Physics 462
Advanced EM: Electromagnetic Waves and Optical Physics
Fall 2007

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Class: Meyer 363, MWF 9:00-9:50
Office hours: TBA

Summary:
This is a course in electrodynamics in which you will learn how EM fields propagate, including how they radiate and interact with matter. Topics include using the Maxwell equations to describe propagation of free and guided waves, polarization, retarded potentials and radiation theory, scattering and dispersion theory, interference, and diffraction theory. We will discuss many applications, including antennas, diffraction gratings, resonators and guided waves.

Course objectives:
In this course, the students should learn
a. to apply the Maxwell equations to derive the EM wave equation in dielectric and conducting media,
b. to use the EM wave equation and boundary conditions to find propagating and standing wave solutions in simple geometries, including interfaces and waveguides,
c. to understand the connection between the mathematical representation of different types of electromagnetic waves and their physical meaning, including plane waves of arbitrary direction and polarization, standing waves, evanescent waves and attenuated waves, and spherical waves and the paraxial approximation,
d. to understand the fundamentals of the polarization states and their mathematical representation
e. to understand the classical model of dispersion in materials and to use this model to calculate the complex refractive index,
f. to understand the origins of EM wave radiation and to calculate the far-field radiation in simple geometries,
g. to understand the origins of interference and diffraction and the importance of the phase in the superposition of waves,
h. to be proficient in the use of Fourier methods to calculate the temporal and spatial propagation of waves.

Textbook:
The book we are using is *Classical Electromagnetic Radiation* by Heald and Marion. Be sure to get the 3rd edition. The text from PH361, Griffiths' book *Introduction to Electrodynamics* (3rd edition) will be a useful supplementary text.

There are many other texts that will prove to be useful references. I have copies of all these. Please ask me if you'd like any recommendations on a particular topic.
General EM, undergraduate level: *Electromagnetism,* Pollack and Stump; *Introduction to Electrodynamics*, Griffiths
General EM: graduate level: *Classical Electrodynamics,* Jackson; *Principles of Electrodynamics,* Schwartz; *Electrodynamics,* Melia; *Classical Electrodynamics,* Schwinger et al;
Optics: *Optics*, Hecht; *Modern Optics,* Guenther; *Optical Physics,* Lipson; *Principles of Optics,* Born and Wolf.

Some additional resources:
A good intro-level text for reviewing vector calculus is *Div, Grad, Curl and all that,* by Schey.
An interesting recent book on the quantum mechanical foundations of EM is found in *Collective Electrodynamics,* by Carver.

Course website:
Most of the class information will be organized and distributed through the course website on the Physic Wiki system. The website is:
http://ticc.mines.edu/csm/wiki/index.php/PHGN-462_Fall

To read and download from this site, no registration is required. Since this is a "wiki" system, logging in allows users to make additions to the website. The main areas will be edited by myself and the TA only, but there will be a section where you can post links to interesting demos and papers.

Class notes: a good fraction of class notes will be posted on this website.

There is another section the "Forum", where HW solutions and reading materials will be posted. This section can be found at:
http://ticc.mines.edu/csm/forum/index.php?f=54
This section is open only to members of the class. You may be registered for the Physics Forum already from other classes, if not, go to the "register" link at the top of the page and follow the instructions. You will receive an email with a link to confirm the registration. Once you are registered for the Forum, I need to add you to the list that is allowed to view the posts.

In-class quizzes:
We will have occasional, short in-class quizzes. These will be about 10 minutes, and will cover basic, but essential topics.

Homework:
The homework will be due weekly, Fridays in class. Some homework will make use of Mathematica. Let me know if you are not comfortable working with the program. You will be able to pick up the homework assignment from the course website. After the homeworks are collected, I will either post the solutions on the website or make them available for you to copy.

On the homework, you make consult with each other and help each other out, but the work must reflect your own understanding. I will not accept copied/identical work **including mathematica notebooks**.

- The first homework will be due Friday 31 August.

Grading proportions:
The proportions to the grades will be (subject to change)

Online/in-class quizzes, participation:	10%
Homework	30%
Midterm 1	15%
Midterm 2	15%
Final	30%

"Participation" can take the form of asking questions or making constructive comments in class, helping me to prepare demonstrations, posting links to online demos or relevant papers on the website, or making posts that contribute to discussion in the Forum area.

Grading/late policy:
Homework:
- I will give each of you two free extensions on homework. To get an extension, you must send me an email *prior* to the day the homework is due.

Syllabus and Schedule:
This schedule is subject to change. A more detailed, updated topic and reading schedule will be on the course website.

- Energy density, momentum and pressure of EM fields and waves
- General properties of scalar and vector waves: 1-D and 3-D
- Polarization, birefringence and related devices
- Boundary conditions, reflection and refraction: Fresnel equations
- Total internal reflection, evanescent waves, metals

- Guided waves and resonators
- Radiation theory
- Electric dipole radiation and linear antennas
- Scattering
- Dispersion theory using classical electron model
- Interference and coherence
- Diffraction, especially Fraunhofer