Advanced Topics in Analytical Electromagnetics
ECE 8833 – Fall 2007

Class Description:

Course	Title	Cr Hrs	Instructor	Days	Time	Location
ECE-8833	Advanced Topics in Analytical EM	3	Greg Durgin	T Th	9:35	TBD

ECE 8833 Advanced Topics in Analytical Electromagnetics
This class provides an in-depth treatment of several common analytical techniques for framing and solving real-world problems in EM wave propagation. Upon completion of the course, the student will have a high degree of confidence and competence in discussing the fundamental mechanisms of scattering, diffraction, and stochastic propagation with the world's top EM researchers. The final project will be a student-chosen topic involving an application of analytical electromagnetics to real-world wireless, radar, or optical problems.

Instructor: Gregory D. Durgin
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Class Web Page: TBD
511 Van Leer
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Textbook: Course notes will be posted online.

Prerequisites: Suggested prerequisites are graduate standing and some background in graduate-level electromagnetics (ECE 6350 or equivalent).

Grading:

20% Homework – Expect approximately 4-5 homework assignments over the course of the semester.

40% Midterm Quizzes (2) – There will be 2 take-home quizzes.

40% Final Project – A final project will be assigned and collected towards the end of the course. The last week of the course will be reserved for student project presentations.

Computer Usage: The web will be used extensively in this class to disseminate homework assignments, lecture materials, and class announcements. Some assignments may involve the use of Matlab^{tm} or equivalent computational software. Most students should have access to this software through a university computer lab or their own personal computing packages. If not, please inform the instructor.

Tentative Lecture Topics:

I. **Review of Maxwell's Equations and Wave Equations –** One or two lectures will be spent reviewing the basics of wave propagation: vector fields and phasors, vector wave equation, Helmholtz equation, and the plane wave basis.

II. **Geometrical Optics (GO) and Ray Tracing –** Rigorous derivation of GO with classification of eikonal shapes, Gaussian curvatures, and astigmatic problems. Several computational algorithms for ray-tracing complicated environments and radioscapes will also be presented.

III. **Physical Optics and Physical Theory of Diffraction (PTD) –** Babinet's principle and the Kirchoff approximation will then lead into a discussion of scalar and physical theories of diffraction.

IV. **Sommerfeld Half-Plane Diffraction and Asymptotic Behavior –** The famous Sommerfeld solution will be presented with the classical plane wave spectral decomposition method.

V. **Geometrical Theory of Diffraction (GTD) –** Using asymptotic expansions of the Sommerfeld solution, we will demonstrate the three principles of GTD: localization of diffraction phenomena, Fermat's principle for diffracted waves, and diffraction coefficients. Parallels will be draw to other canonical problems as well as Unified Theory of Diffraction (UTD).

VI. **Scattering from a Conductive Sphere –** A look at another classical scattering problem, which will introduce the student to spherical Hankel functions, exact series solution, asymptotic solutions/behaviors, and the Watson transform.

VII. **Rough Surface Scattering –** How to characterize the statistics of a random rough surfaces using height standard deviation, 2D autocorrelation, and wavevector spectrum.

VIII. **Perturbation Theory Applied to Random Rough Surfaces –** Derivation of scattering patterns using perturbation theory applied to "slightly roughened" surfaces. Analogies are drawn to simple and familiar Bragg scatterings.

IX. **Statistical Characterization of Space-Time Wireless Channels –** Describing the complicated wireless channel that results from radio wave propagation that fades in space, time, and frequency.

X. **First-Order Characterization of Random Wave Interference –** The common PDFs (Rayleigh, Rician, etc.) used in the characterization of fading channels and their link to fading mechanisms.

XI. **Theory of Multipath Shape Factors –** Description of the fading statistics of stochastic wave interference in terms of angle-of-arrival statistics; applications are presented in terms of real-world wireless problems.

XII. **Student Presentations –** The last week will be spent with students presenting their year-end projects in front of the class.

Honor Code: The Honor Code applies to every aspect of this class, with only one noteworthy exception: student discussion of concepts and techniques for solving homework problems is permitted and even encouraged outside the classroom. However, *all submitted work must be original*.