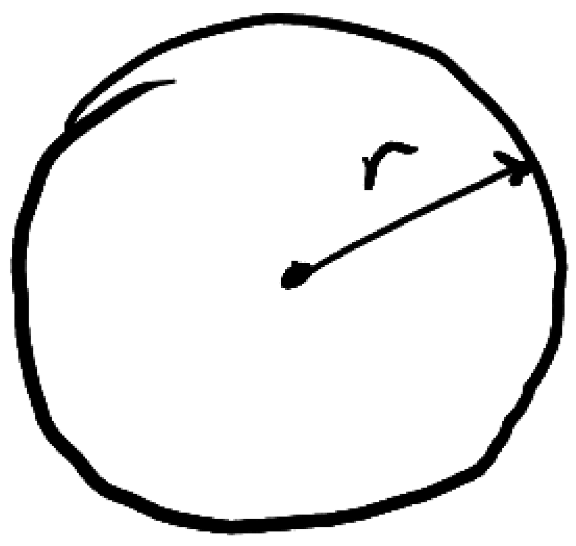


$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

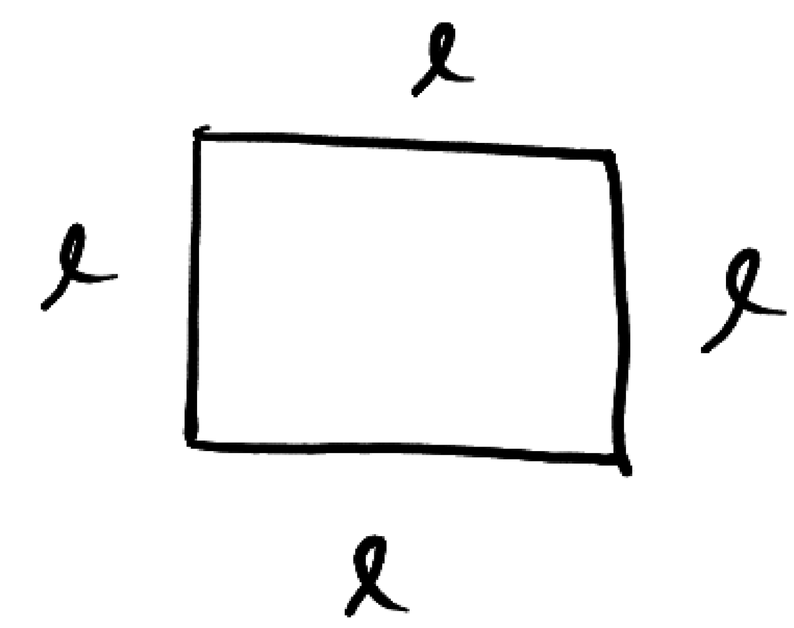
$$\vec{\mu} = I\vec{A} = I(150)(A)(B)$$

$$= \boxed{\qquad\qquad N\cdot m}$$

8.12



VS



a)

$2\pi r = 1 \text{ meter}$

$r = \frac{1}{2\pi}$

$A = \pi r^2 = \frac{1}{4\pi}$

$= \boxed{0.0796 \, m^2}$

$4l = 1 \text{ meter}$

$l = 1/4$

$A = l^2 = 1/16$

$= \boxed{0.0625 \, m^2}$

b)

$\tau_{max} = (\mu \times B)_{max} = IAB\cancel{\sin\theta}$ 1 is max

$\tau_{\substack{max \\ circ}} = \frac{5(1/4\pi)}{4} = \boxed{0.0995 \text{ Nm}}$

$\tau_{\substack{max \\ square}} = \frac{5}{(16)(4)} = \boxed{0.0781 \text{ Nm}}$

c)

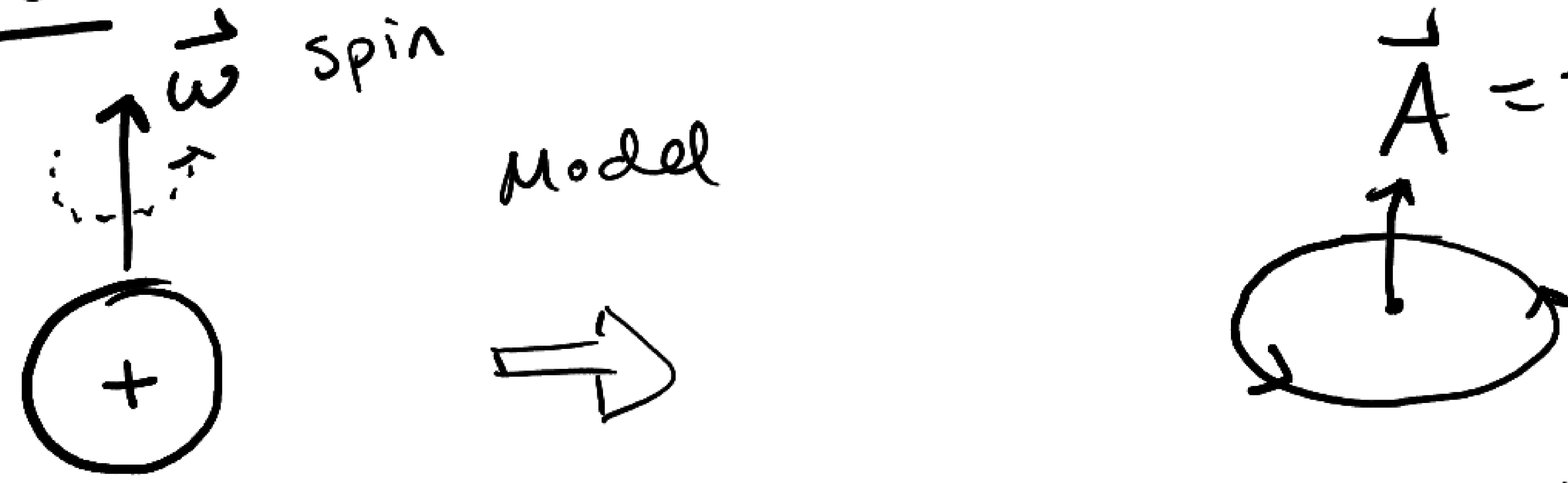
$\tau_{circ} = IA_{circ}B\sin\theta = \tau_{\substack{max \\ square}} = 0.0781$

$5\left(\frac{1}{4\pi}\right)\left(\frac{1}{4}\right)\sin\theta = 0.0781$

$\theta = \sin^{-1}\left(\frac{0.0781}{5\left(\frac{1}{4\pi}\right)\left(\frac{1}{4}\right)}\right) = \boxed{51.75^\circ}$

8.13

proton



$\vec{A} = \pi r^2 = 1.33E\text{-}30\,m^2$

$I = 1.05E4$ Amp

$$\vec{\tau} = \vec{\mu} \times \vec{B} = IAB\cancel{\sin\theta}^{\,1 \to max}$$

$$= (1.05E4)(1.33E\text{-}30)(2.5)$$

$$\boxed{\tau = 3.49 \times 10^{-26} \text{ Newtons}}$$

this is how MRI or NMR works!

8.14: circular Motion

b)

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

$$= \boxed{\qquad\qquad m}$$

$$v = \frac{c}{10} = \frac{3E8}{10} = 3E7\,m/s$$

$q = 1.6 \times 10^{-19}\,C$

$B = 1.5\,T$

$m_p = 1.9 \times 10^{-27}\,kg$

$x = r\theta$

$v = r\omega$

a)

period $T = \frac{1}{f} = \frac{2\pi}{\omega} = \frac{2\pi r}{v} = \boxed{\qquad\qquad sec}$

8.15

$B = 1.25\,T$

$r = 0.4\,m$

$q_p = 1.6\times10^{-19}\,C$

$m_p = 1.9\times10^{-27}\,kg$

a) $qvB = \frac{mv^2}{r}$

$v = \frac{qBr}{m}$

$= \qquad \frac{m}{s}$

$KE = \frac{1}{2}mv^2 = \frac{q^2B^2r^2}{2m}$

$\boxed{= \qquad J}$

b)

MeV is a unit conversion

$1\,eV = 1.6\times10^{-19}\,J$

$1\,MeV = 1.6\times10^{-13}\,J$

add 6 orders of magnitude for "Mega"

$KE = (\qquad J)\left(\frac{1\,MeV}{1.6E\text{-}13\,J}\right)$

$= \boxed{\qquad MeV}$

c)

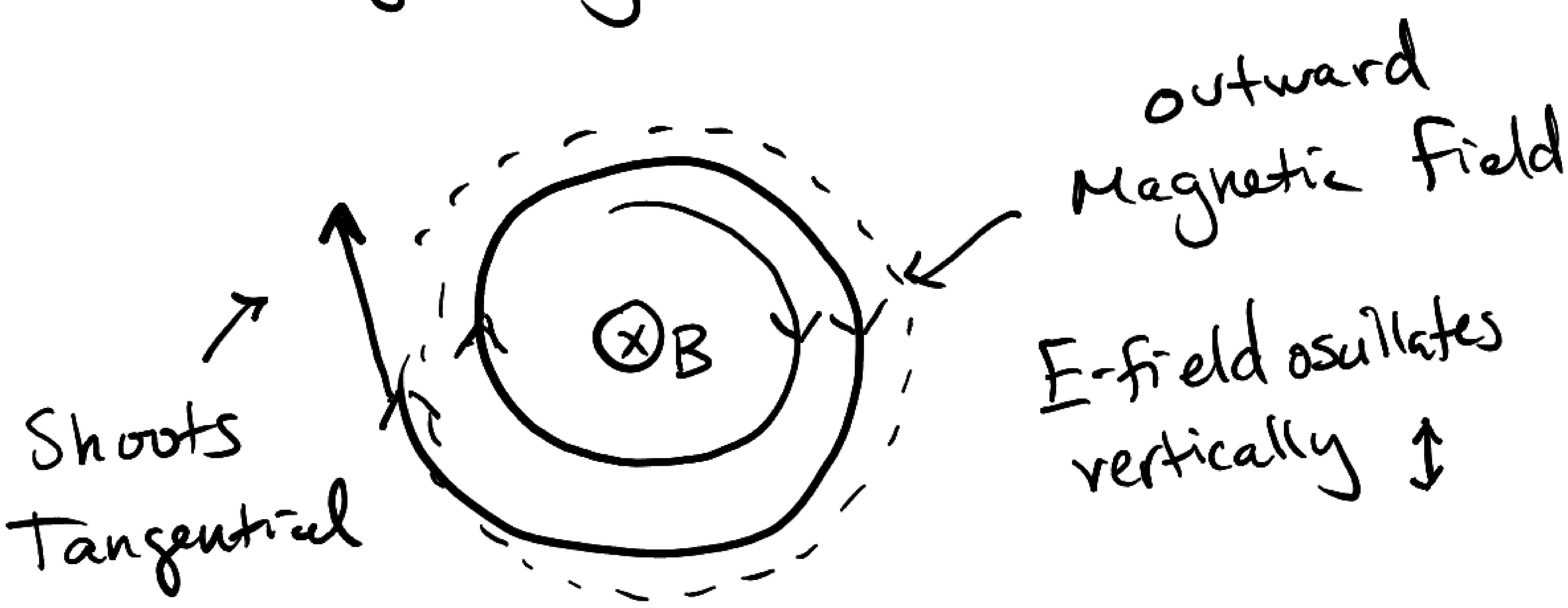
$\cancel{W_{nc}}^{\,0} = \Delta K + \Delta U \Rightarrow \frac{1}{2}mv^2 = q\Delta V$

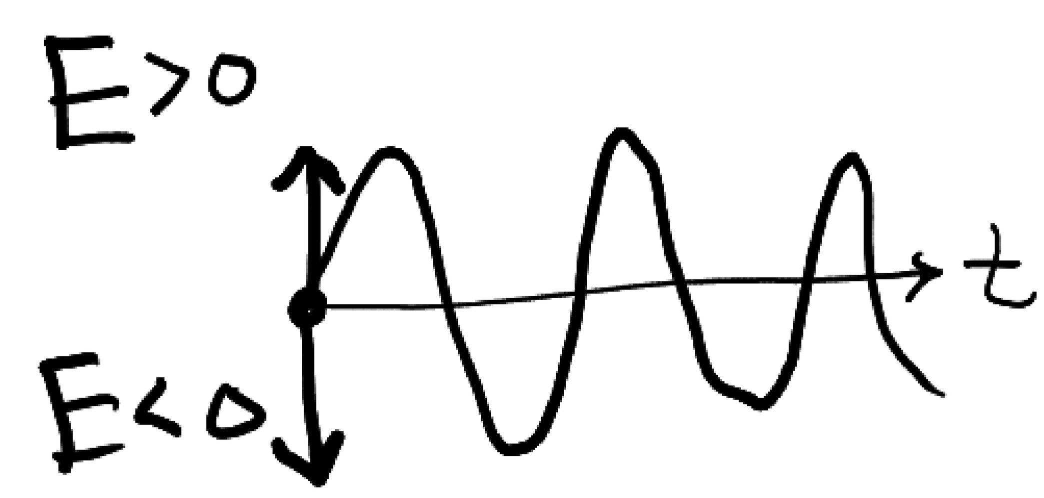
$V = \frac{mv^2}{2q} = \boxed{\qquad \text{Volts}}$

8.15 part 4

- The Magnetic Field is always perpendicular to the Velocity. This means the tangential acceleration is unchanged by B: $\vec{F} = q\vec{v} \times \vec{B}$
- Instead use the Electric Field $\vec{F} = q\vec{E}$

Trajectory spirals out:





E-field oscillates up and down, accelerating the particle as it circles from B-field

Period of Voltage (and thus E field) must match the period of the circular motion

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

$x = r\theta$
$v = r\omega$
$a = r\alpha$

$$f = \frac{qB}{2\pi m} = \boxed{\quad\quad\quad\quad \text{Hz}}$$

$\omega = 2\pi f$

8.15 part 5: Repeat w/ α-particle

"α" $\Rightarrow$ He_2^4 nucleus only (fully ionized)

$$m_\alpha = 6.645 \times 10^{-27}\ kg$$

$$q_\alpha = 2e = 3.204 \times 10^{-19}\ C$$

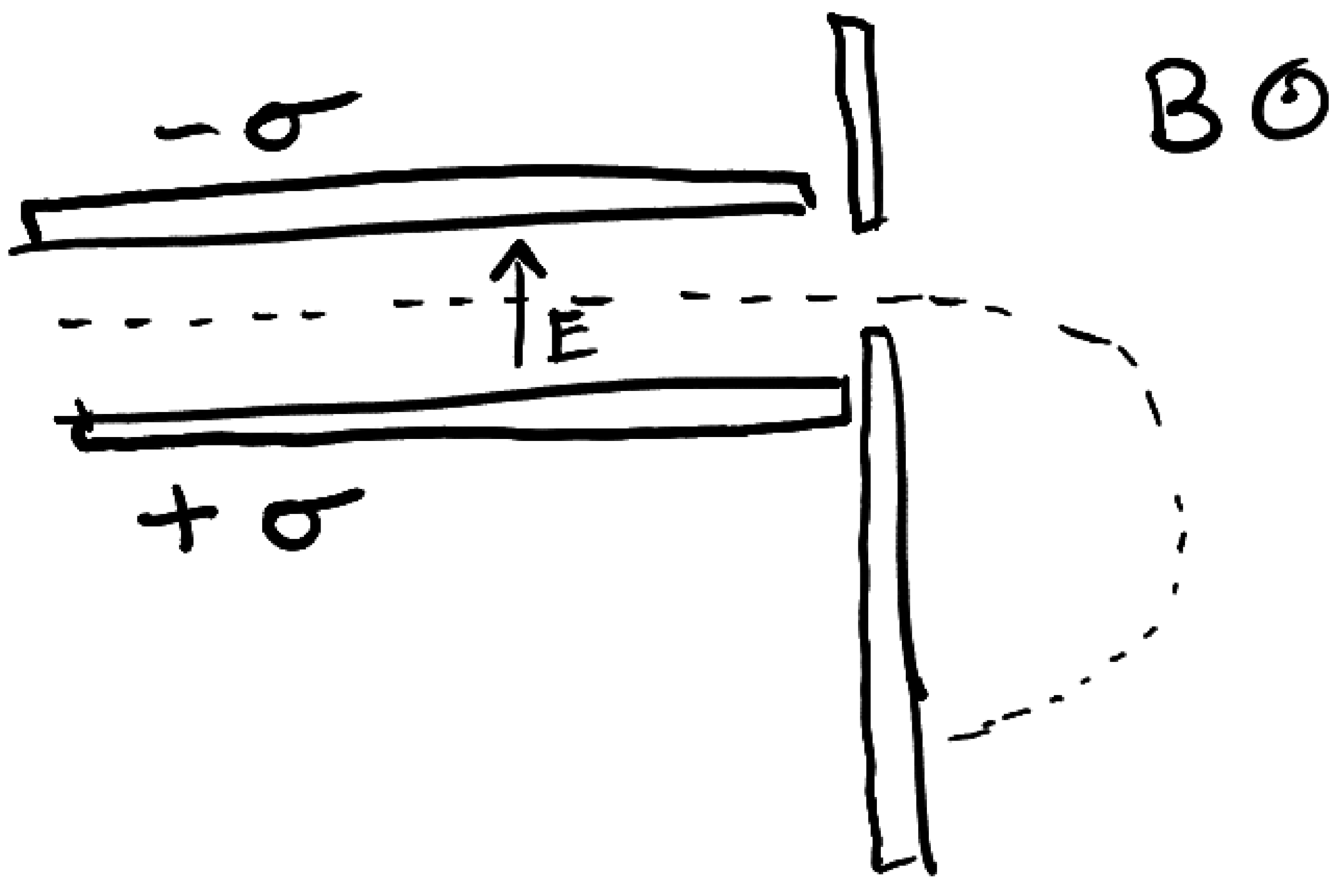
$$KE = \frac{q^2 B^2 r^2}{2m} = \boxed{\quad\quad\quad\quad J}$$

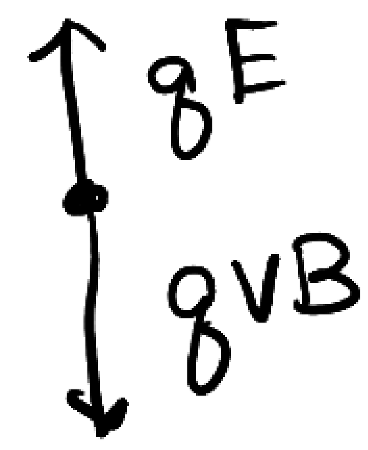
change Units $= \boxed{\quad\quad\quad\quad MeV}$

$$\Delta V = \frac{m v^2}{2q} = \boxed{\quad\quad\quad\quad Volts}$$

$$f = \frac{qB}{2\pi m} = \boxed{\quad\quad\quad\quad Hz}$$

Problem 8.16:





$qE = qVB$

$V = \frac{E}{B}$

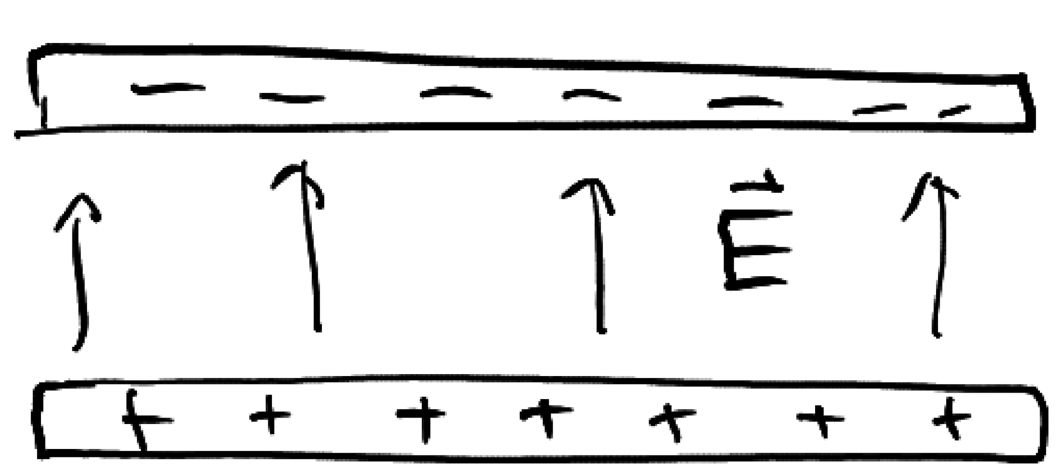
then $qvB = \frac{mv^2}{r}$

a) $E = VB$

$= (4E6)(0.1)$

$$\boxed{|\vec{E}| = 4E5\ N/c}$$

b)



$|\vec{E}| = \frac{\sigma}{\varepsilon_0}$

$\Delta V = -\int \vec{E} \cdot d\vec{l}$

$= -\int \frac{\sigma}{\varepsilon_0} dx = -\frac{\sigma}{\varepsilon_0} \Delta x$

$\Delta V = -E\Delta x$

$\Delta V = (4E5)(0.01) = \boxed{4kV}$