



ECE 7810 – Solution of Fields by Numerical Methods Fall 2018

Course Outline

Instructor

- Prof. Vladimir Okhmatovski, P.Eng
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Office Hours

- Tuesdays and Thursdays
12:45PM-1:45PM

Teaching Assistant

- Reza Gholami
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Contact Hours

- 3 credit hours
- Lectures:
3 hours x 13 weeks = 39 hours
- Laboratories:
3 hours x 5 weeks = 15 hours

Prerequisites:

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

Course Website:

<https://umanitoba.ca/umlearn>

Important Dates

- **Term Test**
None
- **Voluntary Withdrawal Deadline**
November 19th, 2018
- **Thanksgiving Day**
October 8th, 2018
No classes or examinations
- **Remembrance Day & Fall Break**
November 12th, 2018 (observed)
No classes or examinations

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.

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.
 - 2nd order FEM for Laplace equation (Graduate track only)
 - Grid generation using Gmesh.
- 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.
 - RWG MoM (Graduate track only).
- Classical optimization methods (Graduate track only)
 - Steepest descent, conjugate gradient, and Newton's methods.

Other Resources

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)

Requirements and 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 the University's *General Academic Regulations*, as well as Section 3 of the Faculty of Engineering *Academic 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.
- Students should be aware that they have access to an extensive range of resources and support organizations. These include Academic Resources, Counselling, Advocacy and Accessibility Offices as

Accreditation Details

Accreditation Units

- Mathematics: 15%
- Natural Science: 0%
- Complementary Studies: 0%
- Engineering Science: 60%
- Engineering Design: 25%

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 (Ability rephrase information)
- 3 - Application (Ability 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 a whole)
- 6 - Evaluation (Able to judge the worth of something)

Grading Scale

Letter	Mark
A+	95–100
A	85–94
B+	80–84
B	70–79
C+	65–69
C	55–64
D	45–54
F	< 45

Note: These boundaries represent a guide for the instructor and class alike. Provided that no individual student is disadvantaged, the instructor may vary any of these boundaries to ensure consistency of grading from year-to-year.

well as documentation of key University policies e.g. Academic Integrity, Respectful Behaviour, Examinations and related matters.

[➔ Supplemental Information](#)

Learning Outcomes

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 Levels

Outcome	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

Evaluation

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.

Component	Value (%)	Method of Feedback	Learning Outcomes Evaluated
Laboratories	10	F, S	1, 2, 3, 4, 5
Projects	20	F, S	1, 2, 3, 4, 5
Homework	20	F, S	1, 2, 3, 4, 5
Final Examination	50	S	1, 2, 3, 4, 5

* Method of Feedback: F - Formative (written comments and/or oral discussion), S - summative (numerical grade)

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 on Academic Integrity*, students are reminded that plagiarism or any other form of cheating in examinations, term tests, assignments, projects, or laboratory reports is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university). A student found guilty of contributing to cheating by another student is also subject to serious academic penalty.

Retention of Student Work

Students are advised that copies of their work submitted in completing course requirements (i.e. assignments, laboratory reports, project reports, test papers, examination papers, etc.) may be retained by the instructor and/or the department for the purpose of student assessment and grading, and to support the ongoing accreditation of each Engineering program. This material shall be handled in accordance with the University's *Intellectual Property Policy* and the protection of privacy provisions of *The Freedom of Information and Protection of Privacy Act (Manitoba)*. Students who do not wish to have their work retained must inform the Head of Department, in writing, at their earliest opportunity.