



Course Syllabus: Numerical Methods for Electromagnetics - EE 321

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	EE 321
Course Title	Numerical Methods for Electromagnetics
Academic Semester	Spring
Academic Year	2016/2017
Semester Start Date	01/22/2017
Semester End Date	05/18/2017
Class Schedule (Days & Time)	09:00 AM - 10:30 AM Mon Wed

Instructor(s)				
Name	Email	Phone	Office Location	Office Hours
Hakan Bagci	hakan.bagci@kaust.edu.sa	+966128084330 8084330		Time: Tuesday 15:30-17:00 Location: B-3, Room: 3222

Teaching Assistant(s)	
Name	Email

Course Information	
Comprehensive Course Description	<p>This is a PhD level course on numerical methods for solving problems of wave scattering and propagation in electromagnetics. The course focuses on three groups of methods:</p> <p>(i) Finite difference time domain (FDTD) method: Formulation of finite-difference discretization of Maxwell equations fundamentals, stability analysis, and derivation of approximate absorbing boundary conditions and perfectly matched layers. Homework assignments will require implementation of the FDTD method for solving one dimensional (1D) wave equation.</p> <p>(ii) Finite element method: Variational formulation in electromagnetics and Rayleigh-Ritz method for deriving finite element discretization, scalar and vector basis functions and higher-order versions in 1D, 2D, and 3D, and solving waveguide problems with FEM. Project will require implementation of the FEM for solving the 2D Laplace on a closed domain.</p> <p>(iii) Integral equations: Formulation of the electric and magnetic field surface integral equations for perfect electrically conducting and homogenous dielectric scatterers, method of moments in 2D and 3D, iterative solution, preconditioning, and brief introduction to fast solvers. Homework assignments will require implementation of the method of moments for solving the 2D electric field surface integral equation enforced on 2D scatterers.</p>
Course Description from Program Guide	Introduction to computational electromagnetics. Finite difference time domain method: fundamentals, absorbing boundary conditions, perfectly matched layers. Integral equations: fundamentals, method of moments, Galerkin schemes, fast solvers. Finite element method: fundamentals, vector and higher-order basis functions, hybridization of finite and boundary element methods. Applications of these methods in problems of electromagnetics, optics, and photonics.
Goals and Objectives	Students will acquire the basic understanding of finite-difference and finite element methods, and integral equation solvers used for numerical characterization of electromagnetic fields and waves. They will learn how to implement these methods in 1D and 2D.
Required Knowledge	<p>Required: Undergraduate-level electromagnetics and numerical analysis knowledge and experience with a programming language or Matlab</p> <p>Preferred: Master-level electromagnetics and numerical analysis knowledge</p>

Reference Texts	Theory and Computation of Electromagnetic Fields, Jin The Finite Element Method in Electromagnetics, Jin Computational Methods for Electromagnetics, Peterson, Ray, Mitra
Method of evaluation	50.00% - Homework /Assignments 50.00% - Course Project(s)
Nature of the assignments	Project will require implementation of the FEM for solving the 2D Laplace on a closed domain. Any programming language can be used. Homework assignments will require derivation of simple equations discussed in lectures and implementation of numerical schemes to solve them. Any programming language can be used.
Course Policies	Attendance is not mandatory however students should realize that following the lectures will help them significantly with the project and the homework assignments. Late submissions will not be accepted.
Additional Information	

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Mon 01/23/2017 Wed 01/25/2017	Introduction to computational electromagnetics Review of vector analysis and Maxwell equations
2	Mon 01/30/2017 Wed 02/01/2017	Finite difference time domain method (FDTD): 1-D, 2-D, and 3-D formulations
3	Mon 02/06/2017 Wed 02/08/2017	Finite difference time domain method (FDTD): 1-D, 2-D, and 3-D formulations
4	Mon 02/13/2017 Wed 02/15/2017	Finite difference time domain method (FDTD): Stability analysis
5	Mon 02/20/2017 Wed 02/22/2017	Finite difference time domain method (FDTD): Absorbing boundary conditions
6	Mon 02/27/2017 Wed 03/01/2017	Finite difference time domain method (FDTD): Perfectly matched layers
7	Mon 03/06/2017 Wed 03/08/2017	Finite element method (FEM): Variational principles for electromagnetics Finite element method (FEM): 1-D, 2-D and 3-D formulations
8	Mon 03/13/2017 Wed 03/15/2017	Finite element method (FEM): 1-D, 2-D and 3-D formulations Finite element method (FEM): Nodal and vector basis functions
9	Mon 03/20/2017 Wed 03/22/2017	Finite element method (FEM): 1-D, 2-D and 3-D formulations Finite element method (FEM): Nodal and vector basis functions
10	Mon 03/27/2017 Wed 03/29/2017	Finite element method (FEM): Waveguide problems
11	Mon 04/03/2017 Wed 04/05/2017	Spring break
12	Mon 04/10/2017 Wed 04/12/2017	Finite element method (FEM): Waveguide problems
13	Mon 04/17/2017 Wed 04/19/2017	Integral equations (IEs): Surface integral equations
14	Mon 04/24/2017 Wed 04/26/2017	Integral equations (IEs): Surface integral equations Integral equations (IEs): Method of moments
15	Mon 05/01/2017 Wed 05/03/2017	Integral equations (IEs): Surface integral equations Integral equations (IEs): Method of moments
16	Mon 05/08/2017 Wed 05/10/2017	Integral equations (IEs): Iterative solution and preconditioning
17	Mon 05/15/2017 Wed 05/17/2017	Integral equations (IEs): Computational complexity and fast solvers
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Note

The instructor reserves the right to make changes to this syllabus as necessary.