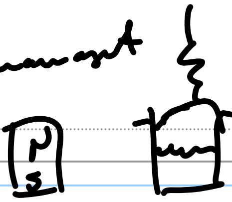
Note Title 4/18/2008

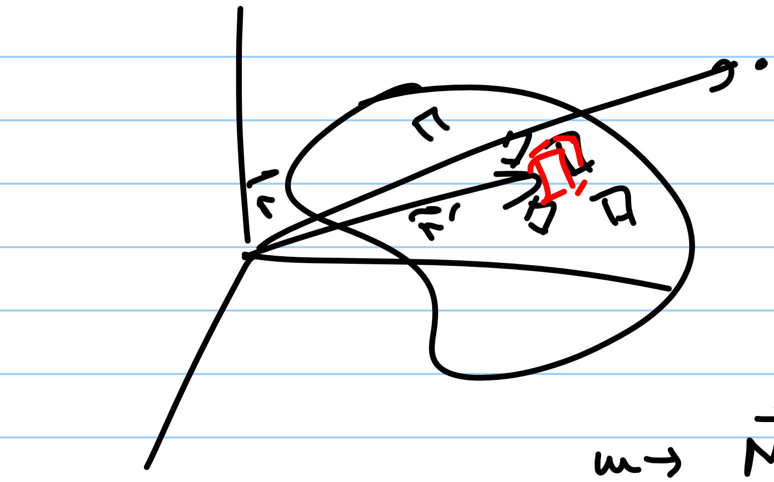
Paramagnet



repel, diamagnet

$$\mathcal{E}_{mf} = -\frac{d\Phi}{dt}$$

details



find $\vec{B}$ first $\vec{A}_{dipole}$

dipole mom for an atom

$$\vec{A} = \frac{\mu_0}{4\pi}\frac{\vec{m}\times\hat{r}}{r^2}$$

$m \to \vec{M}\, d\tau$

dipole mom / vol

$\rho\, d\tau = dm$

mass / vol

$$\int d\vec{A} = \vec{A} = \frac{\mu_0}{4\pi}\int\frac{\vec{M}\times\hat{r}}{r^2}\,d\tau = \frac{\mu_0}{4\pi}\int\frac{\overbrace{\nabla\times\vec{M}}^{\vec{J}_b}}{r}\,d\tau + \frac{\mu_0}{4\pi}\oint\frac{\vec{M}\times d\vec{a}}{r}$$

$\vec{K}_b\, da = \vec{M}\times\hat{n}\, da$

$$\vec{B} = \nabla\times\vec{A}$$

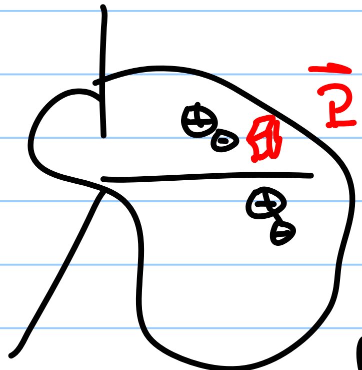
$$\vec{A} = \frac{\mu_0}{4\pi}\int\frac{\vec{J}\,d\tau}{r}$$

$\vec{J}$

$\vec{A}$ $\vec{B}$

Given $\vec{M}$ find $\vec{J}_b = \vec{\nabla}\times\vec{M}$ & K_b

Review



$$\int dV_{dipole} = V = \int \frac{\vec{\nabla}\cdot\vec{P}}{r}\,d\tau + \oint \frac{\vec{P}\cdot\hat{n}\,da}{r}$$

$= \rho_b$

$V = \int \frac{1}{4\pi\epsilon_0}\frac{\rho\, d\tau}{r}$

$\rho \rightarrow V \qquad E$

$\frac{\text{atom}}{\text{vol}} \quad \frac{\text{mag dipole mom}}{\text{atom}}$

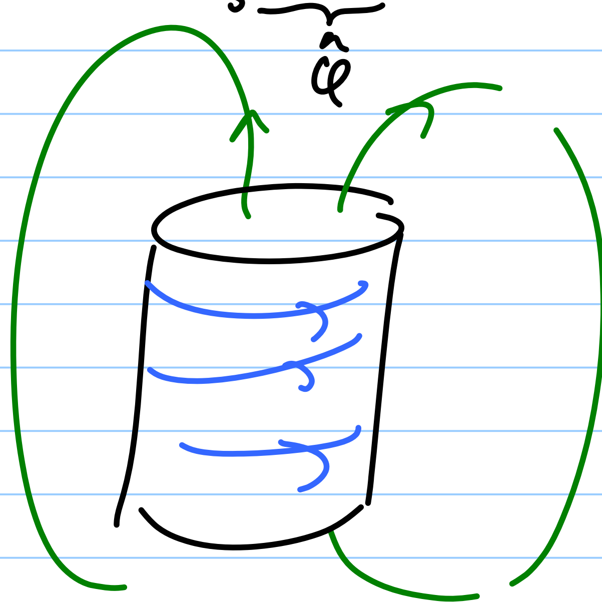
$$\vec{M} = M_0\hat{z}$$

$$\vec{J}_b = \vec{\nabla}\times\vec{M} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 0 & 0 & M_0 \end{vmatrix}$$

$$\vec{K}_b = \vec{M}\times\hat{n}\,da$$

$$= M_0\underbrace{\hat{z}\times\hat{s}}_{\hat{\varphi}}\,da$$

top view



Problem is to find $\vec{M}$

- approx that material is linear

Start with amps law

$$\vec{\nabla}\times\vec{B} = \mu_0 \vec{J}$$

$\longrightarrow$ neglected

$$\frac{1}{\mu_0}\vec{\nabla}\times\vec{B} = \vec{J} = \vec{J}_f + \vec{J}_b + \cancel{\vec{J}_{displacement}}$$

$\cancel{\epsilon_0 \frac{\partial \vec{E}}{\partial t}}$

$$\vec{J}_b = \vec{\nabla}\times\vec{M}$$

$$\underbrace{\vec{\nabla}\times\left(\frac{\vec{B}}{\mu_0} - \vec{M}\right)}_{\vec{H}} = \vec{J}_f$$

$$\vec{\nabla}\cdot\vec{E} = \frac{\rho}{\epsilon_0} = \frac{\rho_f}{\epsilon_0} + \frac{\rho_b}{\epsilon_0}, \quad \rho_b = -\vec{\nabla}\cdot\vec{P}$$

$$\vec{\nabla}\cdot\vec{D} = \rho_f$$

$$\vec{\nabla}\times\vec{H} = \vec{J}_f$$

Stokes th. apply Amp's Law

$$\boxed{\oint \vec{H}\cdot d\vec{l} = I_{free}^{enclose}}$$

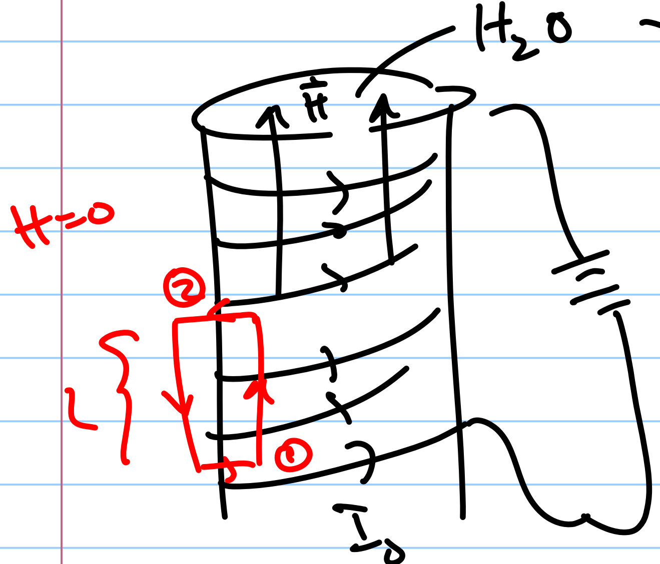
need $\vec{\nabla}\cdot\vec{H}$ to define H (bndy cond.)

Assume linear material $\quad \vec{M} = \chi_m \vec{H}$

$$\vec{H} = \frac{\vec{B}}{\mu_0} - \vec{M} = \frac{\vec{B}}{\mu_0} - \chi_m \vec{H}$$

$$\underbrace{\mu_0(1+\chi_m)}_{\mu}\vec{H} = \vec{B}$$

change sign paramagnetic or diamagnetic



H_2O χ_m

What is B in H_2O?

Principle: Amps Law $\oint \vec{H} \cdot d\vec{l} = I_{enc}^{free}$

\# wires / length

$$H \cancel{l} = I_0 n \cancel{l}$$

$$H = n I_0$$

$$B = \mu_0(1+\chi_m)H = \mu_0(1+\chi_m) n I_0$$

sign