# SYLLABUS

## OPTI 574 Physical Optics Modeling

### Description of Course

This course examines the use of physical optics modeling software to analyze systems not well modelled by exact raytracing code. Specifically, the course will focus on modern AR/VR headsets which combine waveguides, gratings, and holograms to introduce images into the eye. Physical optics modeling software, VirtualLab Fusion, will be used to analyze these more complex systems to provide the student a background in both this class of software, as well as AR/VR systems.

### Course Prerequisites or Co-requisites

Some experience with geometrical optics, interference and diffraction is useful for the class.

### Instructor and Contact Information

Eric Fest
Facebook Reality Labs
ecfest@arizona.edu
No set office hours, but I am happy to meet with students. Contact the instructor to arrange for 1:1 meetings.

Jim Schwiegerling
Meinel 725
jschwieg@u.arizona.edu
(520) 621-8688
No set office hours, but I am happy to meet with students. Contact the instructor to arrange for 1:1 meetings.

TA: Rae Smith, raivensmith@arizona.edu

D2L information: https://d2l.arizona.edu/d2l/home/1184813

### Course Format and Teaching Methods

Live online lecture only

### Course Objectives

The objective of this course is to familiarize the student with physical optics modeling software and its application to modern optical systems that incorporate elements such as waveguides, gratings and holograms. The course provides hands-on experience with one such physical optics modeling software package and explores the various algorithms for propagating light through diffractive optical elements. The final objective of this course is to apply the modeling techniques to real world problems in Augmented and Virtual Reality (AR/VR) headsets. 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

- model complex optical elements and systems in a physical optics modeling program.
- understand the different algorithms for propagating light from conventional raytracing to rigorous solution of Maxwell's equations, as well as when to use these algorithms and what the tradeoffs of the various algorithms are in regards to accuracy and speed.
- describe the history of AR/VR systems and understanding the modern forms of these devices and their inherent tradeoffs related to size, weight, cost, and complexity.
- understand the image quality requirements for AR/VR systems including image clarity, luminance, color fidelity, and contrast.
- fully model an AR/VR systems in a commercial physical optics modeling software program.

## Course Communications

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

## Required Texts or Readings

There are no required texts materials for this class.

## Required or Special Materials

Access to VirtualLab Fusion software (site licensed to the College) for assignments and classwork. Access to Matlab or equivalent.

## Assignments and Examinations: Schedule/Due Dates

There are approximately 5-7 homework assignments and one midterm for the class. Late homework assignments lose 10% per day late. Dates for the assignments and test are TBD.

## Final Project

The final project for this class is to apply the modelling skills learned in the class to a real-world system and performance an analysis of this system to understand its display capabilities, limitations and tradeoffs.

## Grading Scale and Policies

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

| **Assessment Categories** | **Percentage of final grade** |
|---|---|
| Homework assignments | 50% |
| Final Project | 50% |
| Total | 100% |
| | |

## If the course is a 400/500:

OPTI 574 is solely a graduate 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. VirtualLab license info. History of AR/VR, AR/VR architectures, terminology.

SECTION 2

Prerequisite material: TIR, gratings, photometry, CIE coordinates, MTF, coherence

SECTION 3

Overview of projector optics.

SECTION 4

AR display metrics: luminance, uniformity, color, pupil swim

See-through quality metrics: transmittance, unwanted diffraction, haze

SECTION 5

Intro to VirtualLab

AR waveguide design process overview

SECTION 6

Intro to SRG waveguides. k-space design part I

k-space design part II, k-space in VirtualLab.

SRG waveguide spatial layout, spatial layout in VirtualLab.

SECTION 7

The RCWA algorithm

SECTION 8

Component-level design of SRGs.

SRG waveguide design part I

SRG waveguide design part II, VirtualLab demo.

SRG waveguide fabrication and metrology.

SECTION 9

Intro to VBG waveguides, k-space design.

VBG waveguide spatial layout.

SECTION 10

The Kogelnik algorithm

SECTION 11

VBG waveguide design, VirtualLab demo.

VBG exposure systems and metrology.

SECTION 12

Waveguide MTF analysis.

Waveguide tolerancing.

SECTION 13

System level test equipment: luminance, contrast, MTF, color.

Uniformity compensation algorithms.

SECTION 14

Full AR system considerations: power, heat dissipation, weight, survivability

Final project discussion

SECTION 15

AR headset demo day.

Misc. topics

## Classroom Behavior Policy

### Recommended language:

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 recommendations depending on instructor preferences:

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

### Alternate language for those who want to restrict computers and laptops to an area of the classroom:

Some learning styles are best served by using personal electronics, such as laptops and iPads. These devices can be distracting to other learners. Therefore, students who prefer to use electronic devices for note-taking during lecture should use one side of the classroom.

## Alternate recommended language for those who do not wish to permit laptops in the classroom:

The use of personal electronics such as laptops, iPads, and other such mobile devices is distracting to the other students and the instructor. Their use can degrade the learning environment. Therefore, students are not permitted to use these devices during the class period.

## Notification of Objectionable Materials

Recommended language, if applicable: This course will contain material of a mature nature, which may include explicit language, depictions of nudity, sexual situations, and/or violence. The instructor will provide advance notice when such materials will be used. Students are not automatically excused from interacting with such materials, but they are encouraged to speak with the instructor to voice concerns and to provide feedback.

## 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