Physics 570
Physical and Fourier Optics
Spring 2011

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Class: Physics Libraray, 9-10:30 (subject to modification)
Office hours: TBD

Summary:
This course will address topics related to the propagation of light through optical systems. Such an understanding is essential to being able to work with modern optical technology. Diffraction theory shows that the field distribution at the focal plane of a lens is the 2D Fourier transform of the field transmitted through the lens. This enables the use of linear systems theory (transfer functions, convolution) to describe imaging systems: microscopes, spectrometers, holography. We will also cover topics in ultrafast optics, waveguides, and beam propagation. To increase the utility of the course, we will use some numerical methods to be able to calculate beam propagation in complex systems.

General Expectations and Philosophy:
As a more advanced, seminar-style class, this course has room to be tailored somewhat to the interests of the students. Since we will be concentrating on topics that are current, there will be some reading from journal articles in addition to the textbooks.

Textbooks:
The books we are using are *Introduction to Fourier Optics* by Goodman (3rd edition).

Texts some of you already have from earlier courses will be useful for background:
Griffiths' book *Introduction to Electrodynamics* (3rd edition)
Hecht: *Optics*
Heald and Marion: *Classical Electromagnetic Radiation*

There are many other texts that will prove to be useful references. I have copies of all these. Please ask me if you'd like any recommendations on a particular topic.
Lipson: *Optical Physics*
Guenther: *Modern Optics*
Born and Wolf: *Principles of Optics* (this is the classic reference text)
Gaskill: *Linear Systems, Fourier Transforms, and Optics* (good basic intro to Fourier methods in optics, on reserve in library).
Yariv: *Quantum Electronics* (more of a lasers book, but has good sections on Gaussian beam propagation and nonlinear optics).
Bracewell: Fourier Transforms and Applications (on reserve in library).

Course website:
The course website will be on the Physics Wiki page. A good fraction of class notes will be posted on the website.

Computation:
Most of the modeling and calculations will be done with Mathematica. There will also be a section that makes use of Zemax.

Homework:
The homework will be most every week. You will be able to pick up the homework assignment from the course website. After the homeworks are collected, I will make copies of them, then hand them back to you with the solutions. As part of your homework grade, you will go through the solutions and mark for me

what you didn't get. I will be assigning grades. This will ensure you get rapid feedback, and that you'll see alternative ways of approaching problems.

Project:

Instead of a final, you will do a mini-research project that will involve some literature research and calculations. You will need to write it up, and give a ~10 min presentation to the class on your findings. In the spirit of making sure the project is useful, you should coordinate with your advisor to identify a calculation that is relevant to your research.

Grading proportions:

The proportions to the grades will be (subject to change)

Homework	40%
Midterm 1	25%
Final project	35%

Syllabus

- Fourier linear systems theory
  - 1D with applications to ultrafast optics (t/omega domain)
    - Fourier transform theorems, convolution, impulse response and transfer functions, amplitude and phase filters
    - dispersive propagation, pulse compression
    - sampling theory and use of the FFT
  - 2D (spatial/spatial frequency domain)
    - Cartesian coordinates
    - cylindrical coordinates: Bessel transforms
- Alternative representations – e.g. Wigner transforms
- Scalar diffraction theory, Fresnel and Fraunhofer diffraction
  - Fresnel calculation of propagation of Gaussian and arbitrary beams
  - Spatio-temporal propagation
- Numeric Beam Propagation Method (Fresnel)
  - Free space propagation
  - Guided waves and resonators
- Imaging
  - Abbe imaging theory
  - Frequency analysis of imaging systems (Zemax)
- Wavefront modulation and pulse shaping
- Spatial filtering and optical processing

Applications:

Numerous applications will be discussed during the course. The selection and timing will be determined as we go. Possible topics include:

- Imaging analysis of spectrometers
- Spectral interferometry, Holography
- Multilayer systems
- Speckle interferometry
- Solitons
- Confocal microscopy
- Split-step time-domain code for nonlinear pulse propagation, nonlinear beam propagation effects