Physics 507 Project #1 2011
Part 1 Due: Thursday, January 27
Part 2 Due: Thursday, February 3

Note: This project is to be worked on in groups:

Group 1: Gao, Hassan, Kaplan
Group 2: Jones, Ramirez, Xu
Group 3: Edrey, Liu, Seitz
Group 4: Hovey, Meyerson, Park
Group 5: Naudus, Patel, Zhang
Group 6: Dai, Flynn, Hogan

Each group should meet soon to lay out the steps necessary to complete the project. This project is not easily dividable, I have made it a group project mostly because there is lots of opportunity to make mistakes or get discouraged, so you are to reinforce each other.

The project is to be written up consistently, coherently, and neatly, on a computer, preferably in TeX or LaTeX. Each member is responsible for proofreading.

Step one (due January 27) is to write up a preliminary version your group agrees upon, and send it to me, but I will not grade it. What I will do is interchange two groups presentations and ask each group to (strictly) criticize the other groups paper. Then each pair of groups will get together and submit a perfect paper to me, on Feb 3, which I will grade.

You will need to be careful with indices, and probably use $\epsilon_{\alpha\beta\gamma}$ notation. See the notes on epsilon and on indices at the end of the lecture notes page.

So what is the project?

At the end of the first lecture we carefully considered the charges as divided into free and bound charges. The bound charges j we described in terms of the position $\vec{x}_n$ of the molecule n they are attached to and the displacement $\vec{x}_{jn}$ of the charge from that position. Defining macroscopic fields as averaged over a small region, but large compared to a molecule, we expanded the smearing function to second order in $\vec{x}_{jn}$. We defined the molecular charge density, which pretends all charges of the molecule are located at $\vec{x}_n$, and the dipole and quadripole molecular densities $\vec{P}(\vec{x},t)$ and $\mathbf{Q}_{\alpha\beta}(\vec{x},t)$. With these, we were able to define the electric displacement $D_\alpha = \epsilon_0 E_\alpha - \sum_\beta \frac{\partial}{\partial x_\beta}\mathbf{Q}_{\alpha\beta}$, and derive Gauss' law

$$\vec{\nabla}\cdot\vec{D}(\vec{x},t) = \rho(\vec{x},t).$$

The project is to do the same thing for Ampère's law. In addition to $\vec{P}$ and $\mathbf{Q}_{\alpha\beta}$, this involves the macroscopic current density

$$\vec{J}(\vec{x},t) = \left\langle \sum_{j \text{ free}} q_j \vec{v}_j \delta(\vec{x}-\vec{x}_j) + \sum_{n \text{ mol}} q_n \vec{v}_n \delta(\vec{x}-\vec{x}_n) \right\rangle,$$

and the macroscopic magnetization

$$\vec{M}(\vec{x},t) = \frac{1}{2}\left\langle \sum_{n \text{ mol}} \sum_{j(n)} q_j \vec{x}_{jn} \times \vec{v}_{jn} \delta(\vec{x}-\vec{x}_n) \right\rangle,$$

Defining the *magnetic field* $\vec{H}$ by equation 6.99, and using the microscopic Ampère's law

$$\vec{\nabla} \times \vec{b}(\vec{x},t) - \frac{1}{c^2}\frac{\partial}{\partial t}\vec{e}(\vec{x},t) = \mu_0 \vec{\jmath}(\vec{x},t),$$

show that the right hand side is given by 6.96 and all together

$$\vec{\nabla} \times \vec{H} - \frac{1}{c^2}\frac{\partial \vec{D}}{\partial t} = \vec{J}(\vec{x},t).$$