Syllabus for PHY 417G Spring 2015

Electricity and Magnetism

Class schedule:	M W F 10:00–10:50, CP 183
Instructor:	Christopher B. Crawford
	CP 373, 257-2504, crawford@pa.uky.edu
Office hours:	by appointment
Homepage:	http://www.pa.uky.edu/∼crawford/phy417_sp15
Textbook:	David J. Griffiths, "Introduction to Electrodynamics," 3rd Ed. (required)
	Murray R. Spiegel, "Theory and Problems of Vector Analysis," (recommended)

Course description This is the continuation of PHY 416G, with the same goal of becoming proficient in the application of classical field theory in the context of electromagnetism. We begin the course with a study of magnetostatics along the same lines as electrostatics in the first semester, but much quicker, now that we have the necessary tools. The Maxwell equations will be completed with the addition of the time-dependent terms: Faraday's law of induction and the displacement current to restore conservation of charge. Conservation of energy and momentum are also demonstrated.

We will continue development of the theme of longitudinal/transverse separation of fields into two aspects which we label *flux* and *flow*, based on the vector identities $\boldsymbol{v} = \hat{\boldsymbol{n}}\hat{\boldsymbol{n}}\cdot\boldsymbol{v} - \hat{\boldsymbol{n}}\times\hat{\boldsymbol{n}}\times\boldsymbol{v} = (P_\parallel + P_\perp)\boldsymbol{v}$, and $\nabla^2 = \nabla\nabla\cdot - \nabla\times\nabla\times = \nabla_\parallel^2 + \nabla_\perp^2$. In fact we will find that the key difference between electric and magnetic fields is a reversal of the roles of the longitudinal and transverse components. In this sense, the electric and magnetic fields will be combined into a single tensor $F_{\mu\nu}$ in space-time, deriving from a combined 4-potential A_μ, with the sources unified into a single conserved current J^μ. The Laplace equation, which unleashed the full power of field theory last semester, will also be generalized to the wave equation for electromagnetic fields and their potentials. We will extend the derivative chain to include a whole new set of "source" potentials, including the magnetic scalar potential $I(\boldsymbol{r})$, which will be used to calculate magnetic windings based on the desired field, a technique unique to this couse at UK. The addition of gauge potentials will complete the circle to source currents via Noether's theorem.

$$\begin{array}{ccccccccc}
\lambda & \xrightarrow{d} & (V,\boldsymbol{A}) & \xrightarrow{d} & (\boldsymbol{E},\boldsymbol{B}) & \xrightarrow{d} & 0 & & \\
 & & & & \epsilon\downarrow\uparrow\mu & \searrow\sigma & & & \\
 & & (\boldsymbol{\lambda},I) & \xrightarrow{d} & (\boldsymbol{D},\boldsymbol{H}) & \xrightarrow{d} & (\rho,\boldsymbol{J}) & \xrightarrow{d} & 0.
\end{array}$$

The second half of the course is devoted to the effects of Maxwell equations, most notably the radiation of electromagnetic waves. We will study the wave equation in both the fields and potentials, and use appropriate boundary conditions to calculate the propagation of light through interfaces, dispersive media, and wave guides. We will investigate the source of electromagnetic radiation, and describe the classical scattering of light by matter.

The unifying concepts of this course are on the one hand: the symmetry and elegance of the Maxwell equations and conservation of charge, energy, and momentum; and on the other hand, the powerful methods of vector calculus (field theory) which enable application of these principles to real-life problems.

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. There will be weekly quizzes, two midterm exams (Chapter 5 and Chapters 6-8), and a cumulative final exam. Exams will only be rescheduled only for officially excused absences. Officially excused quizzes will be 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 has a heavy homework load, including textbook and supplemental problems. Students are encouraged to study and discuss homework together, but must turn in their own work (see below). Homework is due before 6:00 AM the day after the due date, under my office door or by email. There is a penalty of 15% per day for late homework, unless an extension is granted prior to the due date.

Grade breakdown		**Letter grade**	
homework	35%	A	80–100%
quizzes	10%	B	65–79%
in-class exams	2×15%	C	50–64%
final exam	25%	D	40–49%
TOTAL	100%	E	00–39%

Graduate credit In order to qualify for credit as a graduate course, students must submit a five page paper summarizing a) the application of fundamental theorems, principles, and imagery of classical field theory to electrodynamics; b) the symmetries and conservation principles inherrent in electrodyanmics and special relativity; and c) the standard techniques for solving practical problems in electrodynamics.

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.