EE581 Fourier Optics and Imaging Theory

Fall 2011
3 credits

Class meetings: Lectures MWF 11:00-11:50 pm in EPS 110

Course Webpage: http://www.coe.montana.edu/ee/davidd/ee581/ee581.html
Course Listserv: ee58101@listserv.montana.edu

Instructor: David Dickensheets
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Office Hours: TBD

Text: *Introduction to Fourier Optics,* 3rd Edition, by Joseph W. Goodman (Roberts and Company, 2005).
Other References: *Fundamentals of Photonics* by Saleh and Teich, (John Wiley & Sons, inc., 1991), *The Fourier Transform and Its Applications*, 3rd Edition, by Ronald N. Bracewell (McGraw-Hill, 2000).

Course Description:

This course will provide an introduction to optical propagation and diffraction using a scalar wave approach and Fourier theory of imaging. Topics introduced will include pupil function, point spread function and line spread function, optical transfer function, image formation with coherent and incoherent light, holography and diffractive optical elements.

Prerequisites:

EM Theory including wave equation and plane wave propagation (EE334 or equivalent), and understanding of one-dimensional Fourier transform, or consent of instructor.

Course Goal:

The goal of the course is to increase students' understanding of light propagation phenomena and image formation, and to provide them new tools useful for analysis of both monochromatic and polychromatic optical systems.

Course Objectives:

Students completing this course will:

1. Develop familiarity with 2-dimensional Fourier transforms and Hankel (Fourier-Bessel) transforms.
2. Understand diffraction as described by Rayleigh-Sommerfeld theory, and know conditions for applicability of the theory.

3. Understand what is meant by Fresnel and Fraunhofer diffraction.
4. Learn about Fourier transform properties of lenses.
5. Learn about coherent and incoherent imaging properties of lenses, and how to predict and use system point-spread function and optical transfer function.
6. Appreciate generalization from monochromatic analysis to polychromatic analysis.
7. Develop knowledge of selected topics in coherent optics, wavefront modulation, high resolution imaging or other areas per class interests.

This course will emphasize problem solving skills through homework assignments and group activities. After completing this course you should be able to apply your understanding of this material to solve various problems related to diffraction, beamforming and imaging systems.

Course Organization and Grading:

The course will consist of lectures and student-provided demonstrations. Grading will be based on homework assignments, participation in demonstrations, two midterm examinations and a final exam, with the following relative weights:

Homework and quizzes	40%
Fourier Optics Demonstrations	15%
First midterm	15%
Second midterm	15%
Final exam	15%

Important Dates:

August 29	First day of instruction
Week of October 10	First midterm examination
Week of November 14	Second midterm examination
December 15, 8:00am	Final examination

Other Optics Courses at MSU:

EE482	Electro-Optical Systems (**Lab**, yearly, Fall)
EE483	Fiber and Integrated Optics (**Lab**, alt odd years, Spring)
EE484	Laser Engineering (alt even years, Spring)
EE581	Fourier Optics (alt odd years, Fall)
EE582	Optical Design (alt odd years, Spring)
EE583	Remote Sensing Systems (alt even years, Spring)
EE 538	Advanced Topics In Electromagnetics And Optics (on demand)
PHYS 253	Physics of Photography
PHYS 353	Holography
PHYS 426	Modern Optics
PHYS 427	Laser Applications
PHYS 531	Nonlinear Optics and Laser Spectroscopy
CHEM 527	Analytical Optical Spectroscopy
CHEM 560	Symmetry, Orbitals and Spectroscopy

Fourier Optics Demonstration

You the students have the opportunity to design and present unique and exciting "demonstrations" of phenomena relevant to the subject matter of Fourier optics! We have the resources of the Optics Teaching Lab, as well as our research labs, to put together physical demonstrations. You may also put together Matlab demos, or other types of "soft" illustrations. The goal is to identify a specific concept, come up with a way to physically demonstrate it, and then pull off the demo for the class in a way that rocks the house.

Here's the mechanism. You will work in small groups. The groups can be dynamic through the semester. However, each of you must carry out two demos during the semester, and each one will be worth 7.5% of your grade (for a total of 15%, equal to one exam!). You will need to come up with the idea, put together the demo, and then provide a one to two page report describing the concept that you are trying to illustrate, with any necessary abbreviated theoretical considerations, and then a description of the demonstration you created. You will be graded on both the presentation and the write-up.

In general, simpler is better, and be sure to consider the "cool" factor.

COURSE OUTLINE

Weeks 1&2	2-D Fourier Transforms
Weeks 3&4	Foundations of Scalar Diffraction Theory
Weeks 4&5	Fresnel and Fraunhofer Diffraction
Weeks 6&7	Lenses, Fourier Transformation and Imaging
Weeks 8-10	Imaging Systems Analysis
Weeks 11-15	Selected topics to potentially include: wavefront modulation and spatial light modulators, holography, CGHs and binary optics, superresolution, vortex beams, lightfield imaging, analog optical processing and correlation, Fourier optics in communications. Coverage will depend on class interests.