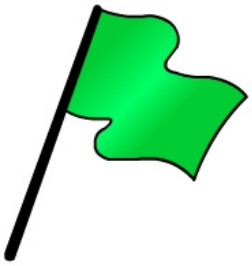
EE 5303

Electromagnetic Analysis Using Finite-Difference Time-Domain



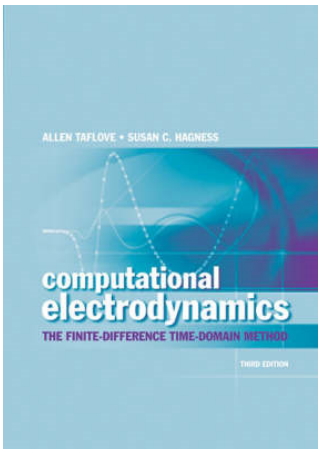
Course Overview, Policies, and Procedures

Instructor

Dr. Raymond C. Rumpf

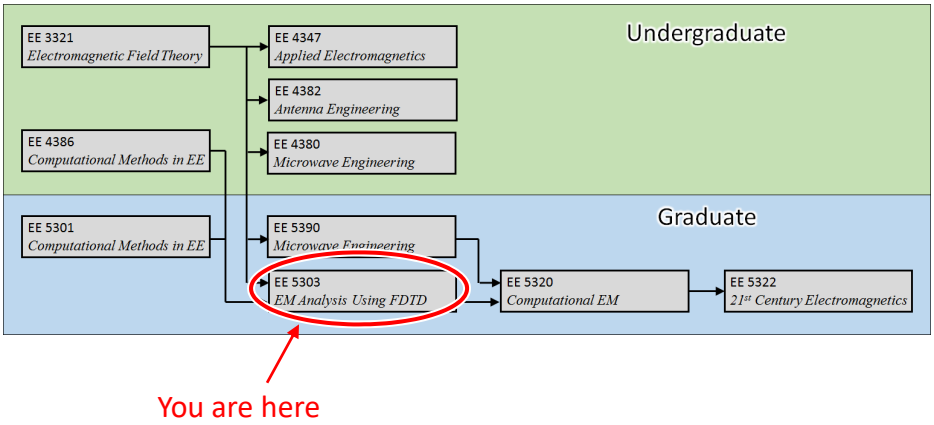
Lecture Outline

- Course Overview
  - Mission
  - Course Objectives
  - Course Outline
- Policies and Procedures
  - Grading
  - Homework
  - Final Project
- Policies & Best Practices for Coding



Course Overview

Flow of Courses for Electromagnetics



Mission of This Class

The mission of this class is to begin teaching the art of computational electromagnetics using MATLAB. The course will take a slow and methodical approach to teach finite-difference time-domain (FDTD) including theory, formulation of the equations, and implementation in MATLAB.

Course Objectives

- Teach the finite-difference time-domain method.
- Teach students the art of computation and visualization in MATLAB.
- Teach best practices for developing and implementing new numerical algorithms.
- Motivate students in the areas of simulation and electromagnetics.
- Provide the students with real skills that are in high demand in industry.

Course Outline

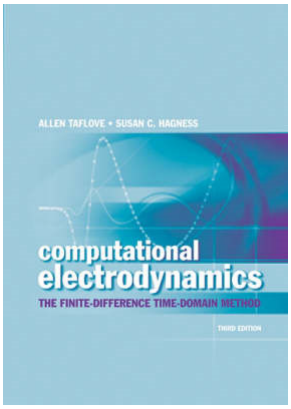
- Review of MATLAB
  - Graphics, movies, and helpful tidbits.
  - Building geometries in arrays.
- Introduction to FDTD
- One-Dimensional FDTD
  - Formulation, implementation, and examples.
- Two-Dimensional FDTD
  - Formulation, implementation, and examples.
- Advanced Concepts
  - Perfectly match layer boundary condition
  - Grid strategies and alternatives
  - Periodic structures in FDTD
  - Modeling waveguide devices
  - Three-dimensional FDTD
  - Near-field-to-far-field transformation
  - More…

Policies and Procedures

The Book

Allen Taflove, Susan C. Hagness, *Computational Electrodynamics, the Finite-Difference Time-Domain Method*, 3rd edition, Artech House, 2005.

- Good aspects of the book
  - This is the most rigorous and comprehensive book on FDTD available.
  - Many topics and references are provided.
- Drawbacks of the book
  - This is not a good book to learn FDTD from scratch.



The Syllabus (1 of 4)

- Instructor Information
  - Dr. Raymond C. Rumpf
  - Office: ENGR A-337
  - Telephone: (915) 747-6958
  - E-Mail: rcrumpf@utep.edu
  - Course website: http://emlab.utep.edu/ee5390fdtd.htm
- Prerequisites
  - Basic electromagnetics
  - Differential equations
  - Programming / MATLAB

The Syllabus (2 of 4)

- Course Objectives
  - Be able to use the FDTD method to model electromagnetic devices
  - Strengthen MATLAB and graphics skills
- Attendance
  - Attendance is required
  - Attendance is accounted for in participation grade
  - Coordinate with instructor ahead of time if you need to miss a class
  - In some cases, absence can be excused if coordinated with instructor well before the lecture is missed.

The Syllabus (3 of 4)

- Exam Policy
  - Exams represent 20% of final grade
  - Two midterm exams and one final exam
  - May be take-home or in-class
  - In-class exams, students can have a calculator and a single 8.5”x11” paper with whatever they wish
  - **Take home exams will require working FDTD codes*!!!!***
- Homework
  - **Worth 40% of final grade**
  - Homework will build on prior homework so keeping up is essential
  - Homework is due by midnight on the due date
  - Subtract 10% from homework for every day late
  - 12:01am will be considered late
  - Do you own work. Do not copy from other students.

The Syllabus (4 of 4)

- List of Topics
  - MATLAB
    - Programming and graphics
    - Representing devices on a grid
  - Finite-Difference Time-Domain
    - One-Dimensional FDTD
      - Formulation, implementation, visualization, post processing
    - Two-Dimensional FDTD
      - Formulation, implementation, PML, sources, visualization
      - Modal sources, analysis of waveguide devices
    - Advanced Topics
      - Boundary conditions, periodic structures, PML, and more.

Grading

Homework 40%	90% – 100% → **A**
Project 20%	80% – 89% → **B**
Midterm Exam 1 ..... 15%	70% – 79% → **C**
Midterm Exam 2 ..... 15%	60% – 69% → **D**
Participation 10%	0% – 59% → **F**

HOMEWORK IS 40%
OF YOUR FINAL GRADE!!!!!!!

Homework Policy

- Due before midnight on due date. 12:01am is late.
- Submit a single PDF file
- Neat, organized, answers provided in the order they are asked.
- Unless specifically requested otherwise, all codes must be in an appendix placed at the end of your homework document.
- Cover page: name, 800#, date, assignment #, etc.
- Do your own work. Do not ever copy from other students.

The Final Project

- Purpose – to learn, practice, and share something outside of what was taught in class.
- Project should be summarized in Power Point.
  - Must be complete enough that instructor can reproduce your work if needed.
- Projects will be presented during the final exam period. Duration ~10 minutes for presentation.
- May work alone or in teams, but teams must do proportionally more work.
- Must submit all electronic files (i.e. slides, codes, movies, etc.) to course instructor or project will be given a grade of zero.
- *Get started on this early!!*

Project Ideas

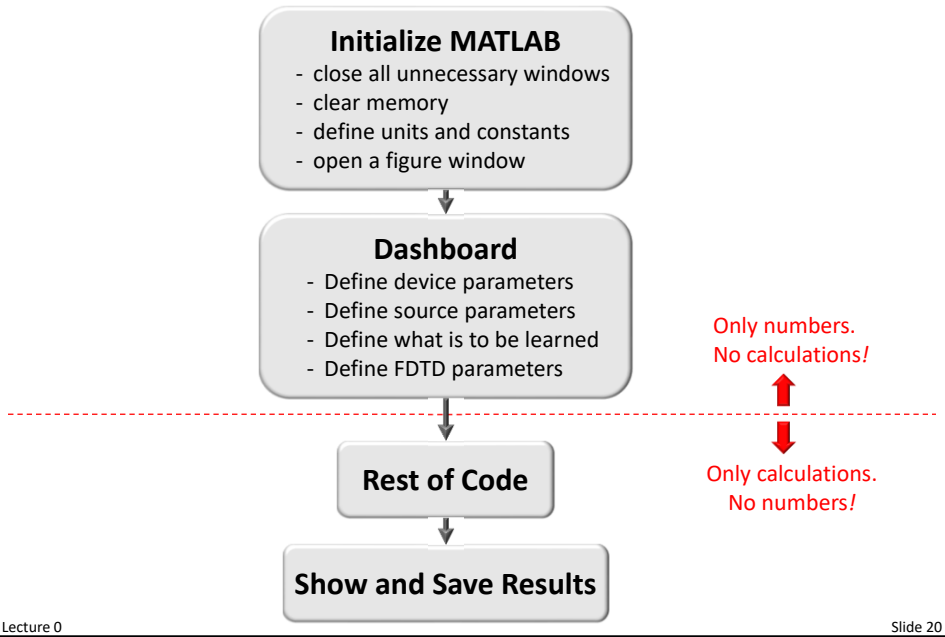
- Optimize PML parameters
- Implement a different boundary condition
- Implement higher-order accurate derivatives
- Implement a different type of source
- Model a new device
- Implement 3D FDTD
- Use FDTD to calculate a band diagram
- Do part of your research as this project*!*
- Others…

Graphics

- All figures and graphics must be of professional quality and easy to understand and use.
- The best figure is made as small as possible so that it is still neat and reads clearly
- Lines should be thick enough to be identified, but not awkwardly thick
- Fonts should be large enough to be read easily, but not awkwardly large
- All entities of the figure should be labeled and given proper units

Policies and Best Practices for Coding

Structure of the Ideal Code



Lecture 0 Slide 20

Coding Requirements

- Codes must be clean, commented, and well organized.
- Codes must follow the block diagrams in the lecture notes exactly.
- Constants must include units and as many significant digits as possible.
- Do not breakup codes into subroutines (i.e. functions) unless instructed specifically to do so.
- No calculations in the dashboard, unless absolutely necessary.
- All hard-coded numbers should appear only once within the “dashboard” at the start of your code.

Coding Best Practices

- Do not hard code any numbers you may want to change.
- If you have to change more than one thing in your code or change something outside of your dashboard to alter a devices dimensions, material properties, etc., you are probably doing something wrong.
- Develop your codes in small increments that you can benchmark at each step.