ECE 309 — Electromagnetic Fields

University of Virginia

Fall 2005

Electromagnetics is the foundation of all electrical engineering. Although many specialized topics in electrical engineering focus on areas and subjects that seem remote from fundamental electromagnetics, electromagnetic fields are responsible for the inner workings of all electrical components — from small molecules to giant pulsars, from complex systems like your laptop or pcs phone to simpler solid-state devices like MOSFET's and LED's. Even Kirchhoff's Laws (which you learned in your electrical circuits classes) and the laws of geometrical optics are just simplified versions of electromagnetic field theory.

The goal of this class is to understand the fundamental laws that govern electromagnetic waves and to learn how to apply these laws to engineering problems. We will start by applying standard circuit theory to the study of transmission lines. This will introduce you to waves and how they are propagated. We will then cover electrostatics and magnetostatics leading to Maxwell's equations that describe how these waves are created by moving charges and currents. Finally, we will see how the waves interact with various boundaries through reflection and transmission, and how they are radiated or detected by antennas. You will need some maths to fully appreciate these topics, specifically, complex analysis to keep track of phases of fields and vector analysis to keep track of their directions or orientations.

Coordinator

Avik Ghosh
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Class: MWF 1100-1150 in Rm. THN E316
Problem Session: T 1700-1830 in Rm. THN E316
Tutors: Erin Mastrantonio (eem2k@virginia.edu), Ramakrishna Parthasarathy (rp9r@virginia.edu)
Office Hours: M 10-11 am, E 315; F 2-3 pm (E. Mastrantonio), C241 Thornton.

Textbook

Required:

Fundamentals of Applied Electromagnetics, 2004 Media Ed., by Fawwaz T. Ulaby; Prentice Hall 2004.

> This is an introductory text on electromagnetics which starts out with transmission lines. The book comes with a CD-ROM containing numerous examples that should be useful in helping your understanding of electromagnetics.

Other Useful References:

Fields and Waves in Communication Electronics, 3rd ed. by S. Ramo, J. R. Whinnery, and T. Van Duzer; John Wiley & Sons, Inc., 1994.

> This is the third edition of a classic textbook that has been around (in one form or another) since 1944! The book is at an intermediate level and contains a wealth of information on all aspects of electromagnetics, from statics to microwave circuits and optics. This book is an excellent reference and can probably be found on the shelf of nearly all microwave engineers.

Field and Wave Electromagnetics, 2nd ed., by D. K. Cheng; Prentice Hall Publishing Company, 1989.

> This is an intermediate text on electromagnetics. Cheng's book has many example problems worked out and is a very useful reference.

Applied Electromagnetism, 3rd ed., by L.C. Shen and J.A. Kong; PWS Publishing, Inc., 1995.

> This book begins with electrodynamic fields first and later presents static electric and magnetic fields. Like Cheng, this text has numerous examples – many of which illustrate the practical use of electromagnetics in real engineering problems.

Advanced Engineering Electromagnetics by C.A. Balanis; John Wiley & Sons, Inc., 1989.

> As the name implies, this text is at a more advanced level. It covers the fundamentals of wave propagation and waveguides as well as advanced topics such as reciprocity, scattering, Green's functions, and the method of moments.

Field Theory of Guided Waves, 2nd ed., by R.E. Collin; IEEE Press, 1991.

> This is the second edition of a classic textbook on waveguides and wave propagation. Collin's approach is rigorous and he uses many useful and advanced-level mathematical techniques. An indispensable book for the serious student and researcher working on field theory.

Class

The classes will cover material in the text as well as some supplementary material which will be put on the course webpage. Together with the text, these items will try to achieve a balance between rigorous mathematics needed to quantify what you learn, and convenient animations or visual aids that will help you to develop an intuitive understanding of the concepts. As a scientist or engineer, you should be able to look at a subject from several different points of view – not only as an aid to solving technical problems but as a means for seeing how concepts in seemingly different fields are related.

Grading

Your grade in the class will be determined from a weighted average of homeworks, exams, and the final, as shown below. Homework must be turned in at the *beginning* of class on the day it is due (Wednesday). Because I intend to post the solutions on the web, late homework will NOT be accepted! However, I will drop your lowest homework score from the final average.

Homework	25%
Exams	20% each
Final Exam	35%

Honor Policy

It is my expectation that you will respect and adhere to the Honor System. With regards to this class I encourage you to work together on homework, however I require that each of you do the problems yourself (ie. copying is explicitly forbidden) and then sign the following pledge:

> On my honor as a student I have neither given nor received any unauthorized aid on this assignment.

Naturally the exams will be pledged as well and if any unauthorized aid is detected, you will receive a zero for that exam and the case will be turned over to the honor committee.

Topics to be Covered

Below is an outline of the subjects I plan to cover in class. Also included are the tentative dates and corresponding chapters in Ulaby.

Dates	**Topic**	**Reference** (Ulaby)
Aug. 24–26	Course Overview	Chapter 1
Aug. 29–Sept. 5	Transmission Lines	Chapter 2
Sep. 7–Sept. 12	Vector Calculus	Chapter 3
Sep. 14–26	Electrostatics	Chapter 4
Sep. 27	**1st Exam**	
Sep. 30–Oct. 12	Magnetostatics	Chapter 5
Oct. 14–19	Maxwell's Equations	Chapter 6
Oct. 21–31	Plane Waves	Chapter 7
Nov. 1	**2nd Exam**	
Nov. 2–11	Reflection and Transmission	Chapter 8
Nov. 14–18	Antennas and Radiation	Chapter 9
Dec. 10	**Final Exam**	