

Polarization in Optical Design, OPTI 586, Fall 2023

Course contents: Polarized Light and Polarization Elements. Geometrical Optics and Optical Design. Polarization Ray Tracing. Polarization Effects at Reflecting and Refracting Interfaces. Polarization Aberrations and Mitigation. Realistic Polarization Models. Common Polarization Elements.

Pre-requisites: OPTI 502, students are encouraged to concurrently enroll in OPTI 586L

Learning Outcomes:

- 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.
- Describe sources of polarimetric aberrations and mitigation strategies.
- Given an optical design assess the system's polarization aberrations and report the sources and physical phenomena which create these aberrations.

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Class Hours: Tuesday & Thursday 2:00 – 3:15 pm in Meinel 307

Office Hour: Monday 12:00 pm on zoom (see D2L course page)

Teaching Assistant: Quinn Jarecki, qjarecki@email.arizona.edu

TA Office Hours: In person and on zoom, TBD based on polling for maximum availability:

<https://strawpoll.com/BJnX8RN3xnv>

D2L Web Site: is set up for posting problem sets and solutions, and submitting homework. Homework is assigned about once per week on a Monday and due the following Monday at 11:59 PM-MST. Due dates are the same for in-person and distance students. Assignments are submitted through D2L. In order to publish solutions within a week of the due date, the late policy is as follows:

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

i.e. the *maximum* score attainable for submissions more than one week late is 50%. All students will receive a one-time late submission grace period of one week without any grade reduction. On time homework will be graded and returned within a week of submission, late assignments will be graded within 2 weeks of submission.

Please put the problem number and your name on every page to facilitate grading. Only D2L homework submissions will be accepted.

Required Textbook: Polarized Light and Optical Systems, 1st Edition,

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Russell A. Chipman, Wai Sze Tiffany Lam, Garam Young

Available at the UA bookstore ISBN 9781498700566

UA library (electronic version)

https://arizona-primo.hosted.exlibrisgroup.com/permalink/f/6ljalh/01UA_ALMA51596646030003843

Required Software: None, assignments will require writing original code for polarization ray tracing. These assignments can be written in a programming language of the students' choice.

Grading:

Due on 11:59 PM-MST of dates listed below

- | | | |
|-------------------------------|-----|---|
| • Eleven Homework Assignments | 50% | Mondays:
Aug 28
Sept 4, 11, 18, 25
Oct 2, 9, 30
Nov 6, 13, 20 |
| • Take home midterm project | 25% | Oct 23 |
| • Final Report | 25% | Dec 4 |

Course Outline:

Chapter 2 & 5

- **Jones Vector.** Elliptical representations of polarization states.
- **Jones Matrix.** 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 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 Etendue. Wavefront Aberration and Polarization Aberration Function. Wavefront Analysis.

Chapter 11

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- **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 13

- **Thin Films.** Single and Multilayer. Contributions to wavefront aberration.

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.

Chapter 17 & 18

- **Non-Polarization Aberration.** Parallel Transport. Skew Abberation.

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.

Absence and Class Participation Policy

The UA's policies concerning Class Attendance, Participation, and Administrative Drops is available at: <http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop>

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated, <http://policy.arizona.edu/human-resources/religious-accommodation-policy>.

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: <https://deanofstudents.arizona.edu/absences>

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Absences may affect a student's final course grade. If you anticipate being absent, are unexpectedly absent, or are unable to participate in class online activities, please contact me as soon as possible. *To request a disability-related accommodation to this attendance policy, please contact the Disability Resource Center at (520) 621-3268 or drc-info@email.arizona.edu.* If you are experiencing unexpected barriers to your success in your courses, the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office is located in the Robert L. Nugent Building, room 100, or call 520-621-7057.

Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work must be the product of independent effort unless otherwise

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instructed. 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>. The UA Libraries have some excellent tips for avoiding plagiarism, available at: <http://new.library.arizona.edu/research/citing/plagiarism>. Sharing class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

Students with a Learning Disability

If a student is registered with the Disability Resource Center, he/she must submit appropriate documentation to the instructor if he/she is requesting reasonable accommodations. (<http://drc.arizona.edu/instructor/syllabus-statement.shtml>).

Nondiscrimination and Anti-harassment Policy

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others. The UA is committed to creating and maintaining an environment free of discrimination; see <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>

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.).

Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See <http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>.

Subject to Change Statement

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