ECE 540 for Spring 2025

1. Course: Department and Number: ECE 540

2. Title of Course: Computational Electromagnetics

3. Catalog Description: The course will cover basic computational techniques for numerical analysis of electromagnetics problems, including the finite difference, finite element, and moment methods. Emphasis will be placed on the formulation of physical problems into mathematical boundary-value problems, numerical discretization of continuous problems into discrete problems, and development of rudimentary computer codes for simulation of electromagnetic fields in engineering problems using each of these techniques.

4. Prerequisites: (1) ECE 520; (2) Good computer programming skill

5. Credit: 4 credit hours

6. Semester: Spring 2025

7. Prepared by: Professor Jianming Jin

8. Topical Outline:

	Hours
▪ Overview of course; review of Maxwell's equations; overview of computational electromagnetics	2
▪ Finite difference method (basic concepts, accuracy, stability, application to Poisson, Laplace, and Helmholtz equations)	3
▪ Finite difference time domain method (Yee algorithm, solution of Maxwell's equations, numerical implementation)	3
▪ Absorbing boundary conditions; perfectly matched layers	3
▪ Applications of FDTD to electromagnetic problems	3
▪ Project #1 (on the FDTD method)	
▪ Finite element method (basic concepts, classical methods, Galerkin's formulation, matrix assembly, matrix solvers)	5
▪ High-order elements, parametric elements, vector elements	3
▪ Applications of FEM to electromagnetic problems	4
▪ Project #2 (on the FEM)	
▪ Integral representations and integral equations (Green's functions and equivalence principles for scalar and vector wave equations)	3
▪ Method of moments (basis functions, point collocation and Galerkin's methods)	3

- MoM solution of electromagnetic problems 4
- Advanced MoM methods (FFT-based algorithms, vector basis functions) 2
- Project #3 (on the MoM)
- Hybrid techniques and fast algorithms 3
- Summary and discussion on the future of computational electromagnetics 1
- Project presentations 3

Total: 45

Homework will be assigned on the basic concepts and formulation of numerical methods; three projects will be assigned whereby students develop computer programs and apply to a practical problem. A formal technical report is required for each project, documenting the motivation of work, formulation of method, numerical results including validation, and discussions and summary.

9. Proposed Text:

- J. M. Jin, *Theory and Computation of Electromagnetic Fields, Second Edition*. Hoboken, NJ: John Wiley & Sons, 2015.
- Lecture notes.

Recommended readings include

1. A. Taflove and S. C. Hagness, *Computational Electrodynamics: The Finite Difference Time Domain Method (3rd edition).* Norwood, MA: Artech House, 2005.
2. J. M. Jin, *The Finite Element Method in Electromagnetics (3rd edition)*. Hoboken, NJ: John Wiley & Sons, 2014.
3. A. F. Peterson, S. L. Ray, and R. Mittra, *Computational Methods for Electromagnetics.* New York: IEEE Press, 1997.

10. Basis for grade

Homework	15%
Projects	75% (= 3 x 25%)
Presentation	10%
TOTAL:	**100%**