SYLLABUS

ECE / OPTI 202R Geometrical and Instrumentational Optics II

Spring 2023
T/Th: 11:00 – 12:15 AM
HSIB 605 / 625

Description of Course
This course will provide the student with a fundamental understanding of optical system design and instrumentation. The course builds upon the foundations of geometrical optics that were presented in OPTI-201R to discuss a variety of elementary optical systems. Other topics include chromatic effects, camera systems and illumination optics. A special emphasis is placed on the practical aspects of the design of optical systems.

Course Prerequisites or Co-requisites
OPTI 201R

Instructor and Contact Information
Prof. Travis W. Sawyer
Bioscience Research Laboratory 324
tsawyer9226@arizona.edu
Web information: The class information will be available through D2L

Course Format and Teaching Methods
Lecture only.

Course Objectives and Expected Learning Outcomes

Course objectives:
1. Provide students with a basic background in geometrical optics.
2. Apply first-order optics to understand and describe optical systems.
3. Provide students with a comprehensive understanding of optical system characteristics, and cover common optical systems.
4. Explore some topics in quantum information science.

Expected Learning Outcomes:
1. Specify the requirements of an optical system for your application including magnification, object-to-image distance, and focal length.
2. Diagram ray paths and do simple ray tracing.
3. Describe the performance limits imposed on optical systems by diffraction and the human eye.
4. Predict the imaging characteristics of multi-component systems.
5. Determine the required element diameters.
6. Apply the layout principles to a variety of optical instruments including telescopes, microscopes, magnifiers, field and relay lenses, zoom lenses, and afocal systems.
7. Adapt a known configuration to suit your application.
8. Understand the process of the design and layout of an optical system.
Absence and Class Participation Policy

The UA’s policy concerning Class Attendance, Participation, and Administrative Drops is available at: [http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop](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 where reasonable, [http://policy.arizona.edu/human-resources/religious-accommodation-policy](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](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. Students who miss class due to illness or emergency are required to bring documentation from their health-care provider or other relevant, professional third parties. Failure to submit third-party documentation will result in unexcused absences.

It is expected that students will regularly attend class and be on time for class. If attendance drops to an unacceptable level, the instructor may implement live quizzes that will count as part of the homework grade. Any such quizzes will be given at the start of class and may not be made up, and will constitute up to 1/3 of the homework grade.

In Keeping with University policies: All holidays or special events observed by organized religions will be honored for those students who show affiliation with that particular religion. Absences preapproved by the UA Dean of Students (or Dean's designee) will be honored. Since there is no grade for attendance for this course, these policies would apply primarily to scheduled exams. The instructor must be notified at least two weeks prior to any such absence so that appropriate accommodations can be made.

Required Texts or Readings
Field Guide to Geometrical Optics      J. E. Greivenkamp 081945294-7

Note that this book is available as an e-book through the UA library as well as an app for Android (search “SPIE”). Class notes will be made available through the webpage. Alternative reading sources will be referred to throughout the class and made available in the reading room and Science Library.

Required or Special Materials
Students should have access to python and “Jupyter notebooks” and the capability to perform numerical calculations. Recommended to install anaconda: [https://www.anaconda.com/](https://www.anaconda.com/)

Assignments and Examinations: Schedule/Due Dates.

Homework: Homework will be assigned regularly throughout the semester with a total of 8 (plus an initial assignment), and it will be due at least one week later, usually 10 to 14 days. The purpose of the homework is for you to practice the techniques discussed in class or to reinforce this material. Completion of the homework is important to fully master this material. Collaboration and discussion of the homework is encouraged.

Homework will consist primarily of hand-worked problem sets, along with several programming questions to provide students an opportunity to build up their skillset in programming.

Homework will be turned in to D2L by 11:59 PM on the due date. Anything turned in after that time is considered late. Only electronic submissions are allowed. Approval for late homework must be obtained in advance from the instructor. Last-minute extensions will not be granted.
Late Homework Policy:
- Homework that is turned in after 11:59 PM on the due date is considered late.
- Late HW will receive a 10% penalty for every 24 hours it is late. Solutions will be posted 10 days after the homework is due.
- When issues arise, please contact the instructor as soon as possible so that appropriate accommodations can be made.

Homework due dates are posted on D2L. Midterm 1 is scheduled for Thursday March 2 and Midterm 2 is scheduled for Thursday April 6. There will be a review session prior to each midterm.

Final Examination
The date and time of the final exam or project, along with links to the Final Exam Regulations, https://www.registrar.arizona.edu/courses/final-examination-regulations-and-information, and Final Exam Schedule, http://www.registrar.arizona.edu/schedules finals.htm

Grading Scale and Policies
The final grade will be based on homework, two midterm exams, and a final exam.

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<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Homework</td>
<td>30%</td>
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<tr>
<td>Midterm exam</td>
<td>20%</td>
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<tr>
<td>Midterm exam</td>
<td>20%</td>
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<tr>
<td>Final exam</td>
<td>30%</td>
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<tr>
<td>Total</td>
<td>100%</td>
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Each homework will constitute 12% of the total homework grade, except for “homework 0” which will be 4% of the total homework grade (12*8+4 = 100).

The grade will be determined according to the cumulative percentage earned such that 90-100% = A, 80-89% = B, 70-79% = C, 60-69% = D, below 60% = E. A curve may be applied at the end of the semester depending on the distribution on final grades, but this is not a guarantee. The final distribution of grades should reflect the following assessment:

A: Excellent – has demonstrated a more than acceptable understanding of the material; exceptional performance; greatly exceeds expectations

B: Good – has demonstrated an acceptable understanding of the material; good performance; meets or exceeds expectations

C: Average – has demonstrated a barely acceptable understanding of the material; adequate performance; meets minimum expectations

D: Poor – has not demonstrated an acceptable understanding of the material; inadequate performance; does not meet expectations

E: Failure – little to no demonstrated understanding of the material; exceptionally weak performance

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.
Scheduled Topics/Activities

**Foundations of Geometric Optics**
1. Stops and pupils; marginal and chief rays; field of view; Lagrange invariant.
2. Determination of pupil location by Gaussian optics and raytracing; numerical aperture; f-number.
3. Vignetting; real ray traces; afocal systems
4. ABCD Matrices

**Elementary Optical Systems**
5. Simple magnifier; magnifying power.
6. Keplerian telescope; eye relief; field lenses; eyepieces; Galilean telescope; mirror systems.
7. Image erection and relay systems; microscopes.
8. Telecentric systems; imaging properties of afocal systems.
9. Eye
10. Camera Systems; depth of focus and field; image quality; photographic systems; viewfinders and focusing aids; autofocus systems; autocollimator; scanners.

**Optical Materials and Dispersion**
11. Materials; glass properties; Abbe number; other optical materials.
12. Dispersing prisms; minimum deviation; index measurement; thin prisms; combinations of thin prisms; achromatic prism; direct vision prism.
13. Chromatic effects; longitudinal chromatic aberration; thin lens achromat.

**Other Optical Systems**
14. Radiometric Transfer; AΩ product; camera equation.
15. Illumination systems; diffuse illumination; projection condenser system; Kohler illumination; critical illumination; slide projector.
16. Light Sources; integrating sphere and bars; practical considerations; dark field and Schlieren systems; overhead projector; Fresnel lenses; optical fabrication techniques; grinding and polishing; spherometer

**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](http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students).

**Accessibility and Accommodations**
At the University of Arizona we strive to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, you are welcome to let me know so that we can discuss options. You are also encouraged to contact Disability Resources (520-621-3268) to explore reasonable accommodation.

If our class meets at a campus location: 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.
Code of Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity.

Students enrolled in academic credit bearing courses are subject to this Code. Conduct prohibited by this Code consists of all forms of academic dishonesty, including, but not limited to:

1. Cheating, fabrication, facilitating academic dishonesty, and plagiarism as set out and defined in the Student Code of Conduct, ABOR Policy 5-308-E.10, and F.1
2. Submitting an item of academic work that has previously been submitted or simultaneously submitted without fair citation of the original work or authorization by the faculty member supervising the work.
3. Violating required disciplinary and professional ethics rules contained or referenced in the student handbooks (hardcopy or online) of undergraduate or graduate programs, or professional colleges.
4. Violating discipline specific health, safety or ethical requirements to gain any unfair advantage in lab(s) or clinical assignments.
5. Failing to observe rules of academic integrity established by a faculty member for a particular course.
6. Attempting to commit an act prohibited by this Code. Any attempt to commit an act prohibited by these rules shall be subject to sanctions to the same extent as completed acts.
7. Assisting or attempting to assist another to violate this Code.

The University Libraries have some excellent tips for avoiding plagiarism, available at http://new.library.arizona.edu/research/citing/plagiarism.

Selling 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.

UA Nondiscrimination and Anti-harassment Policy

The University is committed to creating and maintaining an environment free of discrimination; see http://policy.arizona.edu/human-resources/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.

Additional Resources for Students

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

Student Assistance and Advocacy information is available at http://deanofstudents.arizona.edu/student-assistance/students/student-assistance.

Confidentiality of Student Records


rev. 1/10/2023
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.

References and Other Resources

Optics of the Human Eye
Optical Instrumentation
Field Guide to Lens Design
Radiometry and the Detection of Optical Radiation
Geometrical and Trigonometric Optics
Modern Geometrical Optics
Seeing the Light
Optical System Design
Camera Technology - The Dark Side of the Lens
Field Guide to Radiometry
Optics
Schaum’s Outline of Theory and Problems in Optics
Building Electro-Optical Systems
Fundamentals of Optics
Optics and Optical Instruments
Optical Systems Engineering
Introduction to Geometrical Optics
Fundamental Optical Design
History of the Telescope
Optical System Design
History of the Photographic Lens
Lens Design Fundamentals
Optics in Photography
Lens Design
Optical Imaging and Aberrations
Geometrical and Instrumental Optics
Handbook of Lens Design
Geometrical Optics and Optical Design
Visual Instrumentation
Elements of Modern Optical Design
Art of Radiometry
Introduction to Optics
Mirror, Mirror
Applied Photographic Optics

Atchison & Smith
Begunov at al
Bentley and Olson
Boyd
Dereniak
Ditteon
Falk, Brill & Stork
Fischer, et al.
Goldberg
Grant
Hecht
Hecht
Hobbs
Jenkins & White
B. K. Johnson
Kasunic
Katz
Kidger
King
Kingslake
Kingslake
Kingslake
Laikin
Mahajan
Malacara
Malacara & Malacara
Mouroulis & Macdonald
Mouroulis
O’Shea
Palmer and Grant
Pedrotti & Pedrotti
Pendergrast
Ray
Scientific Photography and Applied Imaging  Ray
Fundamentals of Photonics  Saleh & Teich
Aberrations in Optical Imaging Systems  Sasián
The Science of Imaging  Saxby
Field Guide to Visual and Ophthalmic Optics  Schiegerling
The Art and Science of Optical Design  Shannon
Modern Lens Design  W. Smith
Practical Optical System Layout  W. Smith

The Eye and Visual Optical Instruments  G. Smith & Atchison
Concepts of Classical Optics  Strong
Optical Engineering Fundamentals  Walker
Useful Optics  Welford
Aberrations of Optical Systems  Welford
Infrared Handbook  Wolfe
Optical Engineer’s Desk Reference  Wolfe
Handbook of Optics  Optical Society of Am.
Military Handbook 141 - Optical Design  Department of Defense
Basic Optics and Optical Instruments  Bureau of Naval Pers.
Optics Source Book  Schott
Glass Catalog  McGraw Hill

My signature below confirms that I have read and understand the policies in this syllabus and agree to follow them in taking OPTI 202R in Spring 2023.

________________________________________   __________________
Signature         Date

________________________________________
Print Name