OPTI/ECE 527 (Fall 2024)
Diffractive Optics and Holographic Principles

Instructor: Yuzuru Takashima, Ph.D., Professor
Class Hours: Tu/Th 11:00-12:15; **Room:** OSC 305
Office: Meinel 627 and GCRB 244
Office Hours: Tu/Th 12:15-1:00pm
Phone: 626-6992
e-mail: ytakashima@optics.arizona.edu

Web Page: D2L

Grading:

HWKs:	40%
Mid Term Exam:	30% (Mid October)
Final Exam/Project:	30% (Tuesday Dec. 17 10:30am - 12:30pm) No substitution day planned.

100%-89%: A | 88%-75%: B | 74%-60%: C |59%-49%: D | 48%-0%: E
Note: this grading scale based on college's general grading guideline

Objective: Prepare students for advanced research in academia and in industry by understanding basics, and cultivating ability to read classic and modern literatures in optics and photonics.

The class overviews and discusses theory and analysis of light matter interaction including holography, diffractive optics, and spatial light modulators.

Analysis frameworks such as Fourier optics, approximated coupled wave analysis, and rigorous coupled wave analysis are introduced.

For holography we overview basic principles, recording and reconstruction process, spatial frequency analysis, Fourier analysis of gratings, image analysis of holograms, requirements for holographic recording, recording materials, computer generated holograms, digital holography and applications.

Since this is an advanced graduate class to prepare students for advanced research in academia and in industry by understanding basics in holography, optics and photonics, it is critical that students read through the textbook (#1). Reference textbook (#2), and papers distributed in class are critical resources. Also, it is critical to follow each of the derivation steps presented in class by self. Evolution of equations and logic behind the derivation described in class by instructor needs to be understood.

Text Books: Available on line
Note: *The book by Goodman is highly recommended and the new book by Toal also provides a good overview.*

Required
1. R. K. Kostuk, "Holography: Principles and Applications," CRC Press, 2020. Available online.
2. J. W. Goodman, "Introduction to Fourier Optics, 3rd ed." McGraw Hill, 2005. Available online.

Required Software:

Rsoft (available online)
https://wp.optics.arizona.edu/helpdesk/osc-site-licensed-software/

CodeV/Zemax
https://wp.optics.arizona.edu/helpdesk/osc-site-licensed-software/
https://wp.optics.arizona.edu/helpdesk/osc-site-licensed-software/other-links/
Password OSCstudent

U of A VPN Client:
Using the software off-site from home requires VPN connections.
Information: https://it.arizona.edu/service/ua-virtual-private-network-vpn
Download: http://softwarelicense.arizona.edu/cisco-anyconnect-vpn-client

Lecture Content:

1. Basic concepts
    a. Differences between holographic and intensity imaging
    b. Holographic recording and reconstruction process
    c. Normal and conjugate reconstruction
    d. Grating equation

2. Basic Holographic Recording Process
    a. Construction, exposure, and reconstruction- real and virtual image
    b. Relation between basic holographic processes and the response of photographic film
    c. Enhanced scattering from a periodic structure – grating equation, grating period
    d. Example – interference of two plane waves using propagation vectors
    e. Grating vector – calculation from propagation vectors –examples

3. Analysis of Holographic Recordings – spatial frequency analysis
    a. In-Line, Gabor type hologram – analytical equations
    b. Analysis of zone plate –basic concepts of focus, phase matching at different locations on the aperture.
    c. Off-axis hologram

4. Fourier Analysis of gratings
    a. Review of Rayleigh Sommerfeld far-field diffraction formulas
    b. Diffraction patterns from rectangular and circular apertures
    c. Fourier analysis of periodic absorption and phase grating apertures
    d. Fourier analysis of off-axis gratings
    e. Different types of holograms characterized by Fourier properties.

5. Image analysis of holograms
    a. K-space diagram
    b. Exact ray tracing
    c. Aberrations of holographic lenses –basic aberration characteristics
    d. Monochromatic aberrations.
    e. Modeling holographic optical elements

6. Coupled wave analysis
    a. Kogelnik's approximate coupled wave analysis

b. Basic description of other types of approximate models – Born approximation
c. Basic description of diffraction efficiency modeling
    i. Transmission holograms
    ii. Reflection holograms
    iii. DE of TE and TM polarization
d. Criteria for thin and thick holograms
e. Wavelength and angular selectivity of volume holograms

7. Rigorous Coupled Wave Analysis
    a. Theory
    b. Software practice, Rsoft

8. Computer generated holograms
    a. Beam steering by CGH
    b. Spatial Light Modulators

Grading policy:
All problem sets and design projects are to be turned in to D2L on the date due (by 11:59 pm). Late homework will be marked off by 50%. No late turn in is allowed after 1 week of the due date. All homework, exams, design projects, etc., must include your **name, and course number (OPTI 527) as header, and page number at bottom, deliverables without that information is -5pt deduction of grading**. Must be done on one side of an 8½ x 11 sheets of paper. Scan and uploaded in a single PDF format. Figures and answers, if handwritten, must be readable. Submission in a form of separate pictures, such as jpeg, bmp format will not be graded.

No re-grading after one week from the day the solution is posted (i.e., solution posted on Monday, students need to complete regrading by following Sunday). We consider late turn in of assignments to accommodate students' academic and health needs, such as attending academic conference, and sick, provided that students obtained ***a prior permission, at least one day before the due date*** from the instructor, the instructor keep a right to make a final decision. No same day request is granted.

For deepening the understanding of the material (text and paper), homework mainly covers essential aspects in conjunction with the papers, and the most critical concepts only. Therefore, we expect students to spend substantial amount of the time understand the class "contents" not just memorizing homework, past exams, and such. The exam covers not only homework but all the contents discussed in class.

Students are expected to study materials (textbooks, reference papers) along with actively participating in the discussions in class. I encourage students to ask questions during/after the class.

Recorded lectures:
Lectures will be given in class, pre-recording, and live broadcasting.

Recorded lectures are only provided to distant students, and for a review purpose only for on campus students who attended the corresponding class in person. Those who could not attend the class due to health, family, and academic needs, with permission from the instructor, access to the recorded lecture is granted.

Note that this class adopts the grating scale as described. Instructor reserves the right to apply own grading scale over the general definition adopted by the college.

Accessibility and Accommodations:
It is the University's goal that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, please let me know immediately so that we can discuss options. You are also welcome to contact Disability Resources (520-621-3268) to establish reasonable accommodation.
Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.