ECE 569 - Inverse Problems in Optics

Instructors:

This course is always taught by Professor Carney, typically in the fall semester every other year. He is an optics professor in the ECE Department, and this course is his speciality.

Prerequisites:

ECE 460 is listed as the only prerequisite. A familiarity with optics and electromagnetics from other courses is necessary, as this course breezes quickly through intuition behind its ideas. Mathematically, courses in linear algebra, complex variables, or courses involving Hilbert spaces are very useful. Familiarity with Dirac notation for linear algebra will also be helpful, but a crash course of linear algebra, Hilbert spaces, and Dirac notation are the focus of the first portion of the class.

When to Take It:

This course is best taken in graduate school after a familiarity with optics is obtained. Mathematical maturity is a must, as Professor Carney teaches in a mathematically rigorous manner. Advanced undergraduates with an interest in optics may take the course as well, but given how seriously the prerequisites are taken, an undergraduate must be prepared to dedicate serious time.

Class Content:

The course covers a framework in which optics problems can be modeled using linear algebra which is amenable to solving inverse problems. The first portion of the course covers the language of Dirac notation and linear algebra, rigorously defining a vector space and its associated tools. The course hits its stride when operators begin being introduced to model the physics of optics: propagation of fields, scattering, lenses, and more are described using linear algebra, as opposed to simple equations typically given in an undergraduate physics or optics course. The meat of 569 is restating results that students should be familiar with, but in a new language that is amenable to inversion. Along the way, each of the components are shown in both their forward case, which is covered in prior courses, and then “inverting” these components to show how, if the end data is given, how can the initial conditions be reconstructed. Towards the end, examples from research topics are covered to show how versatile the material of the course is, such as imaging, basic coherence theory, and possibly some unique topic from a guest lecturer.

Work:

The work load for ECE 569 is typical of graduate courses. Every few weeks, a problem set is due. Problem sets are difficult and extend material from lecture into applications (e.g. lenses are derived in homework, not in class), but there are two chances given for every homework. The time investment could range from 3-5 hours for an easier homework to 10+ for more difficult assignments. The end of the class is a research project, where students are asked to apply material from the semester to solve a problem they propose. Projects are expected to be of publishable quality, but plenty of time is given to work out a project.

Life After:

There is no "sequel" to ECE 569, as there are for many undergraduate courses. However, material from this course is invaluable for research applications. After this course, students will have a new approach for problems that may assist them in research down the road.