Syllabus for PHY 416G Fall 2012

Electricity and Magnetism

Class schedule:	M W F 10:00–10:50, CP 397
Instructor:	Christopher B. Crawford
	CP 373, 257-2504, crawford@pa.uky.edu
Office hours:	by appointment
Homepage:	http://www.pa.uky.edu/∼crawford/phy416_fa12
Textbook:	David J. Griffiths, "Introduction to Electrodynamics," 3rd Ed. (required)
	Murray R. Spiegel, "Theory and Problems of Vector Analysis," (recommended)

Course Description The goal of this course is to become proficient applying the techniques of classical field theory in the context of the archetype example, electromagnetic fields. Although you have studied both electromagnetism and vector calculus in the past, don't be fooled! This course will employ a level of mathematical sophistication that will be challenging for even the most prepared student. It will take hard work and dedication to master this material. We will study electric forces, fields, sources, potentials, multipoles, and dielectrics. This new approach will a) provide powerful methods of solving practical problems, including continuous media with both free and bound charge, b) give new insight into the significance and behavior of electromagnetic quantities, and c) provide a concrete example with which to identify the basic principles of field theory. We will develop physical intuition of abstract electrodynamic concepts, and also master computational skills.

A prevalent theme in the course is longitudinal/transverse separation of fields, simply stated by the following projection identities, which illustrate the geometric meaning of dot and cross products:

$$\begin{aligned} \boldsymbol{v} &= \hat{\boldsymbol{n}}\hat{\boldsymbol{n}}\cdot\boldsymbol{v} - \hat{\boldsymbol{n}}\times\hat{\boldsymbol{n}}\times\boldsymbol{v} &&= (P_{\parallel} + P_{\perp})\boldsymbol{v}. \\ \nabla^2 &= \nabla\nabla\cdot \quad - \nabla\times\nabla\times &&= \nabla_{\parallel}^2 + \nabla_{\perp}^2 \end{aligned}$$

This is the basis of the Helmholtz theorem and Poincaré lemma, at the heart of Maxwell's equations and the potential formulation. The theme of transverse and longitudinal field components continues in the form of the integrals for flux $\Phi_F = \int_S \boldsymbol{F}\cdot\boldsymbol{da}$ and what we call flow, $\mathcal{E}_F = \int_C \boldsymbol{F}\cdot\boldsymbol{dl}$, embodying the two complementary characteristics of the field. This is equivalent to the geometrical representation of fields as either equipotential surfaces or field lines, the connection being that the flow along a path equals the number of equipotential surfaces pierced by the path, while the flux through a surface equals the number of field lines passing through the surface. We will treat sources of flux and flow using the divergence and Stokes' theorems. This course will present a geometrical view of electrostatics, borrowing from the imagery of differential forms. We will briefly use the formalism to treat curvilinear coordinates and give interpretation to the deep theorems discussed above.

We will develop five different formalisms of electrostatics and learn the relation between each. We will emphasize the use of the fifth formulation, Poisson's equation for electric potential, as tool for solving practical electrostatic problems. Separation of variables and Sturm-Liouville theory will be treated with in the context of infinite-dimensional linear function spaces. We will also explore the multipole expansion and application of Laplace's equation to dielectric media in more depth than in the Griffiths.

Attendance There is no credit for attendance; however, students are responsible for all material covered in class and in the textbook. Assigned textbook reading is a compulsory prerequisite of attending class. This is important because we will not simply repeat textbook material, but will discuss additional insights and points of view. Relevant questions and discussions are strongly encouraged and will be given priority over lecture notes. One class per week is devoted to problem-solving and a quiz.

Office Hours I am committed to helping you succeed if you are willing to do the necessary work. I have an open door policy; come by my office and discuss physics at anytime unless my door is closed (for a phone conference or approaching deadline). Please turn off cell phones and text messaging while in my office. I expect you to read the textbook before coming to my office. I will hold an optional one hour homework recitation each week in my office.

Grading The course material is strongly cumulative, and so it will be impossible to dismiss misunderstandings and try to move on. If you are falling behind, please seek assistance promptly from either your instructor or classmates. To encourage keeping current, there will be weekly quizzes, and an exam after each of the first three chapters. The final exam will be cumulative. Exams will only be rescheduled only for officially excused absences. Officially excused quizzes will be not be made up, but dropped from the grade calculation. Extra credit will be awarded for finding new errors in the textbook, or solving special questions posed during class.

This course has a heavy homework load, including problems from the textbook (credit for completion) and supplemental problems (graded). Students are encouraged to study and discuss homework together, but must turn in their own work (see below). A class list will be circulated the first day of class.

Grade breakdown

homework	35%
quizzes	15%
in-class exams	3×10%
final exam	20%
TOTAL	100%

Letter grade

A	80–100%
B	65–79%
C	50–64%
D	40–49%
E	00–39%

Academic Conduct Copying homework or exams from people, solution manuals, online, or any other source is plagiarism and will not be tolerated. University policies and procedures regarding cheating and other academic conduct will be strictly adhered to and can be reviewed at www.uky.edu/StudentAffairs/Code.

Course evaluation Course evaluations are an important component of our Department's instructional program. An on-line course evaluation system was developed to allow each student ample time to evaluate each component of the course and instructor, thus providing the Department with meaningful numerical scores and detailed commentary while minimizing the loss of instructional time in the classroom. Access the system at http://mercury.pa.uky.edu/∼evaluation, or go to the Department of Physics Web page at www.pa.uky.edu and click on the link for Course Evaluations under the Undergraduates header; then follow the instructions. You will need to use your student ID# to log into the system, and this will also allow us to monitor who has filled out evaluations. However, when you log-in you will be assigned a random number that will keep all your comments and scores anonymous.

Academic accommodations due to disability If you have a documented disability that requires academic accommodations, please see me as soon as possible during scheduled office hours. In order to receive accommodations in this course, you must provide me with a Letter of Accommodation from the Disability Resource Center (Room 2, Alumni Gym, 257-2754, email address jkarnes@email.uky.edu) for coordination of campus disability services available to students with disabilities.

See http://www.pa.uky.edu/∼crawford/phy416_fa12/student_academic_services.pdf for student resources.