Instructor: Prof. Meredith Kupinski
Office: Meinel 727
Email: meredith@optics.arizona.edu
Lecture: Monday & Wednesday
12:30 -1:45 PM, Meinel 305
Course Website: d2l.arizona.edu
Office Hours: Wednesdays 2:00 PM, in-person
Zoom:
https://arizona.zoom.us/meeting/register/tIZS2K6IT5q4qlsD66brAQ

Teaching Assistant (TA): Chuan Luo
TA Email: chuanluo@arizona.edu
TA Office Hours: Monday, 2:30 PM
In-person, Meinel 654
Zoom:https://arizona.zoom.us/j/81561138355
TA support also available by appointment

Course Description

Welcome! This course begins with a quantitative description of coherent polarization states and linear light-matter interactions using Jones calculus. Polarization properties and common polarization elements are identified using a physical interpretation of Jones matrix eigenanalysis. A polarization ray tracing formalism is introduced as an extension of conventional 2D Jones calculus into global 3D coordinates. A special case of a unitary operator is used to track the transverse plane rotations through refraction and reflection at interfaces of an optical system. Geometric optics principles of wavefront aberrations are generalized to a Jones pupil and a polarization-dependent point spread function. Polarization aberrations from geometric effects, such as those found in corner cube retroreflectors, are differentiated from Fresnel aberrations. In a final project, students perform a polarization ray trace of multi-surface optical designs to quantify polarization aberrations. In a final report, students discuss the engineering trade-offs of common mitigation strategies.

Pre-requisites

OPTI 502. Students are encouraged to concurrently enroll in OPTI 586L.

Learning Outcomes

- **Develop** original code to compute polarization effects when light propagates through optical systems and interpret the resulting aberrations.
- **Explain** the operation of polarization elements, e.g. polarizers and retarders.
- **Write** descriptions of sources of polarimetric aberrations and mitigation strategies.
- Given an optical design, **assess** the system's polarization aberrations, **create** visual data representations, and **report** the sources and physical phenomena which create these aberrations.

Attendance and Participation

Attendance at lectures and discussion sections is expected. Absences may affect the final course grade. Please contact the instructor as soon as possible if you anticipate or experience an absence.

Academic Integrity

Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog: https://deanofstudents.arizona.edu/policies/code-academic-integrity

Schedule

Lectures	Topics	Assessment
1/14	Course Introduction and Overview	Prior Knowledge Assessment Due (1/14)
1/19 1/21	No Class - Martin Luther King Jr. Day Polarization Ellipse	
1/26 1/28	Jones Vectors Jones Matrices	HW 1 Due (1/26)
2/2 2/4	Diattenuation & Retardance Fresnel Equations Dielectrics	HW 2 Due (2/2)
2/9 2/11	Fresnel Equations Metals Thin Films	HW 3 Due (2/9)
2/16 2/18	Polarization Ray Trace (PRT) Calculus PRT Interferometer Example	HW 4 Due (2/16)
2/23 2/25	Guest Lecture: Prof. Chipman Guest Lecture: Prof. Chipman	HW 5 Due (2/23)
3/2 3/4	Optical Ray Tracing I Optical Ray Tracing II	
3/9 3/11	No Class - Spring Break No Class - Spring Break	
3/16 3/18	Dipole and Double Pole Coordinates I Dipole and Double Pole Coordinates II	Midterm Project Due (3/16)
3/23 3/25	Fresnel Aberrations Jones Pupil Definition and Visualization	HW 6 Due (3/23)
3/30 4/1	Paraxial Polarization Aberrations I Paraxial Polarization Aberrations II	HW 7 Due (3/30)
4/6 4/8	Image Formation with Polarization Aberrations Amplitude Response and Mueller Point Spread Matrix	HW 8 Due (4/6)
4/13 4/15	Pauli Spin Matrix Jones Decomposition Q Matrix Definition and Application	HW 9 Due (4/13)
4/20 4/22	Non-polarization Aberrations Mitigation Strategies	HW 10 Due (4/20)
4/27 4/29	Guest Lecture: Prof. Anche Guest Lecture: Prof. Anche	
5/4 5/6	Course Review I Course Review II	
	FINAL PROJECT DUE 5/11	

Course Assessments

D2L is used for posting problem sets and solutions and for homework submission. Homework is typically assigned once per week on Monday and is due the following Monday at 11:59 PM (MST). Due dates are the same for in-person and distance students. **Please put the problem number and your name on every page to facilitate grading. Only D2L homework submissions will be accepted.**

Grading

Item	Grade Percentage
Participation	10%
10 Homeworks	25%
Midterm Project	25%
Final Project	40%

Late Policy

To publish solutions within one week of the due date, the following late policy applies:

- Within 24 hours of due date: (-10%)
- Within 1 week of due date: (-20%)
- More than 1 week late: (-50%)

All students receive a one-time late-submission grace period of one week without grade reduction. Submissions more than one week late may receive a maximum score of 50%.

Required Resources

Software

Assignments require writing original code for polarization ray tracing. Students may use a programming language of their choice.

Textbook

Polarized Light and Optical Systems, 1st Edition
Russell A. Chipman, Wai Sze Tiffany Lam, Garam Young
ISBN: 9781498700566
Available at the UA Bookstore and electronically through the UA Library.

Selected Textbook Chapters and Chronology

Chapter 2 & 5

Jones Vector. Elliptical representations of polarization states. Jones Matrix. Eigenanalysis. Retardance, diattenuation, and eigenpolarizations.

Chapter 8

Fresnel equations. Retardance for total internal reflection. Critical angle. Brewster's angle. Jones matrix of reflection and refraction. Complex index.

Chapter 13

Thin films. Single and multilayer films. Contributions to wavefront aberration.

Chapter 9

Polarization ray trace calculus. Local and global coordinates. Unitary transformations. Polarization ray tracing matrix.

Chapter 10

Optical ray tracing. Numerical aperture, Lagrange invariant, and Ã©tendue. Wavefront aberration and polarization aberration function.

Chapter 11

Jones pupil and local coordinate systems. Entrance and exit pupils. Dipole and double-pole coordinates. High numerical aperture wavefronts.

Chapter 12

Fresnel aberrations. Fold mirrors. Telescopes.

Chapter 14

Jones representations with Pauli spin matrices.

Chapter 15

Paraxial polarization aberrations. Polarization piston, tilt, and defocus.

Chapter 16

Image formation with polarization aberration. Jones entrance and exit pupil functions. Amplitude response matrix. Mueller point spread matrix.

Chapters 17 & 18

Non-polarization aberration. Parallel transport. Skew aberration.

Subject to Change Statement

Information contained in this syllabus, other than the grade and absence policy, may be subject to change with advance notice as deemed appropriate by the instructor.

Accessibility and Accommodations

At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, https://drc.arizona.edu) to establish reasonable accommodations.