Topics in Mathematics (ECE)

Instructors: Dr. Shobha Sundar Ram, Dr. M. S. Hashmi

Credits: 4

Pre-requisites: None

Text Book: Electromagnetic Simulation Using the FDTD Method, D. Sullivan,2000, Wiley-IEEE Press

Reference Materials:

Introduction to electrodynamics by Griffiths, David J. (David Jeffery). 3rd Edition,

ISBN: 9788120316010.

Post Conditions:

Students, on successful completion of the course, should have

- Strong foundation of fundamental mathematical concepts pertaining to Vector Calculus and Electromagnetics.
- Exposure to the basics of popular computational electromagnetic techniques.
- Detailed understanding and capability to implement 1D, 2D and 3D finite difference time domain simulations.

Brief Course Descriptions:
This course is designed to introduce students to mathematical concepts specially focused towards electromagnetic field theory. During the first section of the course, the students will be a refresher course on single and multivariable calculus. The second section of the course will cover vector calculus. Students will be tested through homework assignments and class examinations.
In the third section of the course, the students will be introduced to popular computational electromagnetic simulation techniques that will build upon the mathematical concepts learnt from the previous two sections. Detailed examination of 1D, 2D and 3D Finite Difference Time Domain technique will be undertaken. Student, divided into groups of 2/3, will be required to simulate a 2D FDTD problem and submit the results as a part of their final project.

Break-up of Lectures:

Lecture (1-3): *Review of multivariable calculus*

- Single variable function and multiple variable functions
- Partial derivatives
- Integration in 1D, 2D, 3D

Lecture (4-8): *Introduction to vector calculus*

- 2D Cartesian coordinates, Polar coordinates, coordinate transformation

- 3D Cartesian coordinates, Cylindrical coordinates, Spherical coordinates, coordinate transformation
- Dot product and Cross product
- Divergence, Curl, Directional derivative and Gradient
- Vector identities (Proofs)
- Line integrals, conservative vector fields
- Flux through a surface
- Stoke's theorem
- Divergence theorem
- Green's theorem

Lecture (9-26): *FDTD simulations*

- Review of Maxwell's equations
- Requirement for numerical methods: mention of other numerical methods such as FEM, explain cases for which each method is adopted
- Boundary value conditions
- 1D FDTD (Example in class)
- 2D FDTD (Example in class)
- 3D FDTD (Example in class)

Assignments, Quizzes, and Evaluations: There will be homework every week (or after every 3 lectures). There mid-term exam will either be an in-class test (if they are questions that can be completed in a short duration) or a take-home examination to be completed in one day (in case of longer questions). The final exam will be in class. For their in-class exams, students will be allowed to bring a single cheat sheet (A4 size paper) with formulae.

Project: As part of their project requirement, they will have to complete a 2D FDTD simulation of a problem assigned by the instructor. Alternately, students can also choose problem frameworks of their own interest.

Grading Scheme: Homework (30%), Project (30%), Mid-term exam (15%), Final Exam (25%)