Fall 2011 PHYSICS 408a - Electricity and Magnetism

Instructor: Vitaly Kresin
Office: SSC 209, *phone* (213)740-0868
Lab: SSC 108
E-mail: <kresin@usc.edu>
Office Hours: After class (please mention to me in class if you plan to stop by), and by appointment.

Texts

Required: David J. Griffiths, *Introduction to Electrodynamics*, 3rd edition.
This book covers the standard material of our course, with a good balance between physics and mathematical tools.

Recommended: Edward M. Purcell, *Electricity and Magnetism*.
This textbook was written by a brilliant physicist, a winner of the Nobel Prize for discovering nuclear magnetic resonance (the effect underlying MRI imaging) in 1946. Many people, including me, consider it to be one of the finest textbooks ever written. It includes a superb explanation of the techniques of vector calculus as well as of the quintessence of electromagnetism. It is aimed at a somewhat lower level and is very good as a supplementary reference. The only thing to watch out for is that it uses not the SI, but the Gaussian system of electromagnetic units (which is not truly a drawback because it's a much more elegant system). (I'll ask the Science and Engineering Library to put it on reserve; hard copies and electronic downloads are also available online.)

Course contents

We'll cover Chapters 1-6 in Griffiths:

- Electrostatics
- Magnetostatics
- Electric and magnetic fields in matter
- Mathematical techniques of vector fields and potential theory

I'll assume familiarity with vector analysis: vector algebra, vector calculus (*div, grad, curl,* ∇*,* etc.), and the related integral theorems. This material is summarized in Chapter 1 of the text. We'll spend a couple of lectures on a quick review of these concepts, but please be sure to refresh your memory ahead of time.

Please come to class having looked at the upcoming textbook sections in advance, and prepared to discuss the subject and to ask lots of questions.

Grading

Your grade will be determined by your work on:

- the problem sets (30%)
- two midterms and occasional in-class worksheets (40% total)
- the final (30%)

The percentages are approximate; class participation will also be taken into account.

Midterms

We'll have two midterm exams (probably, early October and November, exact dates to be discussed). The midterms and the final will be closed-book, but one double-side sheet of notes will be allowed.

Homework

As with all of physics, the *only* way to learn the material is to do *lots* of problems. There will be weekly homework assignments. Homework will be due <u>at the beginning of class</u> on date due. Since solutions will be posted on Blackboard right away, I won't be able to accept late homework.

You are encouraged to work together on the problem sets (in fact, the best way to make sure you understand how to solve a problem is to see if you can explain it to someone else), but the final write-up *must* be your own.

I'll appreciate (actually, insist on) your taking care to prepare complete and legible homework solutions. Specifically, be sure to:

- *Explain in detail what you're doing. Write as if you are preparing a solutions manual that understandable to a student reader like yourself. Use *plenty of words* to elucidate your reasoning, and to dilute the equations.
- *Show all intermediate steps.
- *Box and underline the final results
- *Verify that the answer works out to have the correct dimensional units. This is an invaluable check that an error hasn't been made along the way.
- *Also confirm that the final result seems to make physical sense (e.g., is the order of magnitude reasonable? does the dependence on the given variables appear logical? etc.). Practicing physicists and engineers use such checks as a matter of course.

These requests are made not just for the ease of grading, but more importantly because if you follow them, you'll feel comfortable that you have fully mastered the problem. Again, it is only if you have prepared a detailed explanation that you can be sure you understand the solution.

The same applies to the tests. In general, credit only will be given if the reader can follow the arguments.

Important dates

University Holidays: September 5, November 23-26
Last day of classes: Friday, December 2
Final exam: Wednesday, Dec. 14, 11 a.m. – 1 p.m.

Approximate Physics 408a outline

Week	Topics
1	Coulomb's law, electric field, field lines Gauss's Law
2	Review of vector fields: ***div, grad, curl*** Gauss's and Stokes's theorems Spherical and cylindrical coordinates
3	$\vec{\nabla} \cdot \vec{\boldsymbol{E}}, \vec{\nabla} \times \vec{\boldsymbol{E}}$ Dirac delta function Electrostatic potential
4	Work and energy Conductors
5	Capacitors Laplace's equation Method of images
6	Separation of variables in rectangular and spherical coordinates
7	Multipole expansion Review of electrostatics in vacuum
8	Dielectrics, polarizability, polarization Induced (bound) charges Field inside and outside polarized objects
9	Electric displacement ***D*** Linear dielectrics
10	Energy in dielectric systems Clausius-Mossotti relation Magnetic fields and forces
11	Biot-Savart law Linear and volume currents Equation of continuity
12	$\vec{\nabla} \cdot \vec{B}, \vec{\nabla} \times \vec{B}$ Ampere's Law Maxwell's eqns. for electro+magnetostatics
13	Vector potential, gauge transformations Boundary conditions Magnetic dipoles Para- and diamagnetics
14	Magnetization ***M*** Fields of magnetized objects; N&S poles
15	Field ***H*** Linear magnetic materials Ferromagnetic materials Overview and review