Syllabus

ECE 5350/6350 – Fall 2017

Metamaterials and Advanced Antenna Theory

3.0 Credits

Pre-requisites:	ECE 3300
Time:	Tue/Thur 3:40 PM-5:00 PM
Location:	MEB 2555

Instructor:	David Schurig
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Phone:	(801) 503-9415
Office Location & Hours:	MEB 2274, Friday 4:00-5:00PM

Course Objectives

1. *Students will learn to use an electromagnetic simulation software package,* Microwave Studio.

Microwave Studio can solve Maxwell's Equations in very general material and source configurations with three different solvers: Finite Difference Time Domain (FDTD), frequency domain Finite Elements, and Eigen-Mode. This functionality is very useful across most disciplines of electrical engineering.

2. *Students will gain an understanding of metamaterial and advanced antenna concepts by exploring archetypical, computational, problems relevant to current research.*

Metamaterial topics may include: material parameter extraction, effective medium theory, resonant unit cell analysis, and unit cell coupling. Examples will be drawn from invisibility cloaking and negative index media. Antenna topics may include: complex antenna shapes, real array effects, co-located antenna interference, high-impedance ground-planes, and Specific Absorption Rate (SAR).

Metamaterial and antennas topics are connected not only by the tools used to analyze them, but conceptually (particularly in the case of antenna arrays). I will try to make these connections where appropriate.

Required Texts

None

Teaching and Learning Methods

The class will meet in the a computer lab where I will typically give a brief lecture and then be accessible to answer questions and assist with the projects. There will be approximately five project assignments, all of which will have simulation components. Students will learn the metamaterial and antenna concepts as they simultaneously explore the capabilities of the software. Deeper understanding will come from the required post-simulation analysis, answering of assignment questions, and written presentation of results.

Pre-requisites

The prerequisite for this course is ECE3300 or equivalent course that gives a fairly thorough introduction to electromagnetics and Maxwell's Equations (such as PHYS 3220 or 4420). Antenna Theory and Design (ECE 5324) is recommended, but not necessary to complete the projects.

Academic Integrity

Students may work together on assignments, but every student must be able to explain their submitted work. Students are expected to exhibit integrity in their conduct and are subject to the University of Utah Code of Student Rights and Responsibilities (http://www.regulations.utah.edu/academics/6-400.html).

Americans with Disabilities Act (ADA) Statement
The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building, 581-5020 (V/TDD). CDS will work with you and the instructor to make arrangements for accommodations. All information in this course can be made available in alternative format with prior notification to the Center for Disability Services. (http://disability.utah.edu)

Wellness Statement
Personal concerns such as stress, anxiety, relationship difficulties, depression, cross-cultural differences, etc., can interfere with a student's ability to succeed and thrive at the University of Utah. For helpful resources contact the Center for Student Wellness - www.wellness.utah.edu; 801-581-7776.

Grading Policy (Evaluation Methods & Criteria)
Grades will be based exclusively on the projects, with each submitted report accounting for an approximately equal portion of the grade. 5350 students will be graded on one fewer project than 6350 students (they will be graded on the their highest scored assignments or may omit one report at their discretion). The assignment reports will be due approximately every three weeks. There will be no exams. Correct and complete fulfillment of all assignments will result in an excellent grade. Within reason, late assignments will be accepted and given substantial credit. Reasonable attendance is expected but not graded.

Potential Metamaterial Projects

Material property extraction
Perform S-parameter simulations on a known material, with and without correct de-embedding. Export data and compare with theory.

Effective medium theory
Perform S-parameter simulations on a composite material. Export data and extract effective material properties from the S-parameters. Compare with Maxwell-Garnett theory which includes only the volume fraction and component material properties.

Resonant unit cells
Perform S-Parameter simulations on a family of resonant unit cells (from the microwave invisibility cloak). Export data and extract effective material properties. Compare with desired material properties.

Advanced extraction and effective medium theory.
Consider branch selection failure, Kramers–Kronig theory and spatial dispersion in characterizing a metamaterial. Use CST scripting in Visual Basic to write a structure macro (for creating a more complex unit cell) and an analysis script for a more sophisticated effective medium extraction.

Unit cell coupling
Simulate varying numbers of unit cells in the propagation direction. Extract material properties and find asymptotic values.

Metamaterial apertures
Design and simulate a metamaterial modulated aperture, such as those used in satellite communications (http://www.kymetacorp.com) or microwave security imaging (http://evolvtechnology.com).

Potential Antenna Projects

Complex antenna shapes.

Increasingly antenna shapes are dictated by requirements of the packaging or platform. Simulate a complex antenna shape, the iPhone 4 GSM antenna, and determine its far field properties and input impedance both with and without a “finger” on the “death spot”.

Real antenna array effects

Coupling between elements in a real antenna array can effect current distributions and thus input impedance and radiation fields. Simulate an antenna array with real coupling. Calculate input impedance and radiation parameters and compare with an ideal array factor calculation.

Co-located antenna interference

Multiple antennas in the same package can interfere with each other. Simulate a GSM and a GPS antenna in close proximity and calculate the cross talk. Try an isolation strategy, such as placing a high-dielectric material between the antennas.

High-impedance ground-planes

Electric antennas in contact with electric ground-planes do not radiate. Model a dipole antenna on a finite-sized, high-impedance ground-plane (also known as a magnetic ground-plane) of two types - one that supports surface waves and one that does not. Calculate input impedance and radiation parameters. Compare with ideal image solution.

Specific Absorption Rate (SAR)

Model an antenna in close proximity to a human head. Export field data and calculate SAR.

Tentative Schedule

Project 1	August 23 - September 8
Project 2	September 13 - September 29
Project 3	October 4 - October 27
Project 4	November 1 - November 17
Project 5	November 22 - December 8