# OPTI 330
# Physical Optics II

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**OPTI330. Physical Optics II (3). Linear system theory, Fourier optics, Interference and diffraction, Image formation, Optical transfer function. P, OPTI 310.**

## 1 Course Objectives

(a) Become proficient in analyzing linear shift-invariant systems.

(b) Learn the Fourier transform and its properties.

(c) Understand discrete representation of continuous signals and Fourier transform.

(d) Learn to manipulate discrete signals on a computer.

(e) Understand diffraction and image formation using physical optics principles.

(f) Understand the principles of Fourier optics and sspatial image processing.

## 2 Textbook

Course notes will be provided for all the lectures, free of charge via the class D2L website. However, it is strongly recommended that the students purchase the following textbook:

- J.D. Gaskill, "Linear Systems, Fourier Transform, and Optics," John Wiley and Sons, 1978.

## 3 Course Website

The course's online component will be conducted via the University of Arizona's D2L software system. The D2L can by accessed by this link: www.d2l.arizona.edu

Log in using your UA NetID, and you will see a list of all classes that use D2L. All homework assignments, Matlab assignments, homework solutions, announcements, etc., will be made through D2L. All homeworks and Matlab assignments will be turned in on the dropboxes in D2L.

## 4 Homework Policy

There will be *weekly homework assignments* and the due date in *most* cases will be one week from the date of assignment. All homework assignments are to be turned in electronically through the D2L website. Assignments should be in a SINGLE PDF FILE NO MORE THAN A FEW MB IN SIZE. Assignments turned in using other formats, assignments turned in as multiple files, and assignments turned in that are large files WILL NOT BE GRADED. All homework assignments will have a due date and a late due date. There will be a *20% reduction* in the score for assignments turned in after the initial due date. No assignments will be accepted after the late due date. Students may drop their LOWEST homework assignment score.

## 5 Matlab Assignments

There will be approximately *biweekly assignments* due on Fridays that ask you to perform computer exercises. The assignments will be designed so that Matlab can be used. Matlab is available free to all UA Students and employees. If you would prefer to use another computational package, you should arrange that with the instructor. Late assignments will be accepted up to two days after the due date for a *20% reduction* in grade. Students may drop their LOWEST Matlab assignment score.

## 6 Examinations

There will be two 1-hour, in-class examinations on the following dates:

- To be announced (Lectures 1 - 10)
- To be announced (Lectures 11 - 20)

The final examination will be a cumulative 2-hour examination in the regular class location at the following time:

- To be announced

All examinations will be in the classroom. Examinations will be CLOSED BOOK, CLOSED NOTES, NO CALCULATORS. All equations, formulas, etc., that you might need will be provided by the instructor.

## 7 Grading

The final grade for the class will have following components:

(a) Homework: 20%
(b) Matlab Assignments: 10%
(c) Midterm Exams: 40%
(d) Final Exam: 30%

## 8 Academic Integrity

Integrity and ethical behavior are expected of every student in all academic work. This Academic Integrity principle stands for honesty in all class work, and ethical conduct in all labs and clinical assignments. This principle is furthered by the student Code of conduct and disciplinary procedures established by **ABOR Policies 5-308 through 5-404**, all provisions of which apply to all University of Arizona students. The Code of Academic Integrity is intended to fulfill the requirement imposed by **ABOR Policy 5-403.A.4** and otherwise to supplement the Student Code of Conduct as permitted by **ABOR Policy 5-308.C.1**.

For more details please see:
`http://deanofstudents.arizona.edu/codeofacademicintegrity`

You are expected and encouraged to consult with your colleagues in the preparation of your homework assignments. As I stated above, homework assignments are for the benefit of the student, so if you do not understand the homework you are the only one that will suffer. However, please do not insult your colleagues, the grader, or me by turning in directly copied homework. If you work with a colleague closely enough that your solutions might appear (legitimately) to be copied, then please disclose the collaboration on the top of the page. It is quite acceptable to consult references, other course notes, other faculty, senior graduate students, etc., in preparing your solutions. However, any consultation with an outside source that contributes significantly to the solution you turn in should be disclosed.

*Examinations are to be your own work and exclusively your own work.*

# Topics Covered

1. **Mathematical and Physical Background (1 Week)**
   (a) Huygen's principle
   (b) Complex numbers
   (c) Signals and Special functions
2. **Linear Systems Theory (2 Weeks)**
   (a) Linear Shift Invariant (LSI) Systems
   (b) Convolution and Correlation operators
3. **Fourier Transforms, Linear Systems, and Filtering (3 weeks)**
   (a) Fourier series
   (b) Fourier transform and its properties
   (c) Convolution theorem
   (d) Filters and signal processing
4. **Sampling and Discrete Signal Processing (3 weeks)**
   (a) Sampling theorem and reconstruction
   (b) Discrete Fourier Transform (DFT) and its properties
   (c) Interpolation, sub-sampling, and discrete filters
   (d) Discrete convolution
5. **Diffraction and Propagation (2 weeks)**
   (a) Wave propagation and coherence
   (b) Fresnel diffraction
   (c) Fraunhofer diffraction
   (d) Diffraction from lenses
6. **Diffraction Effects in Imaging Systems (3 weeks)**
   (a) Image formation
   (b) Fourier optics and frequency domain description
   (c) Coherence and resolution

## Class Schedule

| Week | Date | Topics Covered | Exams |
|---|---|---|---|
| Week 1 | January 16 | Introduction | **Class Assessment Quiz** |
| Week 2 | January 23 | Complex Numbers | |
| Week 3 | January 30 | Special Functions | |
| Week 4 | February 6 | Impulse Response Function | |
| | | Linear Shift Invariant Systems | |
| Week 5 | February 13 | Convolution and Correlation | |
| | | Properties of Convolution and Correlation | |
| | | Fourier Series | |
| Week 6 | February 20 | Fourier Transform | **Mid-term 2** |
| | | Convolution Theorem | |
| | | Special Properties of Fourier Transform | |
| Week 7 | February 27 | Two-dimensional Functions | |
| | | Two-dimensional Convolution | |
| | | Two-dimensional Fourier Transform | |
| Week 8 | March 5 | Filtering | |
| | | Sampling | |
| Week 9 | March 12 | **Spring Break** | |
| Week 10 | March 19 | Discrete Fourier Transform (DFT) | |
| | | Interpolation/Downsampling | |
| | | Discrete Convolution | |
| Week 11 | March 26 | Wave equation solutions | |
| | | Coherence and Interference | **Mid-term 2** |
| Week 12 | April 2 | Fresnel and Fraunhofer Diffraction | |
| Week 13 | April 9 | Imaging Systems | |
| Week 14 | April 16 | Point Spread Function (PSF) | |
| | | Modulation Transfer Function (MTF) | |
| Week 15 | April 23 | Coherent and Incoherent Imaging Systems | |
| | | Aberrations in Imaging Systems | |
| Week 16 | April 30 | Applications and Review | **Final Exam** |