SYLLABUS

ECE / OPTI 201R Geometrical and Instrumentational Optics

Fall 2024
F (recitation): 3:00PM – 3:50PM
M/W (lectures): 3:400PM – 4:15 PM
Room: Meinel 410

Description of Course

This course will provide the student with a fundamental understanding of geometrical optics, optical system design, and instrumentation. The course will cover the foundations of geometrical optics and use this basis 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

Grades of C or higher in MATH 124 or 125, MATH 129, PHYS 141, and MSE 100.

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.

TA: Andrew Kotoski

Course Format and Teaching Methods

Lecture and recitation. TA-led recitation sessions will be used for working through example problems, answering questions, conducting exam reviews, and holding midterm exams.

Course Objectives

1. Provide students with a basic background of 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.

Expected Learning Outcomes

Expected Learning Outcomes:

1. Understand and explain fundamental principles of first-order optics.
2. Specify the first-order design of an optical system for different applications, including magnification, object-to-image distance, and focal length.
3. Diagram ray paths and do simple ray tracing.
4. Understanding how Gaussian reduction can be used to reduce a complex system.
5. Predict the imaging characteristics and cardinal points of multi-component systems.
6. Determine the required element diameters for an optical system.
7. Apply the layout principles to a variety of optical instruments including telescopes, microscopes, magnifiers, field and relay lenses, zoom lenses, and afocal systems.
8. Understand the process of the design and layout of an optical system.
9. Evaluate wavelength-dependent performance of optical systems.
10. Develop a basic understanding of third-order aberrations.

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

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.

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 recitation is 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 (both lecture and recitation) and be on time. 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.

If you are experiencing unexpected barriers to your success in your courses, please talk with your Undergraduate Academic Advisor, Amber Soergel (asoergel@optics.arizona.edu).

Do not wait until the end of the semester to reach out for help!

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 D2L

Required or Special Materials

None.

Required Extracurricular Activities

None.

Assignments and Examinations: Schedule/Due Dates.

Homework: Homework will be assigned regularly throughout the semester with a total of 13 (plus an initial assignment HW 0), and it will be due one to two weeks later. 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, but everyone must submit their own work.

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 (e.g., after 5pm on the day it is due) will not be granted.

Homework "short answers" are posted with all assignments to give students a reference to whether they obtained the correct answer, and to allow them to iterate if not. The full solutions will not be posted.

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.
- When issues arise, please contact the instructor as soon as possible so that appropriate accommodation can be made.

Homework due dates all posted on D2L and can be found on the assignments tab and also the calendar tool. The tentative dates are listed below.

Homework	Assigned	Due	Topic
0	26-Aug	30-Aug	Introduction
1	28-Aug	4-Sep	Fundamentals
2	4-Sep	11-Sep	Mirrors and Prisms, Basic Imaging
3	11-Sep	18-Sep	Thin Lens Imaging
4	18-Sep	25-Sep	Gaussian Imaging
5	25-Sep	4-Oct	Gaussian Reduction
6	4-Oct	14-Oct	Paraxial Ray Tracing
7	14-Oct	21-Oct	Stops + Pupils, FOV, F-Number
8	21-Oct	28-Oct	Vignetting
9	28-Oct	4-Nov	Afocal Systems, Telescopes
10	4-Nov	13-Nov	Microscopes, Relays, Telecentricity
11	13-Nov	22-Nov	Camera systems, DOF
12	22-Nov	4-Dec	Chromatic Effects
13	4-Dec	11-Dec	Radiometry and Illumination

Exams: There will be three midterm exams in addition to the final exam. Both exams will be held during the Friday recitation period, with a length of 50 minutes. The midterm dates are September 20, October 18, and November 15.

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 For Fall 2024, the Final will be on 12/17 3:30pm-5:30pm.

Grading Scale and Policies

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

Homework	25%
Midterm exam 1	15%
Midterm exam 2	15%
Midterm exam 3	15%
Final exam	30%
Total	100%

Each homework will constitute 7.5% of the total homework grade, except for "Homework 0" which will be 2.5% of the total homework grade (13*7.5+2.5 = 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

A tentative schedule is shown below, and is subject to change.

Date	Monday Lecture	Date	Wednesday Lecture	Date	Friday Recitation
26-Aug	Fundamentals I	28-Aug	Fundamentals II	30-Aug	Prisms and Mirrors
2-Sep	**LABOR DAY**	4-Sep	Refraction at a Surface	6-Sep	Recitation 1
9-Sep	Optical Spaces and Thin Lens Imaging	11-Sep	Thin Lens 2, General Systems	13-Sep	Recitation 2
16-Sep	Gaussian Optics, Cardinal Points	18-Sep	Gaussian Optics, Cardinal Points	20-Sep	Exam 1*
23-Sep	Gaussian Reduction	25-Sep	Gaussian Reduction	27-Sep	Recitation 3
30-Sep	Paraxial Ray Tracing**	2-Oct	Paraxial Ray Tracing**	4-Oct	Recitation 4
7-Oct	Ray Trace / Gaussian Reduction Review	9-Oct	Stops and Pupils, Vignetting	11-Oct	Recitation 5
14-Oct	Numerical Aperture, F/#, Lagrange	16-Oct	Importance of first-order design**	18-Oct	Exam 2
21-Oct	Afocal Systems	23-Oct	Magnifiers + Telescopes	25-Oct	Recitation 6
28-Oct	Telescopes (2) + Field Lenses	30-Oct	Microscopes, Relays, Telecentricity	1-Nov	Recitation 7
4-Nov	Microscopes, Relays, Telecentricity	6-Nov	Camera Systems (Objectives), DOF	8-Nov	Recitation 8
11-Nov	**VETERANS DAY**	13-Nov	Human Eye & Sensors	15-Nov	Exam 3
18-Nov	Optical Materials	20-Nov	Dispersing + Thin Prisms	22-Nov	Recitation 9
25-Nov	Chromatic effects + Achromatic Doublet	27-Nov	**THANKSGIVING**	29-Nov	**THANKSGIVING**
2-Dec	Radiometry and Illumination**	4-Dec	Radiometry and Illumination**	6-Dec	Recitation 10-
9-Dec	Spectrometers	11-Dec	Final Review	13-Dec	N/A

Special Considerations for Fall 2024:

- *The exam on September 20 will be held in Meinel 307 instead of Meinel 410.
- **Due to travel, guest lecturers will be teaching the course on September 30 and October 2 (lecturer: Dr. Mike Nofzinger; topic: paraxial ray tracing), as well as December 2 and 4 (lecturer: Dr. John Koshel; topic: radiometry and illumination). These are required topics so treat this as a normal lecture. Most likely October 16, topic: Importance of first-order design will also be a guest lecture from some past Optical Sciences students currently in industry.

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.

Safety on Campus and in the Classroom

For a list of emergency procedures for all types of incidents, please visit the website of the Critical Incident Response Team (CIRT): https://cirt.arizona.edu/case-emergency/overview Also watch the video available here.

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

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
https://deanofstudents.arizona.edu/support/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@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@arizona.edu
Phone: 520-621-5767

Confidentiality of Student Records

http://www.registrar.arizona.edu/ferpa

University-wide Policies Link

Links to the following UA policies, some of which are described above, are provided here: http://catalog.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

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	Atchison & Smith
Optical Instrumentation	Begunov at al
Field Guide to Lens Design	Bentley and Olson
Radiometry and the Detection of Optical Radiation	Boyd
Geometrical and Trigonometric Optics	Dereniak
Modern Geometrical Optics	Ditteon
Seeing the Light	Falk, Brill & Stork
Optical System Design	Fischer, et al.
Camera Technology - The Dark Side of the Lens	Goldberg
Field Guide to Radiometry	Grant
Optics	Hecht
Schaum's Outline of Theory and Problems in Optics	Hecht
Building Electro-Optical Systems	Hobbs
Fundamentals of Optics	Jenkins & White
Optics and Optical Instruments	B. K. Johnson
Optical Systems Engineering	Kasunic
Introduction to Geometrical Optics	Katz
Fundamental Optical Design	Kidger
History of the Telescope	King
Optical System Design	Kingslake
History of the Photographic Lens	Kingslake
Lens Design Fundamentals	Kingslake
Optics in Photography	Kingslake
Lens Design	Laikin
Optical Imaging and Aberrations	Mahajan
Geometrical and Instrumental Optics	Malacara
Handbook of Lens Design	Malacara & Malacara
Geometrical Optics and Optical Design	Mouroulis & Macdonald
Visual Instrumentation	Mouroulis
Elements of Modern Optical Design	O'Shea
Art of Radiometry	Palmer and Grant
Introduction to Optics	Pedrotti & Pedrotti
Mirror, Mirror	Pendergrast
Applied Photographic Optics	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	Schwiegerling
The Art and Science of Optical Design	Shannon
Modern Lens Design	W. Smith
Practical Optical System Layout	W. Smith
Modern Optical Engineering - the Design of Optical Systems; Fourth Edition	Warren J. 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 201R in Fall 2024.

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Signature **Date**

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Print Name