EE 471 Computational Techniques in Electromagnetics

Credits: 3

Categorization of credits: engineering topic

Instructors or course coordinator: Magdy F. Iskander

Textbook and Other Required Materials: Magdy F. Iskander, "Electromagnetic Fields and waves," second edition, Waveland Press, 2012, ISBN 1-57766-783-2.

Designation: Elective

Catalog Description: Computational Techniques in Electromagnetics (3) Introduction to computational methods used to simulate/solve engineering design problems focusing on electromagnetics. Finite difference, method of moments, and finite elements methods will be described; students will write computer programs in each. A-F only. BE, EE, ENGR majors only. Pre: 371 or consent. (Spring only)

Pre-and Co-requisites: EE 371 (Engineering Electromagnetics I)

Class/Lab Schedule: 3 lecture hours per week

Topics Covered:

- Finite Difference methods for solving engineering problems formulated in terms of differential equations.
- Method of Moments – for solving engineering problems formulated in terms of integral equations
- Finite element methods – a variational technique for solving engineering problems

Course Objectives and Their Relationship to Program Objectives:

The course objective is to introduce students to the basics and fundamental concepts of computational techniques with applications in the electromagnetics research and technology areas. It is well known that in introducing engineering concepts focus has often been placed on simple geometries and ideal sources and simple operating conditions to help students understand these concepts. This is because these simplifications allow simple mathematical operations or analytical solutions and, hence, maintain focus on the fundamental concepts in hand. For example, in introducing Maxwell's equations in electromagnetics, simple geometries and idealized sources are often used to help illustrate the use of these equations while not getting students bogged down with detailed and complex mathematical operations.

At some point in the curriculum, however, students need to deal with realistic engineering problems. In this case, simple analytical solutions will not be possible and it is necessary to use computational techniques. Through these computational methods, engineering problems, whether formulated in terms of integral or differential equations, are converted into a set of simultaneous equations which could easily be solved using commonly available numerical analysis methods. In a way, this course offers for the first time, the missing link between several of the numerical analysis courses taught in the math departments and the engineering design tools required from a

graduating engineering students. Arming students with these invaluable methods and solution procedures in computational techniques would be of significant value throughout their engineering careers.

[Program Objectives this course addresses: 1, 3, and 4.]

Course Outcomes and Their Relationship to Program Outcomes:

The following are the course outcomes and the subset of Program Outcomes (numbered 1-7 in square braces "[ ]") they address:

- Write computer programs that demonstrates their understanding of the solution procedure [1]
- In the Finite Difference method, write a computer program for calculating the characteristic impedance of microstrip transmission lines. [1]
- For the Method of Moments, write a program to calculate charge distribution on a cylindrical rod, and another to calculate the capacitance of a parallel plate capacitor, including the fringing field effects. [1]
- Use different digital mesh structures, or different basis functions for describing geometries and /or expanding the unknown source distribution. [1]
- For the Finite elements program, write a program for calculating the potential distribution in an irregular domain of interest and for which an analytical solution is not available. [1]
- Solidify understanding of the basic computational methods being described, and also boots their programming abilities which are often limited in a typical electrical engineering curriculum. [1, 7]

Contribution of Course to Meeting the Professional Component

Engineering Topics: 100%

Computer Usage:

Students are asked to write a minimum of three computer programs (using any language, mostly Matlab) with one of the programs being on each of the three described computational methods. Each of these programming assignments are designed to solve an engineering problem including the design of two conductors transmission lines of different geometries, calculation of capacitance in a high frequency digital circuit, radiation from wire antennas (Hallen's Integral equation) and scattering by dielectric cylinder . Students also make power point presentations of their developed programs and obtained results.

Design Credits and Features:

EE 471 has1 1/2 hrs of design credit.

Person Preparing Syllabus and Date: Magdy F. Iskander, Jan. 31, 2015. Modified by A. Ohta, Jan. 20, 2021.