1

(a) $\lambda \nu = c$

$$E = h\nu = \frac{hc}{\lambda}$$

$$\Delta E = -\frac{hc}{\lambda^2}\Delta\lambda$$

$$\Delta E = g\mu_B m_J B \underset{\text{on the order of}}{\sim} \mu_B B$$

$$\Delta\lambda = \frac{-\lambda^2 \Delta E}{hc} = \frac{-\lambda^2 \mu_B B}{hc} = \frac{(550\,nm)^2\, 5.8\times10^{-5}\,eV/T \cdot 1T}{1240\,eV\cdot nm}$$

$$= 0.014\ nm$$

(b) first order diffraction peak at

$$\theta \sim \frac{\lambda}{a}$$

$$d\theta = \frac{d\lambda}{a} = \frac{0.014\,nm}{1mm/2{,}600} = \frac{1.4\times10^{-9}\,cm}{10^{-1}cm/1200} = 1.68\times10^{-5}\,rad$$

$$x = L\,d\theta = 25\,cm \cdot 1.68\times10^{-5}\,rad$$

$$= 4\times10^{-4}\ cm = 4\,\mu m.$$

too small!

2

(a)

$$U = -\mu \cdot B$$

$$F = -\frac{dU}{dx} = +\mu \frac{dB}{dx} = 5.8 \times 10^{-5} \frac{eV}{T} \ \frac{10\,T}{cm} = 5.8 \times 10^{-4} \frac{eV}{cm}$$

(b)

$$\frac{Mv^2}{2} = \frac{3}{2} K_B T$$

$$V^2 = \frac{3}{m} K_B T$$

deflection

$$Z = \frac{1}{2} a t^2 = \frac{1}{2} \frac{F}{m} \left(\frac{d}{v}\right)^2 = \frac{1}{2} \frac{\mu \frac{dB}{dx}}{m} \frac{Md^2}{3K_B T} = \underbrace{\mu \frac{dB}{dx}}_{\text{Part (a)}} \frac{d^2}{6K_B T}$$

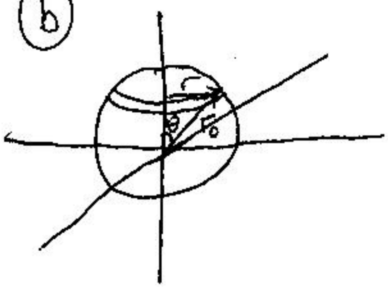
$$= 5.8 \times 10^{-4} \frac{eV}{cm} \frac{(3.5\,cm)^2}{6 \cdot 8.6 \times 10^{5} \frac{eV}{K} \cdot 1000K} = 0.014\,cm$$

$$= 140\,\mu m$$

3/ (a)

$r_0 = \frac{e^2}{(mc^2)}$

(b)



$$\mu = \int d\mu = \int d(I\cdot A) = \int_0^{\pi} \underbrace{\left(e\,\frac{\overset{dQ}{2\pi r\cdot r\,d\theta}}{4\pi r_0^2}\right)\nu}_{I}\,\pi r^2$$

$r = r_0 \sin\theta$

$$\mu = e\frac{\nu\pi}{2}\int_0^{\pi} \frac{r_0^4}{r_0^2}\sin^4\theta\, d\theta$$

$$= e\frac{\nu\pi}{\cancel{2}} r_0^2\ \cancel{2}\cdot\frac{(4-1)!!}{4!!}\,\frac{\pi}{2}$$

$$= e\nu\frac{\pi^2 r_0^2}{2}\ \frac{3}{8}$$

$$= e\frac{3}{16}\pi^2 r_0^2\,\nu = \mu_B$$

Speed @ equator

$$\nu = \frac{V}{2\pi r_0}$$

$$\frac{e3}{16}\pi^{\cancel{2}}\, r_0^{\cancel{2}}\left(\frac{V}{2\cancel{\pi}\cancel{r_0}}\right) = \mu_B$$

$$\frac{3\pi}{32}\,\frac{e^2}{\cancel{m}c^2}\,V = \mu_B = \frac{e\hbar}{2\cancel{m}}$$

$$V = \frac{32}{3\pi}\frac{c^2\hbar}{e^2} = \frac{c}{\gamma}$$

$$\gamma = \frac{3\pi e^2}{32\hbar c}$$

$$= \frac{3\pi}{32}\alpha$$