Physics 47 — Optics

van Schooten—Fall 2017

Class Time: MWF 11:30 am – 12:35 pm
X-Hour: Tue 12:15 – 1:05 pm
Class: 102 Wilder | **Lab:** 209 Wilder

Instructor: Dr. Kipp van Schooten (kipp.j.van.schooten@dartmouth.edu)
Office Hrs: Mon/Tue 3–4 pm (and by appt.) in 002 Wilder

Teaching Assistant: Parth Sabharwal (parth.sabharwal.gr@dartmouth.edu)
Office Hrs: Tue 4–6 pm in 220 Wilder

Required Text: E. Hecht, *Optics*, 5th Edition

Overview

This course is mostly an introduction to classical optics, encompassing the theory of electromagnetic waves, optical systems, polarization, diffraction, interference, and Fourier transform methods. We will also discuss the consequences of the dual wave/particle nature of light, and how to treat light as if composed of rays (geometric optics) or waves (physical optics). Throughout the course we will touch on more advanced topics and discuss the underlying principles for several modern optical technologies and physical phenomena.

Course Objectives

By the end of the course, a student should be able to:

- Explain the basic properties of electromagnetic waves and how to represent them mathematically as complex-valued vector fields.
- Model the propagation of electromagnetic waves in free space and when they interact with bulk materials having different indices of refraction.
- Design and analyze simple optical systems composed of lenses, mirrors, prisms, and phase retarders, using the principles of geometric (ray) optics.
- Explain the principles of scalar diffraction theory and use approximation methods (Fresnel, Fraunhofer) for calculating the effects of diffraction on a propagating wave.
- Apply Fourier techniques to the analysis of propagating waves in time/frequency and space/spatial frequency domains.
- Analyze the properties and limitations of optical instruments such as interferometers, spectrometers, telescopes, microscopes, and lasers, using the above principles.

Course Outline

Below is a tentative course schedule, but you should refer to the Canvas website for up-to-date information throughout the term. Due to time constraints, we will not be covering every section of the chapters listed. The specific reading assignment for each lecture will be posted on Canvas as we progress through the material.

A few more words about class meetings: Essentially all of the information for the course is contained in the text readings, course notes, and supplemental materials that I will make available on the Canvas page. It would be a waste of our time for me to try to present all of that information to you again in class (I'm pretty sure you don't learn more if I talk faster). Our class meetings will focus on parts of the

Unit	Chapter	Topic
1	2,3	Electromagnetic Waves
2	3,4	Interaction with Matter
3	5,6	Ray Optics
4	7(,12)	Superposition of Waves
5	8	Polarization
6	9	Interference
7	10	Diffraction
8	11	Fourier Optics
9	13	Modern Optics

material that are particularly important, conceptually challenging, or have special significance to interesting applications/phenomena. *Therefore, reading the text before class is an essential part of your participation in this course.* Our class meetings will serve to clarify your understanding and help you make sense of the material. Much of the rest of the course assumes that you will keep up with the reading assignments posted on the calendar entries for each class meeting.

Assignments, Exams, and Grading

Pre-Class Reading Quizzes (5%)

I will randomly give short quizzes at the beginning of class based on the assigned reading. These in-class quizzes will be worth a few points each, and will count for no more than 5% of your grade. Start your reading by scanning over the comments posted on the Canvas calendar for every class meeting. I'll try to steer you toward what to focus on and also indicate topics I consider "bonus material" that will not appear on exams. The goal of the pre-reading is not for you to understand everything in the text before class! Your goal is to absorb enough information about to engage in class discussions about the tougher parts of the materials, which I will focus you on with concept questions. To help motivate you to do the assigned reading, I will frequently give a short quiz on the material. If you find yourself struggling to follow lecture or understand the in-class concept questions, allocate more time for the pre-reading assignments.

Homework (35%)

There will be a total of 8 homework assignments in this course. These will be posted on Wednesday night. They are due before class on the following Wednesday – submit to the TA's homework box. Late assignments will be assessed a penalty of 20% per day. Your lowest homework score will be dropped. The homework will consist of textbook problems, which are generally somewhat easier, plus some "additional problems" that are generally more challenging and target specific things I want to emphasize. Some of the homework problems will require use of a computer program to solve, see the Software page of the course website for some recommendations.

Labs (30%)

We will discuss the organization and requirements of the labs in greater detail during the first few weeks of the term. The exact organizational details are subject to change depending on the total number of students enrolled in the course. Lab manuals and assignments will be made available on the Canvas website well in advance of the lab. The subject of the labs are as follows:

Lab 1: Microwave Optics
Lab 2: Interferometry
Lab 3: Diffraction and Fourier Optics

Exams (30%)

There will be three exams, each focused on three of the 9 chapters covered. Because the material is highly interrelated, concepts covered earlier in the term may be needed on the second and third exams, but the exams will be focused on recent material and the third exam is not intended to be a "comprehensive" final in the usual sense.

Class Etiquette

Please silence all mobile phones and put them away during class – laptops too if not actively used for note-taking. During the parts of class when I am "lecturing" I encourage you to interrupt me if you have a question. If you find yourself confused by something in class, chances are that most of your classmates are too, so don't miss the opportunity to stop me and have a real discussion about the subject! If the question would take us too far afield, I may defer answering it until later (office hours), but do not hesitate to ask.

Library Resources

Some copies of Hecht are held on reserve in the Kresge library (see link in the Canvas left sidebar). For some parts of this class you may wish to look up information beyond the text. While some information can be found on the open web, unless you already know where to find high-quality sources, I recommend you start your search from the Library's Physics Research Guide. This research guide has the librarys key physics resources - including books, articles, and data - categorized and organized for easy use. The Kresge Physical Science Library website also has information on useful research tools and services.

Honor Code

This course is subject to Dartmouth's Honor Code, as described in the 2012 ORC. You may discuss concepts and help each other learn the course material, however, homework, lab notebooks, quizzes, and exams (anything with your name on it, submitted for a grade) must all be your own independent work. It is a violation of the Honor Principle to falsely claim credit for work you have not done yourself, in whole or in part, and under any circumstances.

Disabilities

Students with learning, physical, or psychiatric disabilities enrolled in this course that may need disability-related classroom accommodations are encouraged to make an office appointment to see me **before the end of the second week of the term**. All discussions will remain confidential, although the Student Accessibility Services office may be consulted to discuss appropriate implementation of any accommodation requested.

Religious Observances

Some students may wish to take part in religious observances that fall during this academic term. Should you have a religious observance that conflicts with your participation in the course, please meet with me **before the end of the second week of the term** to discuss appropriate accommodations.