Physics 462
EM II: Electromagnetic Waves and Optical Physics
Fall 2006

Instructor: C. Durfee
Office: Meyer 330, **phone:** x3894, **email:** cdurfee@mines.edu
Class: Meyer 363, MWF 9:00-9:50
Office hours: TBA

Summary:
This is a course in electrodynamics in which you will learn how the 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 new 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 BlackBoard system. You must "self-enroll" to get into the system. For information on how to do this, go to
www.mines.edu/academic/computer/blackboard/enroll.shtml
Once you are in the system, login by going to:

blackboard.mines.edu
When you have gotten into the system, please take the survey that will be posted there.

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

In-class quizzes:
We will have periodic in-class quizzes most Mondays. 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 1 September.

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

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

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

Physics 507
EM II: Classical Electrodynamics
Fall 2006

Instructor: C. Durfee
Office: Meyer 330, **phone:** x3894, **email:** cdurfee@mines.edu
Class: Meyer 363, MWF 9:00-9:50 **plus 1 hour TBA**
Office hours: TBA

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This class is combined with the undergraduate, senior-level advanced EM course, but we will cover several advanced topics (see below) by meeting for an extra hour weekly. You will be expected to do the same homeworks as the other students, plus an additional 3 or 4 assignments. The midterms will be the same, but the final will be different for those taking the graduate version.

I will provide handouts from various sources to supplement the reading from Heald.

Undergraduates are welcome to take the graduate version – it is recommended if you are going into the combined BS/MS program in Applied Physics. Students in 462 are welcome to come to the additional lectures if there are particular topics of interest.

507 Extra topics
- Wave propagation in anisotropic media: tensor dielectric functions
- Relativistic EM
- Lagrangian techniques in EM
- More rigorous approach to retarded fields
- Complete fields and spectrum of a radiating dipole, vector potl treatment
- Bremsstrahlung and Cerenkov radiation
- Causality and the Kramers-Kronig dispersion relations
- Antenna arrays
- Introduction to nonlinear optics
- Green’s functions and diffraction
- Fresnel diffraction, transition to geometrical optics
- Variational approach to wave propagation