

Syllabus for OPTI 6271/8271, Spring 2009

Advanced Physical Optics

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1 Schedule:

Grigg 133, M/W 2:00 P.M. - 3:15 P.M.

2 Office hours:

12:15 P.M. - 1:00 P.M. Monday and 11-12:15 P.M. Friday. Students may also contact the instructor for other times.

3 Course objectives:

This course is essentially in depth discussion of the wave properties of light, primarily interference, diffraction, and polarization. We will develop the theoretical tools needed to properly model electromagnetic wave propagation, and discuss the common experimental tools used to measure such phenomena.

4 Tentative topics:

1. Prehistory of physical optics (pre-Maxwell optics): 1 day
2. Foundations of geometrical optics: 1 day
3. Maxwell's equations and scalar waves: 2 days

4. Vector waves and polarization: 2 days
5. Reflection and refraction of a plane wave: 1 day
6. Stratified media and dielectric films: 1 day
7. Interference: division of wave-front, division of amplitude: 2 days
8. Interferometers: 2 days
9. Diffraction theory (Huygens principle and Kirchoff's diffraction theory): 1 day
10. Diffraction theory (Fraunhofer and Fresnel diffraction): 1 day
11. Diffraction theory (Rayleigh-Sommerfeld diffraction integrals): 1 day
12. Diffraction theory (Diffraction gratings and Talbot effect): 1 day
13. Diffraction theory (Angular spectrum representation): 1 day
14. Three-dimensional light distribution near focus: 1 day
15. Holography: 1 day
16. Diffraction theory of aberrations: 2 days
17. Optics of crystals: 2 days
18. Introduction to coherence theory: 2 days
19. More on polarization (Stokes parameters, Jones, Mueller matrices): 2 days
20. Introduction to scattering theory: 2 days

5 Lecture notes

Typed and written lecture notes will be provided for the students in class, provided they keep attending!

6 Tests, homework and grading:

Homework will be assigned roughly every other Monday, and due the following Monday. There will be a take-home midterm exam and a take-home final exam. The final grade will be split 40% homework, 30% midterm, 30% final exam.

7 Recommended texts:

7.1 M. Born and E. Wolf, *Principles of Optics* (Cambridge University Press, Cambridge, 1999, 7th edition)

Still the classic book on physical optics. More detail than any one person has ever needed on the subject; not the greatest book to use as a text, but an excellent reference (that is why it is only recommended, not required).

8 Other resources:

The following list is a collection of books which range from the elementary to the advanced which I have found useful.

8.1 Physical optics texts

The following books are other general references which describe physical optics phenomena.

8.1.1 E. Hecht, *Optics* (Addison-Wesley, Reading, MA, 1987) QC355.2 .H42

The most popular elementary text on optical phenomena.

8.1.2 F.A. Jenkins and H.E. White, *Fundamentals of Optics* (McGraw-Hill, New York, 1957) QC355.J4

Another old and classic text on physical and geometrical optics. Focuses much more on the geometric side.

8.1.3 A. Sommerfeld, Optics (Academic Press, New York, 1964)

Classic optics text by one of the masters. Read about diffraction and dispersion from one of the pioneers in the field. Contains many unique insights and fun observations. An interesting mix of physical optics and quantum optics.

8.1.4 G. Brooker, Modern Classical Optics (Oxford University Press, NY, 2003)

Modern book on physical optics effects. Has more of a ‘solve-it-yourself’ approach to teaching optics, but has some nice insights, plus some qualitative descriptions of modern optical devices (CD players, confocal microscopes).

8.2 Books on Fourier methods

Fourier methods form the mathematical basis of physical optics, and it is worthwhile to have a few books to consult on the subject.

8.2.1 J.F. James, A student’s guide to Fourier transforms : with applications in physics and engineering (Cambridge University Press, Cambridge, 2002, 2nd ed.) QC20.7.F67 J36 2002

A popular and readable introduction to the theory and uses of the Fourier transform.

8.2.2 I.N Sneddon, Fourier transforms (McGraw-Hill, New York, 1951) QA404 .S53 (also in Dover)

This text contains only a little of the theory of Fourier transforms but devotes much space to the application of them to specific problems.

8.2.3 R.J. Beerends, H. G. ter Morsche, J. C. van den Berg, E. M. van de Vrie, Fourier and Laplace transforms (Cambridge University Press, Cambridge, 2003) QA404 .F6513 2003

A recent, readable and thorough book on Fourier methods and related topics. Contains detailed discussions of interesting modern techniques such as Fast Fourier transforms, discrete transforms and z-transforms. I’m a little biased about this one because I know one of the authors, but it is a really nice book.

8.3 Books on wave propagation

- 8.3.1 C.H. Papas, Theory of electromagnetic wave propagation (McGraw-Hill, New York, 1965) QC670 .P3 (also in Dover)**

A nice little book on electromagnetic waves and radiation.

- 8.3.2 B.B. Baker and E.T. Copson, The Mathematical Theory of Huygens' Principle (Chelsea, NY, 1987) QC403 .B3 1987**

More than you ever wanted to know about the mathematics of diffraction theory. A bit tough to read due to the more mathematical notation.

8.4 Books on coherence

- 8.4.1 E. Wolf, Introduction to the Theory of Coherence and Polarization of Light (Cambridge University Press, Cambridge, 2007) QC476.C6 W65 2007**

This recent book is a good elementary introduction to coherence theory. I did most of the figures for the book, so you know it has to be good!

- 8.4.2 L. Mandel and E. Wolf, Optical Coherence and Quantum Optics (Cambridge University Press, Cambridge, 1995) QC403 .M34 1995**

Principles of Optics has a nice chapter on coherence, but if that isn't enough, this book has more.

9 Test schedule and other dates of note:

The two take-home tests will be scheduled as follows:

1. March 16th–23rd (Monday to Monday)
2. FINAL: April 27th – May 4th (Monday to Monday)

There are several days in which there will be no class:

1. January 19th (MLK day)
2. March 9th & 11th (spring break)

10 Miscellaneous policies and comments

Students are free to discuss and collaborate on solutions to homework, but all work handed in must be the student's own; no copying or duplication of other student's answers will be accepted.

Extensions to the due date for homework will not in general be allowed, although exceptions may be made in special circumstances. Homework handed in past the due date will be given a 50% late penalty.

The exams are take-home, but must be worked on individually; they are a measure of the student's individual progress in the course. Students are not to discuss or work together with each other on the problems on the exam. *All university rules concerning academic integrity apply, along with the associated penalties.*