Optics 261: Interference and Diffraction (Spring 2018)

Course Objectives: This course provides an introduction and in-depth examination to wave models of optical interference and propagation. This class considers properties and behavior of light in conditions when the wave nature of light becomes dominant. Topics that will be considered: Complex representation of waves, superposition of waves; scalar diffraction theory; Fresnel and Fraunhofer diffraction and application to measurement; diffraction and image formation; optical transfer function; coherent optical systems, optical data processing, and holography.

Prerequisites:
Physics: Introductory Electricity and Magnetism.
Math: Mth164 (*Mth281 and Mth282 are desirable*.)
Numerical Analysis: Calculation and graphing proficiency with MATLAB, Mathematica, Excel or equivalent.

Instructor:
Prof. Jim Fienup Email: fienup@optics.rochester.edu
Office: Wilmot 410. Phone: 275-8009
Office Hours: Thursday 4:30 - 5:30 pm, Also, by appointment (including TAs)

Teaching Assistants:

Class Periods: Mondays, Wednesdays 10:25 - 11:40 am, Goergen 101

Recitation Periods: Fridays 3:25-4:25pm,

Grading Basis:
20% Homework Assignments
30% Mid-term Exam
45% Final Exam
5% Class Participation

Homework and Test Policy: There will be weekly homework assignments. These will be due one week from the hand-out date, during the class period. Late homework loses 10% of the grade for that homework per 24 hours, beginning immediately following class. The homework will be reviewed at the recitation sections. There will be one midterm exam, one final exam, and possibly one pop quiz (which would count as an additional homework assignment). There will be no make-up exams.

Required Texts
Optics, **5th Ed**., E. Hecht, (Pearson, 2017)
(The course does not follow Hecht per se, but many readings come from Hecht, and Hecht problems are assigned.)

First reading: Hecht Chapter 2.

Recommended Supplementary Texts:
Introduction to Wave Optics, Prof. N. Vamivakas (University of Rochester)
— for internal use only
Introduction to Modern Optics (2nd ed.), G.R. Fowles, Dover, ISBN 0-486-65957-7
Fundamentals of Optics (out of print), F.A. Jenkins & H.E. White
Physical Optics Notebook: Tutorials in Fourier Optics (Available at www.spie.org)
Schaum's Outline of Theory and Problems of Optics, E. Hecht, McGraw-Hill, ISBN 0-07-027730-3.

Lab:

A separate two-credit Lab Course, OPT 202, "Physical Optics Lab," will be held in Wilmot 504, MW 6:15pm - 9:55pm. Its content complements OPT 261. It is required for Optics majors taking OPT 261; it is optional but highly recommended for others. There are several experiments. Labs will be held every two weeks.

Optics 261: Interference and Diffraction: Overview

1. Overview of models of light; Examples of diffraction (NVch.1)
2. Simple harmonic motion and addition of waves (Ch. 2) (NV2.1-2.4)
3. Propagating waves (Ch. 2) (NV2)
   Complex representation of waves:
   Plane waves: sign convention, propagation directions
   Spherical waves:
      Converging waves & diverging waves
      Paraxial approximation
4. Superposition of Waves (Ch. 7) (NV3-4)
   Addition of propagating waves: Introductory interferometry (Ch. 9.1-9.6)
   Two Beam Interference:
      Division of Wavefront Interferometers (Young's Experiment and variants)
      Division of Amplitude Interferometers (Michelson Interferometer)
   Multiple Beam Interference:
      Division of Amplitude Interferometers (Fabry-Perot interferometer) (NV2.4)
      Division of Wavefront Interferometers (Multiple coherent oscillators)
5. Diffraction theory: (Ch. 10) (NV6)
   Huygen's principle,
   Fresnel Formulation of Huygen's Principle,
   Rayleigh-Sommerfeld diffraction
   Paraxial Approximation:
      Fresnel diffraction:
      Fraunhofer diffraction:
6. Diffraction from Apertures (Ch. 10.2)
   Fraunhofer and Fresnel Diffraction from rectangular apertures,
   Fraunhofer diffraction from circular apertures,
   Fresnel diffraction from straight edges;
7. Fourier integrals, Dirac delta function, Fourier theorems (Ch. 11)
8. Wave model of lenses and imaging (NV7)

9. Far-field diffraction using a transform lens (NV6)
10. Coherent Optical Fourier Processor (Ch 13.2, Hand-out)
    Amplitude Impulse Response
    Coherent Transfer Function
11. Introduction to Holography (Ch. 13.3)
12. Incoherent Imaging (NV7)
    Intensity Impulse Response
    Resolution
    Incoherent Optical Transfer Function (Ch. 11.3.6)
13. (Time permitting:) Array Theorem (Ch. 11.3.4), Fresnel zones and zone plate

Miscellaneous Items

Course Philosophy: This class emphasizes engineering understanding and problem solving. I will stress the careful application of the material rather than rigorous derivations. My goal for you is to understand the material sufficiently that you can apply the models presented in your own words.

Much of the class involves applying wave models of light to optical systems. When applying these models and solving problems you should strive to

1. Visualize the optical configuration (use a clear figure),
2. Understand the problem to be solved (write a problem statement in your own words), write down your assumptions,
3. Write the general expressions governing the behavior of the system,
4. Substitute into the general expressions relationships specific to the coordinate system of the problem,
5. Simplify the expressions,
6. Check the answer against the problem statement. **Are the units correct?** Does the answer make sense?
   When struggling with a problem, write down what you know that is relevant to the problem. Or, simplify the problem and attempt to solve the simplified problem. DO NOT TRY TO RUSH TO THE "RIGHT" ANSWER. THE PROCESS IS AS IMPORTANT AS THE ANSWER.

Course Material: You will be responsible for material presented in lectures and in readings from Hecht.

Interactions: You are encouraged to study together. Giving another hints on homework problems is acceptable. Each student should write down his/her homework separately. All homework should be your own effort.

Academic Dishonesty: Copying another's work or allowing another to copy your work is plagiarism (falsely claiming someone else's work to be your own) and is forbidden. Any suspected infraction will be documented in an Academic Dishonesty Incident Report and sent to the College Board on Academic Dishonesty.

Graphing: Homework assignments will often ask for graphs/plots or sketches of a mathematical expression. A graph or a plot is figure that represents a mathematical expression with sufficient information and accuracy that additional *quantitative* information maybe measured directly off the figure. A sketch is a figure of a mathematical expression that represents the approximate shape and behavior of the expression.