EE 518

Advanced electromagnetic theory I

WSU catalog description

Electromagnetic waves, electromagnetic theorems and concepts, solutions to the wave equation in rectangular, cylindrical and spherical coordinates.

Introduction

EE 518 is a graduate-level course in Electromagnetic Theory, i.e., Maxwell's equations. It involves a considerable amount of high-level mathematics, such as multivariate differential and vector operations, series solutions of differential equations, special functions and so on. You have learned all of these subjects in undergraduate courses, but you may not have used them recently. Therefore we will begin with about two weeks of mathematical review.

Here are reference suggestions. Many of the developments in the course notes follow those in these texts.

Reference books

1. Balanis, C. A., *Advanced Engineering Electromagnetics*, Wiley, 1989, ISBN 0-471-62194-3.
2. Harrington, R. F., *Introduction to Electromagnetic Engineering*, Dover, 2003, ISBN 0-486-43241-6.
3. Eyges, L., *The Classical Electromagnetic Field*, Dover, 1980, ISBN 0-486-63947-9.
4. Ishimaru, A., *Electromagnetic Wave Propagation, Radiation, and Scattering*, Prentice Hall, 1991, ISBN 0-13-249053-6.
5. Becker, R., *Electromagnetic Fields and Interactions*, Dover, 1982, ISBN 0-486-64290-9.
6. Kreyszig, E., *Advanced Engineering Mathematics 10th Edition*, Wiley, 2011, ISBN 978-0470458365.
7. Maxwell, J. C., *A Treatise on Electricity and Magnetism*, Dover, 1954 (reprint of 1891 edition), ISBN 0-486-60636-8 (vol. 1) and 0-486-60637-6 (vol. 2). For historical reference.

Instructor

Contact information for Professor Scott Hudson is:

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Phone: 509-372-7254 (dial 2-7254 from any WSU phone)

e-mail: via the lms.wsu.edu site *only*

web: lms.wsu.edu

Note that I will *only* correspond using the lms.wsu.edu (Angel) email system. This is for purposes of security, documentation, course consistency and organization. I will not conduct any course-related correspondence using my personal wsu.edu email account.

Math tools

This course is mathematically intensive. Math tools for both symbolic and numerical calculations can be a great aid in doing the homework and separating the EM concepts from the math operations. Here are my opinions of some of the most common math tools.

Commercial software

Matlab (www.mathworks.com) is a university and industry standard. Matlab versions are available for both Windows and Linux/Unix environments. This is primarily a numerical tool, although a symbolic toolbox is available. It's programming structure is in many ways similar to the C language.

Mathematica (www.wolfram.com) is a powerful symbolic math package available for both windows and Linux/Unix. It is a standard in university and research environments.

Mathcad (www.mathsoft.com) is available for Windows. It is quite intuitive and readable, in my opinion, with input via a graphical math interface as opposed to ascii input. It operates more as a "mathematical spreadsheet," as opposed to a linear programming environment. It does numerical and symbolic calculations and produces nice graphical output.

Open-source (free) software

Scilab (www.scilab.org) is sometimes described as a "Matlab clone." It is similar, although not identical, to Matlab and runs under both Linux and Windows. It does only a limited set of symbolic calculations.

Maxima (maxima.sourceforge.net) is a "sophisticated computer algebra" system that runs under Linux and Windows. The wxMaxima package includes a user-friendly graphical interface with useful menus and so on.

Octave (www.octave.org) is often described as a "Matlab clone." It is largely compatible with Matlab, although there are some differences. It's graphics are usable, but not as advanced as those of Matlab or Scilab. Octave comes standard on some Linux distributions. It does not do symbolic calculations. A Windows version is available.

In this course I will mostly use Scilab for numerical calculations and Maxima for symbolic calculations. However, you are free to use any software you wish to, and/or is available on your personal or department machines.

Of course, you are free to use no software at all and to do all work with pencil and paper. You definitely should not become dependent on math tools, especially as your exams will be strictly pencil and paper based. Still, the intelligent use of a math tool has several advantages, including: 1) when doing homework it can help you check your answers, 2) it can allow you to simulate and graph EM problem solutions so as to "see

what is really going on," 3) it can help you quickly test different solution ideas without spending lots of time on the math mechanics. It should be noted that strong computer skills are essential to a successful career in science and engineering. However, the computer should be considered an extension of your brain, not a substitute for it!

Grading

There are two components to your grade; homework counts for 25% and exams/final for 75%. I assign final grades based on my expectation of how "A," "B," etc. grades should correspond to a student's grasp of the material in a graduate course. As a rough guide, on exam problems you typically:

A: demonstrate a full and clear understanding of the pertinent concepts and their application to the problem at hand. You logically and precisely apply appropriate analytic techniques for deriving the solution. You obtain a rigorously correct answer. In short, you have mastered the material.

B: demonstrate a mostly complete understanding of the necessary concepts. You are able to work through nearly all the mechanics of a solution. You obtain a more-or-less correct answer. In short, you understand and can work with the material but have not mastered it.

C: demonstrate an irregular understanding of the required concepts and analytic techniques. Your solution is roughly correct at the "outline" level but contains significant errors.

D and F: do not demonstrate any substantial understanding of the course material.

Homework

There will be approximately twelve homework assignments during the semester. Homework is due in-class one week after being assigned. No late homework is accepted without prior arrangement with the instructor and for a very compelling reason. I will return graded homework and make available solutions one week after the due date. Most of your homework grade is based on the effort you put into it. I want to see you working vigorously with the course material.

Exams

There will be four exams – three during the semester and a final. All will be given in-class. The "midterms" will cover the material of the about three or four homework assignments. Each will be worth 15% of your grade. The final will be comprehensive, including material from the last assignments, and will be worth 30% of your grade.

Tentative Course Outline (30 lectures)

1. Mathematical review (4 lectures)
   a) Complex numbers, phasors and vectors
   b) Differential operators and orthogonal coordinates
   c) Ordinary differential equations
   d) Boundary-value problems
2. Maxwell's equations (4 lectures)
   a) Maxwell's equations
   b) Constitutive parameters
   c) Vector potentials
   d) Electromagnetic theorems
3. Rectangular Coordinates (10 lectures)
   a) Plane waves in simple media
   b) Reflection and transmission at normal incidence
   c) One-dimensional inhomogeneous media
   d) Ground-penetrating radar
   e) Oblique incidence and wave impedance
   f) Ellipsometry
   g) Rectangular waveguides and resonators
   h) Mode matching
   i) Dielectric-covered ground plane
   j) Microstrip
4. Cylindrical coordinates (7 lectures)
   a) Vectors, operators and potentials
   b) Helmholtz equation and Bessel functions
   c) Cylindrical waveguide, resonator
   d) Coaxial cable, wedges
   e) Fiberoptics
   f) Bipolar cylindrical coordinates
   g) Two-wire transmission lines
5. Spherical coordinates (4 lectures)
   a) Vectors, operators and wave equation
   b) Legendre functions
   c) Spherical cavity
   d) Conical horn
   e) Wire antennas

Disability Services
Reasonable Accommodations Statement

Reasonable accommodations are available for students who have a documented disability. These must be approved by the Disability Services Coordinator. During the first week of class contact

Cherish Tijerina, Disability Services Coordinator, WSU Tri-Cities, 269C West Building, ctijerina@tricity.wsu.edu, (509) 372-7352.

Campus Safety Statement

WSU Tri-Cities is committed to maintaining a safe environment for its faculty, staff and students. The Campus Safety Plan can be found at

http://www.tricity.wsu.edu/safetyplan/

See also the WSU Office of Emergency Management site at

http://oem.wsu.edu/emergencies

Up-to-date WSU emergency alerts are available at

http://alert.wsu.edu/

Academic Integrity Statement

Assignments turned in by each student must be her/his own work. It is not acceptable for one student to simply copy an assigned problem from another student (or any other source). The purpose of homework is for students to *learn the material*. However, students are permitted and encouraged to study together and

Students are not to collaborate with *anyone* when completing any of the following out-of-class work: laboratory reports, take-home exams, semester projects

Any student caught cheating on an examination will be given an F for the course and will be referred to the Office of Student Conduct. Cheating essentially consists of

includes, but is not limited to, the following:

1. Copying from another student's work.
2. Getting help with or discussing any problem on a take-home exam with anyone other than the instructor.
3. “Sharing” computer code

Visit http://www.conduct.wsu.edu/ for more information.