EE 535, Numerical Solutions to EM Problems I

Catalog description: Theory and use of finite-difference time-domain method; numeric dispersion; absorbing boundary conditions; scattering; radiation; time domain vs. frequency domain.

Prerequisites:

By course: EE 351 or equivalent

By topic: Electromagnetic fields and waves, vector calculus, differential equations, distributed parameter systems (transmission lines, waveguides, and antennas), high-level programming language (e.g., FORTRAN, C, or C++). Familiarity with *matlab* or *Mathematica* helpful but not essential.

Courses that require this as a prerequisite: None

Credits: 3


References:


Overarching Objectives for 535/536 Sequence:

Ensure students:

- Understand why numerical methods are needed to solve realistic or practical problems in electromagnetics and why this need will increase.
- Understand the inherent limits of numerical methods as well as the constraints placed on solutions due to current technology.
Can translate a textual or mathematical descriptions of a solution into a well-written computer program.

Can choose between the various numerical methods to use the right method for a particular problem.

Can effectively use computer tools, including hardware, and commercial and open-source software, that are typically employed to solve problems in electromagnetics.

Can effectively communicate their work via an oral and written project report (as well as on the homework assignments).

Understand the mathematical concepts upon which computational electromagnetics relies.

**Topics (with approximate number of 75-minute lectures):**

- Review of electromagnetic theory. (1)
- Constraints of numeric modeling (e.g., consequence of finite precision). (1)
- Fundamentals of finite differences. (1)
- Construction of leap-frog schemes for modeling wave propagation in one dimension. (1)
- Hard and soft source. The Higdon absorbing boundary condition. (2)
- Frequency-domain data from time-domain simulations. (2)
- Generalization to two- and three-dimensional propagation. The Yee cube. (2)
- Rendering of data. (1)
- Total-field/scattered-field boundary. (2)
- The FDTD dispersion relation and its ramifications. (2)
- Discrete scatterers and PEC boundaries. (1)
- Penetrable dielectrics. (1)
- Dispersive materials. (3)
- The perfectly matched layer absorbing boundary condition. (3)
- Modeling printed circuits. (3)
- Antennas and near- to far-field transformations. (3)
- Parallelization. (1)
Higher-order FDTD algorithm and the pseudospectral time-domain technique.

**Structure:** Two 75-minute lectures per week. No labs. Ten to twelve homework assignments. One project requiring a written and oral report. No tests.

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<table>
<thead>
<tr>
<th>Grading</th>
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<tbody>
<tr>
<td>Homework</td>
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<td>Project</td>
<td>20%</td>
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**Homework:** Ten to twelve assignments typically involving extensive programming. Equal weight. No late work accepted.

**Academic Integrity:** Since the majority of your grade is based on the homework, you must do your own work. Collaboration is not allowed! You may ask your classmates about general issues related to the course material or the generic use of a particular piece of software, but not about the solution of homework problems. If submitted work shows evidence of collaboration (and it is often easier to detect collaboration than you think), all the parties associated with the collaboration will be given an F for the course. It doesn’t matter if the work was originally done by one person—sharing your work is a disservice to your other classmates and considered cheating. A word to the wise: *make sure you do your own work!* In addition to failing, the infraction will be reported to the appropriate EE advisor and the Office of Student Affairs. Note that there may be severe repercussions for even a single instance of cheating. See [www.eecs.wsu.edu/~syllabus/eeweungrad/academic-integrity.html](http://www.eecs.wsu.edu/~syllabus/eeweungrad/academic-integrity.html) for additional details.

**Project:** Written and oral presentation. Grading is based both on the “content” (i.e., the amount and scope of the work as well as the quality of the results produced) and the presentation. Projects will be presented during the regularly scheduled final exam period. Projects may be done in a team if the scope is sufficiently large. Project topics are up to the student subject to faculty approval (a project will be assigned if the student does not select a topic).

**Disability Statement:** Reasonable accommodations are available for students who have a documented disability. Please notify the instructor during the first week of class of any accommodations needed for the course. Late notification may cause the requested accommodations to be unavailable. All accommodations must be approved through the Disability Resource Center (DRC) in Administration Annex 206, 335-1566.