PHY 712 Electrodynamics
9-9:50 AM MWF Olin 103

Plan for Lecture 12:

Continue reading Chapter 5

A. Examples of magnetostatic fields

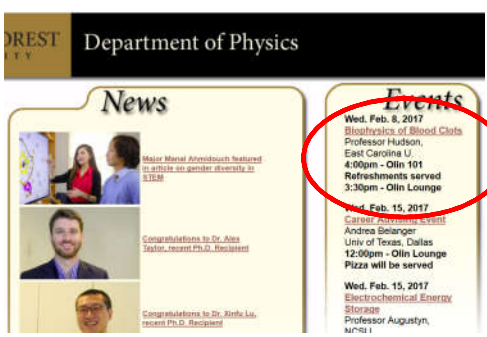
B. Magnetic dipoles

C. Hyperfine interaction

Course schedule for Spring 2017

(Preliminary schedule -- subject to frequent adjustment.)

	Lecture date	JDJ Reading	Topic	HW	Due date
1	Wed: 01/11/2017	Chap. 1	Introduction, units and Poisson equation	#1	01/18/2017
2	Fri: 01/13/2017	Chap. 1	Electrostatic energy calculations	#2	01/18/2017
	Mon: 01/16/2017		*MLK Holiday - no class*		
3	Wed: 01/18/2017	Chap. 1	Poisson equation and Green's theorem	#3	01/20/2017
4	Fri: 01/20/2017	Chap. 1 and 2	Poisson equation in 2 and 3 dimensions	#4	01/23/2017
5	Mon: 01/23/2017	Chap. 1 and 2	Brief introduction to grid solution methods	#5	01/25/2017
6	Wed: 01/25/2017	Chap. 2	Method of images	#6	01/27/2017
7	Fri: 01/27/2017	Chap. 3	Cylindrical and spherical geometries	#7	01/30/2017
8	Mon: 01/30/2017	Chap. 3 & 4	Multipole analysis	#8	02/01/2017
9	Wed: 02/01/2017	Chap. 4	Dipoles and dielectrics	#9	02/03/2017
10	Fri: 02/03/2017	Chap. 4	Dipoles and dielectrics	#10	02/06/2017
11	Mon: 02/06/2017	Chap. 5	Magnetostatics	#11	02/08/2017
12	Wed: 02/08/2017	Chap. 5	Magetostatics and the Hyperfine Interaction	#12	02/10/2017
13	Fri: 02/10/2017				
14	Mon: 02/13/2017				



Various forms of Ampere's law :

$$\nabla \times \mathbf{B}(\mathbf{r}) = \mu_0 \mathbf{J}(\mathbf{r})$$

Vector potential : $\mathbf{B}(\mathbf{r}) = \nabla \times \mathbf{A}(\mathbf{r})$

For Coulomb gauge : $\nabla \cdot \mathbf{A}(\mathbf{r}) = 0$

$$\Rightarrow \nabla^2 \mathbf{A}(\mathbf{r}) = -\mu_0 \mathbf{J}(\mathbf{r})$$

For confined current density :

$$\mathbf{A}(\mathbf{r}) = \frac{\mu_0}{4\pi} \int d^3r' \, \frac{\mathbf{J}(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|}$$

Other examples of current density sources:

Quantum mechanical expression for current density

for a particle of mass M and charge e and of probability amplitude $\Psi(\mathbf{r})$:

$$\mathbf{J}(\mathbf{r}) = -\frac{e\hbar}{2Mi}\left(\Psi^*(\mathbf{r})\nabla\Psi(\mathbf{r}) - \Psi(\mathbf{r})\nabla\Psi^*(\mathbf{r})\right)$$

For an electron in a spherical potential (such as in an atom) :

$$\Psi(\mathbf{r}) \equiv \Psi_{nlm}(\mathbf{r}) = R_{nl}(r) Y_{lm}(\hat{\mathbf{r}})$$

$$\mathbf{J}(\mathbf{r}) = \frac{e\hbar}{2Mi} |R_{nl}(r)|^2 \frac{1}{r \sin\theta} \left(Y_{lm}^*(\hat{\mathbf{r}}) \frac{\partial Y_{lm}(\hat{\mathbf{r}})}{\partial \phi} - Y_{lm}(\hat{\mathbf{r}}) \frac{\partial Y_{lm}^*(\hat{\mathbf{r}})}{\partial \phi} \right) \hat{\boldsymbol{\varphi}}$$

$$= \frac{e\hbar}{M} \frac{m}{r \sin\theta} |\Psi_{nlm}(\mathbf{r})|^2 \hat{\boldsymbol{\varphi}}$$

Note that : $\hat{\boldsymbol{\varphi}} = -\sin\phi \hat{\mathbf{x}} + \cos\phi \hat{\mathbf{y}} = \frac{\hat{\mathbf{z}} \times \mathbf{r}}{r \sin\theta}$

$$\mathbf{J}(\mathbf{r}) = \frac{e\hbar}{M} \frac{m}{r^2 \sin^2\theta} |\Psi_{nlm}(\mathbf{r})|^2 (\hat{\mathbf{z}} \times \mathbf{r})$$