WESTERN UNVERSITY
FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ECE 9702 / ECE 9072 - NUMERICAL METHODS FOR ANALYSIS AND DESIGN OF HIGH-SPEED ELECTRICAL CIRCUITS - COURSE OUTLINE 2017-18

OBJECTIVE: The main objectives of this course are:

1) To understand and implement the fundamentals of analog circuit simulators.
2) To become knowledgeable of high-frequency design issues and interconnect models.
3) To address large complex high-frequency circuits via model-order-reduction algorithms.

PREREQUISITES: Undergraduate courses in circuit theory, linear algebra and differential equations.

CONTACT HOURS: 3 lecture hours/week

COURSE CONTENT:

1) Formulation of Network Equations: Nodal and modified nodal formulations.
2) Frequency-Domain Analysis: Sparse matrix techniques.
3) DC solution of Nonlinear Networks: Convergence, accuracy
4) Time-domain Analysis of Nonlinear Networks: Multi-step methods, stability
5) Sensitivity Analysis: Perturbation and Adjoint network techniques.
6) High-Speed Interconnects and Signal Integrity Analysis: Transmission line effects in high-speed designs, delay and cross-talk simulation.
7) Model-Order Reduction (MOR) Techniques: Asymptotic Waveform Evaluation, Complex-Frequency Hopping, Krylov subspace techniques.

SPECIFIC LEARNING OBJECTIVES:

The first part of the course deals with the basic principles of how circuit simulators formulate and solve electrical networks. The formulation of circuit equations (nodal and modified nodal analysis) and device stamps are described for most commonly used circuit elements. Next, solution methodologies for both linear and nonlinear networks are covered. In addition, computational techniques for determining network function sensitivities based on a generalized adjoint network method is developed.

The next part of the course involves addressing computational complexity of high-speed electrical networks. The analysis of high-speed interconnects and macromodeling algorithms are described to analyze signal integrity (delay, attenuation, crosstalk, etc) of high-speed electrical circuits. Model-order reduction (MOR) algorithms are introduced to address computational complexity of high-speed electrical circuits. Issues such as, stability, passivity and accuracy of various MOR algorithms are discussed. Synthesis of differential equations form MOR models and synthesis of SPICE compatible netlists from differential equations are also covered.

TEXTBOOK:

[1] J. Vlach and K. Singhal, "*Computer Methods for Circuit Analysis and Design*", Van Nostrand Reinhold, New York, 1994.

[2] R. Achar, M. Nakhla, "Simulation of High-Speed Interconnects," *Proc. of the IEEE*, vol 89, pp. 693-728, May 2001.

[3] Class notes.

EVALUATION:

The final course grade will be determined from students' performance in the project, assignments and a final exam. The weighting of each of these components will be as follows:

For graduate students registered in ECE 9702

		Maximum Penalties*	
Component	**Value**	**English**	**Presentation**
Project	20%	10%	10%
Assignments	20%	10%	10%
Final Examination	60%	10%	10%

For graduate students registered in ECE 9072

		Maximum Penalties*	
Component	**Value**	**English**	**Presentation**
Assignments	30%	10%	10%
Final Examination	70%	10%	10%

*In accordance with the policy of the University, the grade assigned to all written and oral work presented in English shall take into account syntax, diction, grammar and spelling. In the professional life of an engineer, the manner in which oral and written communications are presented is extremely important. An engineering student must develop these skills as an integral part of the graduate program. To encourage the student to do so, the grades assigned to all written and oral work will take into account all aspects of presentation including conciseness, organization, neatness, use of headings, and the preparation and use of tables and figures.

All work will be marked first for content after which a penalty not to exceed the maximum shown above may be applied for lack of proficiency in English and/or presentation.

ATTENDANCE

Any student, who in the opinion of the instructor is absent too frequently from class in this course, will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular examination in the course.

CHEATING

University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalties that might include expulsion from the program. If you are caught cheating, there will be no second warning.

PLAGIARISM:

Students must write their essays and assignments in their own words. Whenever students take an idea or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar). The following web site provides some clear examples that will help avoid plagiarism: http://www.hamilton.edu/academics/resource/wc/usingsources.html

COURSE INSTRUCTOR: A. Dounavis (TEB253)