University of Manitoba

Department of Electrical & Computer Engineering
Graduate Course Outline

FALL 2020

ECE 7810 A01 –Numerical Methods for Fields Computations

COURSE DESCRIPTION:

The course covers numerical methods of computational physics and engineering most commonly used in today's computer-aided-design software packages. Both mathematical foundation and practical implementation of the methods is discussed. Laboratory classes and homework assignments provide hands-on experience with the software implementation of the studied numerical techniques. Brief introduction to parallelization of the computational codes is featured.

COURSE OBJECTIVE:

To study the mathematical formulation and apply numerical techniques to the solution of practical problems encountered in electrical and computer engineering. Applications include circuit, transmission-line, and electromagnetic field modelling, both in the frequency and the time domain. Mathematical formulations include linear and non-linear systems of equations, linear and non-linear systems of ordinary differential equations, systems of partial differential equations, and integral equations. Numerical discretization methods to be studied include finite differences, finite element and method of moments.

PRE-REQUISITES:

- MATH 3132 Engineering Mathematical Analysis 3
- ECE 2240 Numerical Methods for Electrical Engineers

COURSE CONTENT:

The following topics will be discussed:

- Circuit modelling (frequency and time domain solutions).
    - Formal methods of formulating circuit equations – KCL, KVL, Modified Nodal Analysis (MNA).
    - Methods of solving systems of ODEs
    - Stability and error analysis of marching-on-time methods for ODEs
- Multiconductor transmission-line (MTL) modelling.
    - Finite-difference solution of MTL equations.
- Finite-differences for electrostatic and magnetostatic problems.
    - Laplace's equation and PUL matrices of MTLs.
    - Iterative matrix solution techniques (Successive-Over-Relaxation, conjugate-gradient).
- Finite Element Method (FEM).
    - Variational method and development of functionals for PDE's.
    - 1st order FEM for the Laplace and Helmholtz equations.
    - 2nd order FEM for Laplace equation.
    - Grid generation using Gmsh.
- Finite-Difference Time-Domain solution of Maxwell's equations.
    - 2D and 3D, scattered and total field formulations.
    - Absorbing boundary conditions.
- Method of Moments (MoM)
    - Green's function.
    - Green's theorem.
    - MoM solution of capacitance extraction problem.

Additional advanced research topics as determined by the instructor.

HOMEWORK:

There are 5 graded homework assignments in the course.

LABORATORIES :

There are 5 laboratory classes in the course.

TEXTBOOKS:

- *Computer Methods for Circuit Analysis*, J. Vlach and K. Singhal, Van Nostrand Reinhold, 2nd edition, 1994.
- *Numerical Techniques in Electromagnetics*, M.N.O. Sadiku, CRC Press, 2nd edition, 2000. Available on-line from library: http://www.engnetbase.com/books/455/front.pdf
- *Introduction to the Finite-Difference Time-Domain (FDTD) Method for Electromagnetics*, S. Gedney, Morgan & Claypool, 2011.
- *Antenna and EM Modeling with Matlab*, S. N. Makarov, Wiley, 2002. (Graduate track only)

GRADE ANNOUNCEMENTS:

Grades for this course will be announced by January 2021

EVALUATION:

Your final course grade is determined by your performance in the components list below in the Evaluation Table (seminar, assignments, project, mid-term, and a final examination. Students must receive a minimum of 50% on the final examination and must complete and pass all components in the course in order to be eligible to receive a passing grade.

Each component is weighted as follows:

COMPONENT	NO	VALUE %	TOTAL VALUE	DETAILS / ADDITIONAL INFO
Laboratories	5	15%	15	
Assignments	5	20%	20	
Project	1	15%	15	Implementation of 2nd order FEM
Mid-Term Exam	0	0%		There is no mid-term in the course
Final Examination	1	50%	50	
TOTAL			100	

GRADE SCALE:

LETTER	MARK	LETTER	MARK	LETTER	MARK	LETTER	MARK
A+	95-100	B+	80-84	C+	65-69	D	45-54
A	85-94	B	70-79	C	55-64	F	<45

INSTRUCTOR INFO:

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Office Hours:..... After lectures or by appointment

VOLUNTARY WITHDRAW:

November 23, 2020

REQUIREMENTS/REGULATIONS

Student Responsibilities: It is the responsibility of each student to contact the instructor if he/she is uncertain about his/her standing in the course and his/her potential for receiving a failing grade. Students should also familiarize themselves with Sections 4 and 6 of the Regulations dealing with, among others, incomplete term work, deferred examinations, attendance and withdrawal, etc..

Lectures: Attendance at lectures is essential for successful completion of this course. Students must satisfy each evaluation component in the course.

ACADEMIC INTEGRITY

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance with the General Academic Regulations and Requirements of the University of Manitoba, Section 7.1, students are reminded that plagiarism* or any other form of cheating is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university) regardless of media

- examinations
- assignments
- laboratory reports
- term exams

A student found guilty of contributing to cheating in examinations or term assignments is also subject to serious academic penalty

Please refer any questions regarding Academic Integrity to your course instructor.

***Plagiarism:** to steal and pass off (the ideas or words of another) as one's own; use (another's production) without crediting the source