(Solutions to Midterm Exam 03, PHYS 205B, Fall 2015)

Prob. 1

(a) $F_p = q v B \sin\theta$

$= 1.6\times10^{-19}\times 6.28\times10^{6}\times 1.54 \sin 90$ direction: $+\hat{z}$

$= 1.55\times10^{-12}$ N

(b) $F_e = 1.55\times10^{-12}$ N direction: $-\hat{z}$

(c) $a_p = \frac{F_p}{m} = \frac{1.55\times10^{-12}\,N}{1.67\times10^{-27}\,kg} = 9.28\times10^{14}\,\frac{m}{s^2}$ direction: $+\hat{z}$

(d) $a_e = \frac{F_e}{m} = \frac{1.55\times10^{-12}\,N}{9.1\times10^{-31}\,kg} = 1.70\times10^{18}\,\frac{m}{s^2}$ direction: $-\hat{z}$.

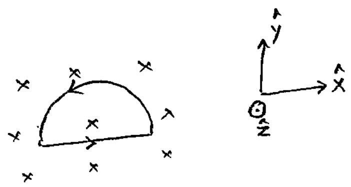
Prob. 2

$F = ma \Rightarrow qvB = \frac{mv^2}{R} \Rightarrow R = \frac{mv}{qB}$

proton: $R_{proton} = \frac{m_p V}{eB} = \frac{1.67\times10^{-27}\times2.0\times10^{6}}{1.6\times10^{-19}\times5.0\times10^{-6}} = 4180$ m

electron: $R_{electn} = \frac{m_e V}{eB} = \frac{9.1\times10^{-31}\times2.0\times10^{6}}{1.6\times10^{-19}\times5.0\times10^{-6}} = 2.28$ m

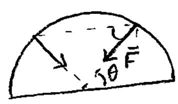
Prob. 3



(a) $\vec{F}_1 = 2IRB\,\hat{y}$

$= 2\times1.0\times5.0\times10^{-2}\times0.10\,\hat{y}$ T

$= 1.0\times10^{-2}\,\hat{y}$ T



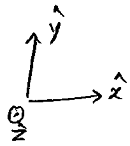
(b) $\vec{F}_2 = IB\int dl\,(-\hat{r})$

$= IBR\int_0^{\pi} d\theta\,\sin\theta\,(-\hat{y})$

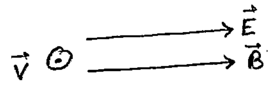
$= -2IRB\,\hat{y}$

$= -1.0\times10^{-2}\,\hat{y}$ T

(c) $\vec{F}_{tot} = \vec{F}_1 + \vec{F}_2 = 0.$



Prob. 4

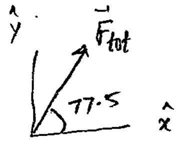


$$\vec{F}_{tot} = q\vec{E} + q\,\vec{v}\times\vec{B}$$

$$= qE\,\hat{x} + qvB\,\hat{y}$$

$$= 2.0\times10^{-6}\times 2.00\times10^{3}\,\hat{x} + 2.0\times10^{-6}\times3.0\times10^{6}\times3.00\times10^{-3}\,\hat{y}$$

$$= 4.0\text{ mN}\,\hat{x} + 18\text{ mN}\,\hat{y}$$



$$|\vec{F}_{tot}| = \sqrt{4.0^2 + 18^2}\text{ mN} = 18.4\text{ mN}$$

direction: $\theta = \tan^{-1}\left(\frac{18}{4}\right) = 77.5^\circ$ w.r.t $\hat{x}$

Prob. 5

$2\pi R = 5.00\times10^{-2}$ m

$R = 7.96\times10^{-3}$ m

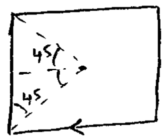
$$\tau = NIAB$$

$$= NI\pi R^2 B$$

$$= 1\times4.40\text{ A}\times\pi\,(7.96\times10^{-3}\text{ m})^2\times1.50\text{ T}$$

$$= 1.3\times10^{-3}\text{ Nm}$$

Prob. 6



B_1 = field due to one side $\qquad \theta_1 = \theta_2 = 45^\circ$

$$= \frac{\mu_0 I}{4\pi L}(\sin\theta_1 + \sin\theta_2)$$

$$= \frac{\mu_0 I}{4\pi L}\sqrt{2} \quad \text{(into the page)}$$

$$B_{tot} = 4B_1$$

$$= \frac{\mu_0 I}{4\pi L}\,4\sqrt{2}$$

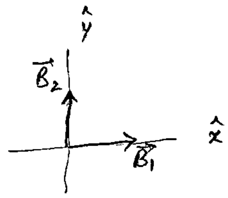
$$= \frac{4\pi\times10^{-7}\times2.00}{4\pi\times1.00\times10^{-2}}\,4\sqrt{2}$$

$$= 0.113\text{ mT} \quad \text{(into the page)}$$

Prob. 7

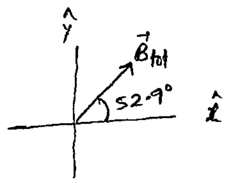
$$\vec{B}_1 = \frac{\mu_0 I_1}{2\pi y}\,\hat{i} = \frac{4\pi\times10^{-7}\times1.0}{2\pi\;\;8.0\times10^{-2}}\,\hat{i}\;T = \hat{i}\;2.5\,\mu T$$

$$\vec{B}_2 = \frac{\mu_0 I_2}{2\pi x}\,\hat{j} = \frac{4\pi\times10^{-7}\times2.0}{2\pi\;\;12\times10^{-2}}\,\hat{j}\;T = \hat{j}\;3.3\,\mu T$$



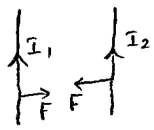
$$\vec{B}_{tot} = \vec{B}_1 + \vec{B}_2 = 2.5\,\mu T\;\hat{i} + 3.3\,\mu T\;\hat{j}.$$

$$|\vec{B}_{tot}| = 4.14\,\mu T \qquad \text{direction: } \theta = \tan^{-1}\left(\frac{3.3}{2.5}\right) = 52.9^\circ$$



Prob. 8

$$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r} = \frac{4\pi\times10^{-7}\times5.00\times8.00}{2\pi\times14.0\times10^{-2}} = 5.71\times10^{-5}\,\frac{N}{m} \qquad \text{(attract)}$$



Prob. 9

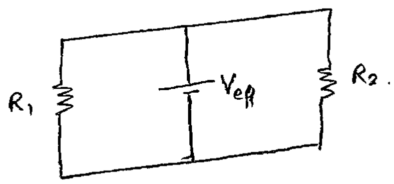
(a) Increasing

(b) Clockwise.

(c) $IR = B l v$ $\qquad v = \frac{IR}{Bl} = \frac{9.0\times10^{-3}\times8.0}{0.300\times1.00\times10^{-1}} = 2.4\,\frac{m}{s}$

Prob. 10

$$V_{eff} = B l v = 0.20\times10.0\times10^{-2}\times10.0 = 0.20\text{ Volt}$$



$$I_1 = \frac{V_{eff}}{R_1} = \frac{0.20}{100.0} = 2.0\text{ mA}$$

$$I_2 = \frac{V_{eff}}{R_2} = \frac{0.20}{200.0} = 1.0\text{ mA}$$