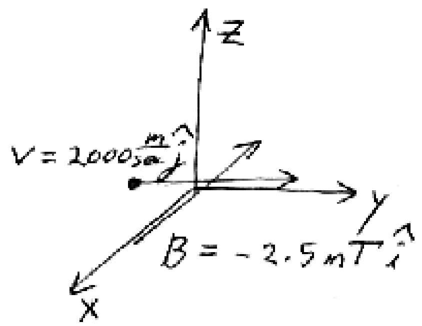
Homework # 6

(29-1) a) $F_B = |q| v B \sin\phi = (3.2\times10^{-17}C)(550\frac{m}{sec})(0.045T)\sin 52^\circ$

$= \boxed{6.24\times10^{-18}N}$

b) $a = \frac{F_B}{m} = \frac{6.24\times10^{-18}N}{6.6\times10^{-27}kg} = \boxed{9.46\times10^{8}\frac{m}{sec^2}}$

c) The magnetic force can do no work on a charged particle, so the speed of the particle remains equal to $550\frac{m}{sec}$.



For all three cases, the magnetic force on the proton is

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

$$\vec{F}_B = (1.6\times10^{-19}C)(2000\frac{m}{sec}\hat{j})\times(-2.5\times10^{-3}T\hat{i})$$

$$\vec{F}_B = 8\times10^{-19}N\hat{k}$$

(29-2) a) $\vec{F} = \vec{F}_E + \vec{F}_B = q\vec{E} + \vec{F}_B$

$= (1.6\times10^{-19}C)(4\frac{N}{C}\hat{k}) + 8\times10^{-19}N\hat{k}$

$= \boxed{1.44\times10^{-18}N\hat{k}}$

b) $\vec{F} = q\vec{E} + \vec{F}_B = (1.6\times10^{-19}C)(-4\frac{N}{C}\hat{k}) + 8\times10^{-19}N\hat{k}$

$= \boxed{1.6\times10^{-19}N\hat{k}}$

c) $\vec{F} = q\vec{E} + \vec{F}_B = (1.6\times10^{-19}C)(4\frac{N}{C}\hat{i}) + 8\times10^{-19}N\hat{k}$

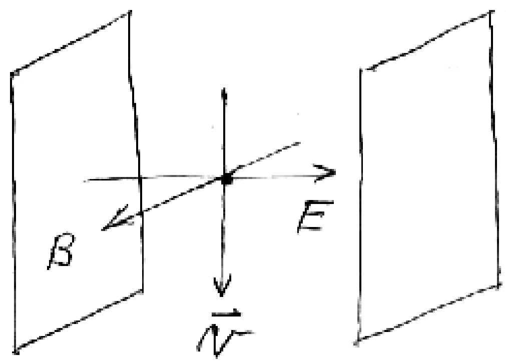
$= 6.4\times10^{-19}N\hat{i} + 8\times10^{-19}N\hat{k}$

The magnitude of the force is

$$F = \sqrt{(6.4\times10^{-19}N)^2 + (8\times10^{-19}N)^2} =$$

$$= \boxed{1.02\times10^{-18}\ N}$$

(29-3)



We want

$$\vec{F} = q(\vec{E} + \vec{v}\times\vec{B}) = 0$$

Since $\vec{v} \perp \vec{B}$, this means that

$$\vec{E} \perp \vec{v} \perp \vec{B}$$

(note that $\vec{v}\times\vec{B}$ points opposite $\vec{E}$)

$$E = vB \quad \text{(magnitudes)}$$

or $B = \frac{E}{v}$

We now must find E and v, the electron's speed. Since $\vec{E}$ is constant between parallel plates, we use

$$\Delta V = Ed \quad \text{or} \quad E = \frac{\Delta V}{d} = \frac{100\,V}{20\times10^{-3}m} = 5000\,\frac{V}{m}$$

The electron's kinetic energy is 1 keV, so

$$\frac{1}{2}mv^2 = 1\,keV \quad \text{with } m = 9.11\times10^{-31}\,kg$$

$$\Rightarrow \quad v = \sqrt{\frac{2(10^3\,eV)\left(\frac{1.6\times10^{-19}J}{1\,eV}\right)}{9.11\times10^{-31}\,kg}} = 1.87\times10^{7}\,\frac{m}{sec}$$

So $$B = \frac{E}{v} = \frac{5000\,V/m}{1.87\times10^{7}\,m/sec} = \boxed{2.67\times10^{-4}\,T}$$

(29-4) From $n = \frac{Bi}{(\Delta V)\ell e}$, $\Delta V = \frac{Bi}{n\ell e}$ so

$$\Delta V = \frac{(0.65T)(23A)}{(8.47\times10^{28}\frac{1}{m^3})(150\times10^{-6}m)(1.6\times10^{-19}C)} = \boxed{7.35\times10^{-6}V}$$

(29-5) a) Using $K = |q|\Delta V = \frac{1}{2} m v^2$ since the electron starts at rest,

$$v = \sqrt{\frac{2|q|\Delta V}{m}}$$

$$= \sqrt{\frac{2(1.6\times10^{-19}C)(350V)}{9.11\times10^{-31}kg}}$$

$$= \boxed{1.11\times10^{7}\ \frac{m}{sec}}$$

b) $r = \frac{mv}{|q|B} = \frac{(9.11\times10^{-31}kg)(1.11\times10^{7}\frac{m}{sec})}{(1.6\times10^{-19}C)(200\times10^{-3}T)} = \boxed{3.16\times10^{-4}m}$

(29-6) $T = \frac{2\pi m}{|q|B}$ so $m = \frac{1}{2\pi}(T|q|B)$

So $m = \frac{1}{2\pi}\left[\left(\frac{1.29\times10^{-3}sec}{7}\right)(1.6\times10^{-19}C)(45\times10^{-3}T)\right]$

$$= 2.11\times10^{-25}kg\ \left(\frac{1\,u}{1.66\times10^{-27}kg}\right) = \boxed{127\,u}$$

(29-7) a) $r = \frac{mv}{|q|B}$ so $v = \frac{|q|Br}{m}$

$$\Rightarrow v = \frac{2(1.6\times10^{-19}C)(1.2T)(0.045m)}{4(1.66\times10^{-27}kg)} = \boxed{2.60\times10^{6}\frac{m}{sec}}$$

b) $T = \frac{2\pi r}{v} = \frac{2\pi(0.045m)}{2.6\times10^{6}m/sec} = \boxed{1.09\times10^{-7}sec}$

c) $K = \frac{1}{2}mv^2 = \frac{1}{2}(4)(1.66\times10^{-27}kg)(2.6\times10^{6}\frac{m}{sec})^2\left(\frac{1\,eV}{1.6\times10^{-19}J}\right)$

$$= \boxed{1.40\times10^{5}eV}$$

d) Since the alpha particle has charge of $q = +2e$, it was accelerated (assumed starting at rest) through

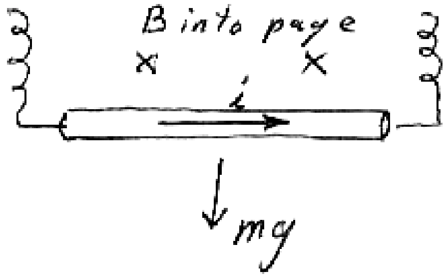
$$\Delta V = \frac{1.40\times10^{5}V}{2} = \boxed{7.0\times10^{4}V}$$

(29-8) a) $r = \frac{mv}{|q|B} = \frac{(1.67\times10^{-27}\,\text{kg})\overbrace{(0.1)(3\times10^{8}\,\text{m/sec})}^{\frac{1}{10}c}}{(1.6\times10^{-19}\,\text{C})(1.4\,\text{T})}$

$= \boxed{0.224\ \text{m}}$

b) $f_{osc} = \frac{1}{T} = \frac{v}{2\pi r} = \frac{(0.1)(3\times10^{8}\,\text{m/sec})}{2\pi\,(0.224\,\text{m})} = \boxed{2.13\times10^{7}\,\text{Hz}}$

(29-9)



By the right hand rule for $\vec{F}_B = i\vec{L}\times\vec{B}$,

the current flows from left to right to create an upward force that balances gravity.

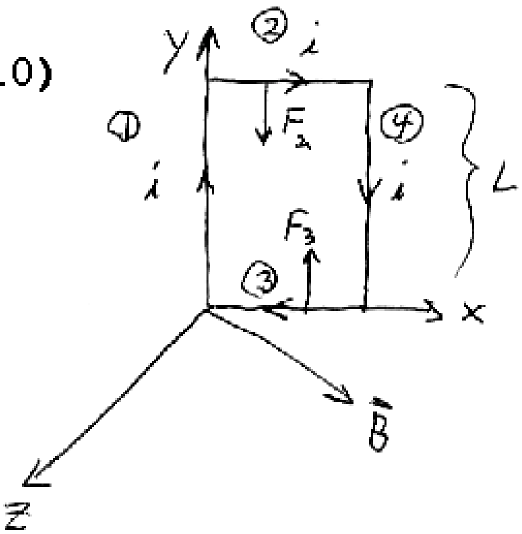
Because $\vec{L}\perp\vec{B}$, we have

$$F_B = mg \quad \text{(magnitudes)}$$

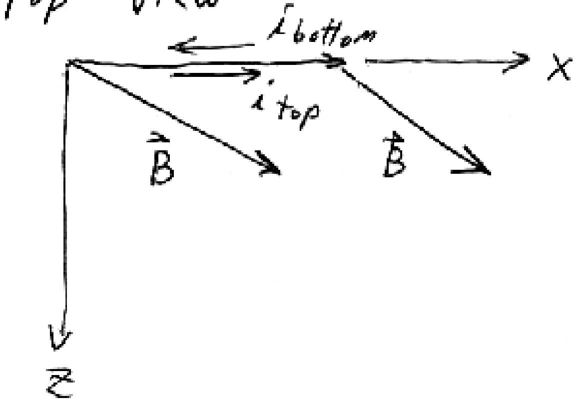
$$iLB\sin 90^\circ = mg$$

So $i = \frac{mg}{LB} = \frac{(13\times10^{-3}\,\text{kg})(9.8\,\text{m/sec}^2)}{(0.62\,\text{m})(0.440\,\text{T})} = \boxed{0.467\ \text{A}}$

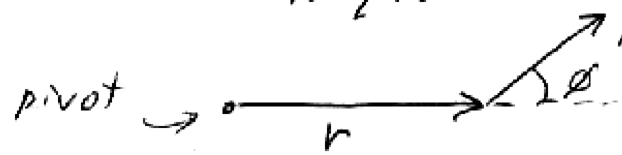
(29-10)



top view



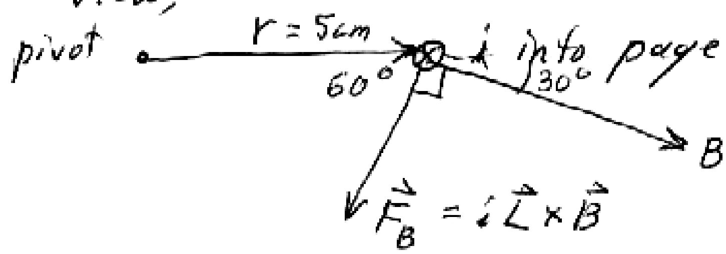
Recall that torque is $\tau = rF\sin\phi$



There is no torque on side ① (the pivoted side), because $r=0$.

Using $\vec{F}_B = i\vec{L}\times\vec{B}$ on the top (side ②) and bottom (side ③), we find that the magnetic forces $\vec{F}_2$ and $\vec{F}_3$ are in the plane of the coil. This can't cause the coil to rotate, so the torques on sides ② and ③ are zero.

For side ④, the torque is $\vec{\tau} = \vec{r}\times\vec{F}$. Another top view,



The magnitude of the torque on side ④ is

$$\tau = rF\sin 60^\circ \times (\#\text{ turns})$$

$$= riLB\sin 60^\circ N$$

$$= (0.05\,m)(0.1\,A)(0.1\,m)(0.5\,T)\sin 60^\circ(20)$$

$$= \boxed{4.33\times10^{-3}\,N\cdot m}$$

The direction of the torque vector is in the direction of $\vec{r}\times F_B$, downward ($-y$) direction

(29-11) a) $\mu = NiA = Ni\pi r^2$ for a circular loop

So $i = \frac{\mu}{N\pi r^2} = \frac{2.30\,A\cdot m^2}{(160)(\pi)(0.019m)^2} = \boxed{12.7\,A}$

b) $\tau = \mu B \sin\phi$ For max μ, set $\phi = 90°$

$\Rightarrow \tau_{max} = \mu B = (2.3\,A\cdot m^2)(35\times10^{-3}T)$

$= \boxed{8.05\times10^{-2}\,N\cdot m}$

(29-12) With $N=1$ turn, $\mu = iA = i\pi R^2$ for a circular loop

$i = \frac{\mu}{\pi r^2} = \frac{8\times10^{22}A\cdot m^2}{\pi(3500\times10^3 m)^2} = \boxed{2.08\times10^9\,A}$

Wow!