ECE 4390 Engineering Computations 4E
Course Outline – Fall Term 2011

Course Objectives

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. Optimization problems will be studied both as alternative mathematical formulations of the modelling problem as well as for design. Numerical discretization methods to be studied include finite differences, finite element and boundary element methods, as well as the Method of Moments.

Prerequisites

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

Course Content

The following topics will be covered:

- 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.
- 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.
  - Variational method and development of functionals for PDE's.
  - FEM for the Laplace and Helmholtz equations.
  - Grid generation using Gmesh.
- Finite-Difference Time-Domain solution of Maxwell's equations.
  - 2D and 3D, scattered and total field formulations.
  - Absorbing boundary conditions.
- Modelling of antennas.
  - Pocklington's and Hallen's integral equations
  - Solution using Method of Moments.
- Classical optimization methods.
  - Steepest descent, conjugate-gradient, and Newton methods.

Accreditation Units

Mathematics: 0
Natural Science: 0
Complementary Studies: 0
Engineering Science: 75%
Engineering Design: 25%

Web Page
http://www.ece.umanitoba.ca/~lovetri/cECE4390/index.html (login: ece4390 password: student4390)

Reference Books
- *Computer Methods for Circuit Analysis*, J. Vlach, 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
- *The Finite-Difference Time-Domain Method for Electromagnetics with Matlab Simulations*, Z. Elsherbeni, V. Demir, Scitech, 2009.

Evaluation Details
The final course grade will be determined from a student's performance on projects, in laboratory quizzes, and on the final examination. Students must complete all the laboratories and projects in order to be eligible to receive a passing grade.

Mid-Term(s)
N/A

Instructor
Prof. Joe LoVetri
Room: E3-546 EITC
Telephone: (204) 474-6295
Email: Joe_LoVetri@umanitoba.ca

Office Hours
Mondays/Wednesdays 2:30-3:30, Tuesdays/Thursdays 1:30-2:30 or by appointment.

Teaching Assistants
Gabriel Faucher, Room: E3-522 EITC, Email: umfauch2@cc.umanitoba.ca

Voluntary Withdrawal Date
Wednesday, November 16th, 2011.

Requirements/Regulations
- Attendance at lectures and laboratories is essential for successful completion of this course. Students must satisfy each evaluation component in the course to receive a final grade.
- It is the responsibility of each student to contact the instructor *in a timely manner* if he or she is uncertain about his or her standing in the course and about his or her potential for receiving a failing grade. Students should also familiarize themselves with Sections 4 and 6 of the Regulations dealing with incomplete term work, deferred examinations, attendance and withdrawal.
- No programmable devices or systems (such as calculators, PDAs, iPods, iPads, cell phones, wireless communication or data storage devices) are allowed in examinations unless approved by the course instructor.

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 in examinations, assignments, laboratory reports or term tests is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university). A student found guilty of contributing to cheating in examinations or term assignments is also subject to serious academic penalty.

Department of Electrical & Computer Engineering
ECE 4390 Engineering Computations 4E

Learning Outcomes (approximately 5 recommended)

1. Ability to formulate any circuit problem in a form amenable to computer solution and solve using appropriate numerical analysis procedure.
2. Ability to formulate electromagnetic field problem using either integral equations or PDEs.
3. Ability to discretize an electromagnetic field problem using finite-differences, finite-elements, or the method of moments and program its solution on a computer.
4. Interpret the numerical solutions to extract typical engineering parameters.
5. Formulate design problems as mathematical optimization problems and apply numerical optimization routines to their solution.

Expected Competency Level **

Learning Outcome	Attribute*											
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**
1	3	3	4	5	3	5	3	3				
2	3	3	4	5	3	5	3	3				
3	3	3	4	5	3	5	3	3				
4	3	3	4	5	3	5	3	3				
5	3	3	4	5	3	5	3	3				3

***Attributes*:**
A1 A knowledge base for engineering
A2 Problem analysis
A3 Investigation
A4 Design
A5 Use of engineering tools
A6 Individual and team work
A7 Communication skills
A8 Professionalism
A9 Impact of engineering on society/environment
A10 Ethics and equity
A11 Economics and project management
A12 Life-long learning

****Competency Levels*:**
1 - Knowledge (Able to recall information)
2 - Comprehension (Able to rephrase information)
3 - Application (Able to apply knowledge in a new situation)
4 - Analysis (Able to break problem into its components and establish relationships)
5 - Synthesis (Able to combine separate elements into whole)
6 - Evaluation (Able to judge of the worth of something)

Student Contact Time (Hrs)

Lectures: 3 hrs lecture/week × 13 weeks/term = 39 hrs
Laboratories: 3 hrs laboratory × 5 weeks = 15 hrs
Tutorials: 0 hr tutorial × 0 weeks = 0 hrs

Evaluation

Component	Value (%)	Methods of Feedback *	Learning Outcomes Evaluated
Assignments			
Laboratory Quizzes	15	F, S	1, 2, 3, 4, 5
Laboratories/Projects	35	F, S	1, 2, 3, 4, 5
Mid-Term Test			
Final Examination	50	S	1, 2, 3, 4, 5

* Methods of Feedback: **F** - *formative* (written comments and/or oral discussion)**, S** - *summative* (number grades)