SYLLABUS
OPTI 574 Augmented Reality Display Waveguide Design
Offered Fully Online

Description of Course

This course will introduce the basics of designing waveguides for augmented reality (AR) displays. Course topics will include an overview of widely-used architectures for stereoscopic AR displays, a review of the basic physics (such as the definitions of photometric units) necessary to design them, an introduction to their basic performance metrics, an introduction to the Rigorous Coupled Wave Analysis algorithm used to compute diffraction grating efficiency, an introduction to the 3 basic steps in waveguide design (k-space layout, spatial layout, grating optimization) and how to perform these steps to design both surface-relief-grating-based and geometric-reflective- based waveguides. Homework assignments will be done using FRED, a commercially available optical design tool. This course will also discuss waveguide fabrication techniques (such as photolithographic etching) and the test equipment used to measure waveguide performance. The final project will be to design a high-performance waveguide for an industrial or commercial application. Commercially available AR headsets will be demonstrated in class.

Course Prerequisites or Co-requisites

Some experience with geometrical optics, interference and diffraction is useful for the class. Suggested enrollment requirements include OPTI 505R, and either OPTI 503 or OPTI 512R.

Instructor and Contact Information

Eric Fest
eric@phobosoptics.com
(520) 820-1687
No set office hours, but I am happy to meet with students. Contact the instructor to arrange for 1:1 meetings.

TA: None

Course home page: TBD

D2L information: TBD

Course Format and Teaching Methods

Live online lecture only

Course Objectives

The objective of this course is to familiarize the student with the design and fabrication of waveguides for Augmented Reality (AR) displays, as well as many of the issues related to the complete AR display system, including the characteristics of micro-LED and Liquid Crystal on Silicon (LCoS) display engines, and prediction of the luminance and color uniformity of the display system. The course provides hands-on experience with the FRED software package and various algorithms for analyzing and optimizing AR waveguides. For the final assignment each student will decide on a use-case for an AR display (e.g. navigation) and design a waveguide that enables the use case. This provides essential skills for optical engineers entering the workforce.

Expected Learning Outcomes

At the conclusion of this class, the student will be able to

- Describe the history of AR systems and understand the modern forms of these devices and their inherent tradeoffs related to size, weight, cost, and complexity.
- Understand the image quality requirements for AR systems including image luminance, color uniformity, and MTF.
- Understand the two basic types of AR display engines, uLED and LCoS.
- Understand the 3 basic steps in AR waveguide design
- Understand the techniques used to model diffraction gratings in FRED.
- Understand how to optimize Surface-Relief and Geometric Reflective waveguides to maximize AR display performance.
- Understand the basics of fabricating waveguides.
- Understand the most significant stray light problems in AR waveguides and how to mitigate them.

Course Communications

Online communication will be using the official UA e-mail address through D2L

Required Texts or Readings

There are no required text materials for this class.

Required or Special Materials

Access to FRED software (site licensed to the College) for assignments and classwork.

Assignments and Examinations: Schedule/Due Dates

Homework is assigned approximately once a week for a total of 11 assignments. Late homework assignments lose 10% per day late. Dates for the assignments are TBD.

Final Project

For the final assignment each student will decide on a use-case for an AR display (e.g. navigation) and design a waveguide that enables the use-case.

Grading Scale and Policies

The grading scale is curved and final grades will be dependent upon the performance of all of the students enrolled in the class.

Assignment Categories	Percentage of Final Grade
Homework assignments	70%
Final Project	30%
Total	100%

If the course is a 400/500:

OPTI 574 is solely a graduate class.

Incomplete (I) or Withdrawal (W):

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at
http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete
and
http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal
respectively.

Dispute of Grade Policy

Students should provide a justified description of their disputed grades within one week of its return.

Scheduled Topics/Activities

SECTION 1

Basic course info. FRED license info.
In class demos
Intro to AR/VR, terminology, VAC, TIR, grating equation

SECTION 2
Photometry, CIE coordinates, polarization
Geometric optics, Gaussian reduction.

SECTION 3
Display projectors, AR display metrics: luminance, uniformity, color

SECTION 4
AR waveguide design process overview, SRG design

SECTION 5
Intro to FRED.

SECTION 6
SRG grating efficiency, quick intro to RCWA
The RCWA algorithm, slanted gratings

SECTION 7
SRG fabrication
Setting up a 1D beam expander in FRED

SECTION 8
Setting up a 2D beam expander in FRED
Full system analysis with SRG waveguides

SECTION 9
Intro to GRWG waveguides and their k-space
Spatial layout of GRWGs in FRED

SECTION 10
Design of coatings for GRWGs
Fabrication of GRWGs, GRWG vs. SRG

SECTION 11
Waveguide MTF analysis
Stray light problems in SRGs and GRWGs

SECTION 12
Waveguide tolerancing
Algorithmic improvement of image quality

SECTION 13
Test equipment
Waveguide design in other tools: VirtualLab, LightTools, Zemax

SECTION 14
In class Q & A to resolve any problems in using FRED
Final project discussion

SECTION 15
Other AR display architectures, final project Q&A
Course summary

Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Additional Resources for Students

UA Academic policies and procedures are available at
http://catalog.arizona.edu/policies

Campus Health
http://www.health.arizona.edu/
Campus Health provides quality medical and mental health care services through virtual and in-person care.
Phone: 520-621-9202

Counseling and Psych Services (CAPS)
https://health.arizona.edu/counseling-psych-services
CAPS provides mental health care, including short-term counseling services.
Phone: 520-621-3334

The Dean of Students Office's Student Assistance Program
http://deanofstudents.arizona.edu/student-assistance/students/student-assistance
Student Assistance helps students manage crises, life traumas, and other barriers that impede success. The staff addresses the needs of students who experience issues related to social adjustment, academic challenges, psychological health, physical health, victimization, and relationship issues, through a variety of interventions, referrals, and follow up services.
Email: DOS-deanofstudents@email.arizona.edu
Phone: 520-621-7057

Survivor Advocacy Program

https://survivoradvocacy.arizona.edu/
The Survivor Advocacy Program provides confidential support and advocacy services to student survivors of sexual and gender-based violence. The Program can also advise students about relevant non-UA resources available within the local community for support.
Email: survivoradvocacy@email.arizona.edu
Phone: 520-621-5767

Confidentiality of Student Records

http://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa?topic=ferpa

University-wide Policies link

Links to the following UA policies are provided here, https://academicaffairs.arizona.edu/syllabus-policies:

- Absence and Class Participation Policies
- Threatening Behavior Policy
- Accessibility and Accommodations Policy
- Code of Academic Integrity
- Nondiscrimination and Anti-Harassment Policy
- Subject to Change Statement