Fall 2004: PHYSICS 408a - Electricity and Magnetism (I)

Phys408a meets MWF, 12-12.50 pm in GFS111.

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(when e-mailing me, please put 'PHYS408' in the subject, so that I will not confuse your e-mails with the tons of spam I get every day!).
class URL: physics.usc.edu/~roscilde/phys408
Office hours: After class on MWF, any other time by appointment.

1) BOOKS:

Required: David J. Griffiths, *Introduction to Electrodynamics*, 3rd edition
(Prentice Hall, NJ, 1999).
This book is an invaluable learning tool, with detailed physical discussion of the mathematical formalism and a lot of precious hints and tricks.

Textbooks on electrodynamics are uncountable. Physicists usually consider the following book as a 'lifelong' reference text:
John D. Jackson, *Classical Electrodynamics*, 3rd edition
(Wiley & Sons, New York, 1999).
Although more advanced than the level of this class, you will find it very useful for future classes to come and, if you are interested, for graduate school.

2) COURSE CONTENTS

The course will cover the first six chapters of the Griffiths' book. The topics will be: electrostatics in the vacuum, in conductors and in dielectrics; magnetostatics in the vacuum and in linear/nonlinear media.
The required mathematical background includes integral and differential calculus, vector algebra, vector calculus (divergence, gradient, curl) and related theorems. I will shortly review the basic math involved by the physical problems in class; the corresponding material can be found in Chapter 1 of the Griffiths' book.

3) GRADING

The final grade will be determined as follows:
homeworks: 35%
two midterm exams: 35%
final exam: 30%
These percentages are not strict. Participation in class and during office hours will also be taken into account.

4) HOMEWORK

There will be a weekly homework assignment starting from the second week of class. Homework assignments will be given every *friday*, starting from friday, August 27th, and will be due on the following *wednesday*. Solutions will be passed and discussed in class on due date, so *late homeworks will in general not be accepted*. If you have special requirements, you will have to discuss them with me well in advance.

To be accepted, homeworks have to be readable and understandable. Here I list some ingredients that make an homework useful to you, and easy to read and evaluate for us:

1) Work out the details (mathematical steps, conceptual steps) and fully explain your line of reasoning. This is the only way to fully test and show your understanding of the technicalities and of the concepts.

2) Use words, not only formulas. This is a class in physics and not math, and usually the math is supplemented with a lot of physical arguments.

3) Highlight your final results.

4) Always check that the final result *makes sense physically,* i.e. whether it has the correct physical units and, if it is a numerical result, the correct order of magnitude. Often I will ask you to come up with a numerical result in some physical units: the *physical units* and the *sign* are as important as the number.

The same suggestions and requirements apply of course to the exams. If the steps of the solution of an exercise are not readable, credit will not be given although the final result seems to be right.

5) EXAMS

There will be two midterm exams, one in early october and one in early november, and a final exam on December 11th, 2004. All exams will be closed-book, but one sheet of notes and calculators will be allowed.

6) INTERNET

Solutions to exams and homework assignments (in .pdf format) will be regularly posted on the web in the webpage of the class: **http://physics.usc.edu/~roscilde/phys408.**

Phys 408a - TENTATIVE SCHEDULE

Weeks and subjects:

W1) Mathematical tools to analyze vector fields:
Gradient, divergence, curl. Gauss's and Stokes' theorems. Helmholtz theorem. Cartesian, spherical and cylindrical coordinates.

W2) Electrostatics in the vacuum (I):
Coulomb's law and electrostatic field. Gauss's law and field lines.

W3) Electrostatics in the vacuum (II)
Electrostatic potential. Poisson's and Laplace's equation. Energetics of vacuum electrostatics.

W4) Electrostatics of conductors
Field and charge distributions in conductors. Capacitance. Method of images.

W5) Special techniques to solve Laplace's equation
Properties of Laplace's equation. Separation of variables. Cartesian coordinates and Fourier analysis. Spherical coordinates and Legendre's polynomials.

W6) Multipole expansion
Large-distance expansion of the electrostatic potential. Electrostatics of the electric dipoles.

W7) Review on electrostatics. FIRST MIDTERM EXAM.

W8) Electrostatics of dielectrics (I)
Electric dipoles in matter. Polarizability and polarization. Bound charges. Electric displacement. Energetics of electrostatics in dielectrics.

W9) Electrostatics of dielectrics (II)
Linear dielectrics: susceptibility, permittivity, dielectric constant. Clausius-Mossotti formula, Langevin formula.

W10) Magnetostatics in the vacuum (I)
Magnetic field. Currents. Lorentz's force law. Biot-Savart law. Divergence and curl of the magnetic field: Ampère's law.

W**11) Magnetostatics in the vacuum (II)**
Maxwell's equations for electrostatics and magnetostatics. Vector potential. Multipole expansion of the vector potential. Magnetostatics of magnetic dipoles.

W12) Review on magnetostatics. SECOND MIDTERM EXAM.

W13) Magnetostatics in matter (I)
Magnetic dipoles in matter. Diamagnets, paramagnets. Bound currents.

W14) Magnetostatics in matter (II)
Auxiliary field **H.** Linear media: susceptibility and permeability. Nonlinear media: ferromagnetism, hysteresis.

W15) Advanced topics, general review and overview.

Friday, December 10th, 8-10 am, GFS111: FINAL EXAM