ECE/OPTI-202R
Geometrical and Instrumental Optics II

Spring Semester

David J Brady
Wyant College of Optical Sciences
University of Arizona

Syllabus

OPTI 202R
David J. Brady

Geometrical and Instrumental Optics II (3)
Spring Semester; Tues -Thurs 8:00-9:15
Meinel Room 422

Objective: 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 Notes: Available on the course website (D2L). Some of the Notes carry over from OPTI-201R.

Required Text:

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").

Learning Outcomes

This course will enable you to:

- specify the requirements of an optical system for your application including magnification, object-to-image distance, and focal length
- diagram ray paths and do simple ray tracing
- describe the performance limits imposed on optical systems by diffraction and the human eye
- predict the imaging characteristics of multi-component systems
- determine the required element diameters
- apply the layout principles to a variety of optical instruments including telescopes, microscopes, magnifiers, field and relay lenses, zoom lenses, and afocal systems
- adapt a known configuration to suit your application
- understand the process of the design and layout of an optical system

References:

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, Tadic-Galeb & Yoder
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	McGraw Hill
Schott Glass Catalog	

Grading:

Homework	25%	
Midterm Exam I	20%	(late Feb/early March)
Midterm Exam II	25%	(mid-April)
Final Exam	30%	8:00-10:00 Thursday May 12

The midterm dates have not yet been determined but will be announced well in advance of the exam dates.

Only a basic scientific calculator may be used for the in-class exams. This calculator must not have programming or graphing capabilities. An acceptable example is the TI-30 calculator. Each student is responsible for obtaining their own calculator.

Please note the final exam date that has been assigned by the University – plan your end of semester travel accordingly as the final exam will not be available prior to this date.

Grading:

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

Homework: Homework will be assigned regularly throughout the semester, and it will usually be due in one week. 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 be turned in to D2L by 10:00 AM 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.

Late Homework Policy:

- Homework that is turned in after 10:00 AM on the due date is considered late.
- Late HW that is turned in on the due date will receive a 20% penalty. - Late HW that is turned in on the day after the due date will receive a 50% penalty.
- Late HW that is turned in two or more days after the due date will receive no credit.

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

Absence: It is expected that students will regularly attend class and be on time for class. If "live" 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.

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 pre-approved 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 one week prior to any such absence so that appropriate accommodations can be made.

Academic Integrity

Students will abide by the University's Student Code of Academic Integrity:

Integrity and ethical behavior are expected of every student in all academic work. This Academic Integrity principle stands for honesty in all class work, and ethical conduct in all labs and clinical assignments. This principle is furthered by the student Code of Conduct and disciplinary procedures established by ABOR Policies 5-308 through 5-404 *(see chapter 5)*, all provisions of which apply to all University of Arizona students. This Code of Academic Integrity (hereinafter "this Code") is intended to fulfill the requirement imposed by ABOR Policy 5-403.A.4 and otherwise to supplement the Student Code of Conduct as permitted by ABOR Policy 5-308.C.1. This Code of Academic Integrity shall not apply to the Colleges of Law or Medicine, which have their own honor codes and procedures.

Prohibited Conduct:

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.

Student Responsibility:

Students engaging in academic dishonesty diminish their education and bring discredit to the academic community. Students shall not violate the Code of Academic Integrity and shall avoid situations likely to compromise academic integrity. Students shall observe the generally applicable provisions of this Code whether or not faculty members establish special rules of academic integrity for particular classes. Students are not excused from complying with this Code because of faculty members' failure to prevent cheating.

Faculty Responsibility:

Faculty members shall foster an expectation of academic integrity and shall notify students of their policy for the submission of academic work that has previously been submitted for academic advancement, as well as any special rules of academic integrity or discipline specific ethics established for a particular class or program (e.g., whether a faculty member permits collaboration on coursework; ethical requirements for lab and clinical assignments; etc.), and make every reasonable effort to avoid situations conducive to infractions of this Code.

Student Rights:

Students have the right to a fair consideration of the charges, to see the evidence, and to confidentiality as allowed by law and fairness to other affected persons. Procedures under this Code shall be conducted in a confidential manner, although a student has the right to an advisor in all procedures under this Code. The Dean of Students serves as advisors to students on any questions of process related to this Code.

Further information can be found at
https://deanofstudents.arizona.edu/policiesand-codes/code-academic-integrity

Misconduct of any kind will be prosecuted and may result in any or all of the following:

- Reduction of grade
- Failing grade

- Referral to the Dean of Students for consideration of additional penalty, i.e., notation on a student's transcript re: academic integrity violation, etc.

It is expected that students observing violations of this code by other students will report these violations to either the Instructor or to the Associate Dean for Academic Programs at the College of Optical Sciences.

Other Policies:

Students must abide by all aspects of the University's Student Policies, Procedures and Codes:
https://deanofstudents.arizona.edu/policies-and-codes/code-academicintegrity
Of particular note are the previously mentioned Code of Academic Integrity and the Policy Against Threatening Behavior By Students.

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

Disability Resource Center:
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.

Students who are registered with the Disability Resource Center must contact the instructor by Friday February 12 so that the necessary accommodations can be arranged. This is your responsibility as DRC does not always contact the instructor. For this course, exams will be administered here at the College of Optical Sciences rather than at the DRC.

Instructor:

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Wyant College of Optical Sciences, Rm. 429
University of Arizona
Tucson, AZ 85721
(520) 626-1778
djbrady@arizona.edu

Office Hours: Monday 2:00-3:00

Course Web Page: D2L

In addition, the site is used for distribution of other course materials, additional course notes and corrections, and exam schedules.

Teaching Assistant and Grader:

Eric Reichel
ereichel16@email.arizona.edu

Office Hours:	Monday	3:00-5:00
	Tuesday	2:00-5:00
	Wednesday	2:00-5:00
	Thursday	2:00-3:30

Tuesday and Wednesday office hours will be held in the 7th floor discussion area (Optical Sciences West Wing), Monday and Thursday will be on zoom at

https://arizona.zoom.us/j/8391732342 (Passcode: Sez9m0)

Course Outline – By Week:

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

Elementary Optical Systems

4. Simple magnifier; magnifying power.

5. Keplerian telescope; eye relief; field lenses; eyepieces; Galilean telescope; mirror systems.

6. Image erection and relay systems; microscopes.

7. Telecentric systems; imaging properties of afocal systems.

8. Eye

9. Camera Systems; depth of focus and field; image quality; photographic systems; viewfinders and focusing aids; autofocus systems; autocollimator; scanners.

Optical Materials and Dispersion

10. Materials; glass properties; Abbe number; other optical materials.

11. Dispersing prisms; minimum deviation; index measurement; thin prisms; combinations of thin prisms; achromatic prism; direct vision prism.

12. Chromatic effects; longitudinal chromatic aberration; thin lens achromat.

Other Optical Systems

13. Radiometric Transfer; AΩ product; camera equation.

14. Illumination systems; diffuse illumination; projection condenser system; Kohler illumination; critical illumination; slide projector.

15. Light Sources; integrating sphere and bars; practical considerations; dark field and Schlieren systems; overhead projector; Fresnel lenses; optical fabrication techniques; grinding and polishing; spherometer

Course Outline – By Note Chapter:

Foundations of Geometric Optics

10. Stops and pupils; marginal and chief rays; field of view; Lagrange invariant.

10A. Determination of pupil location by Gaussian optics and raytracing; numerical aperture; f-number.

11. Vignetting; real ray traces.

12. Afocal Systems

Elementary Optical Systems

13. Simple magnifier; magnifying power.

13A. Keplerian telescope; eye relief; field lenses; eyepieces; Galilean telescope; mirror systems.

14. Image erection and relay systems; microscopes.

15. Telecentric systems; imaging properties of afocal systems.

16. Eye

17. Camera Systems; depth of focus and field; image quality; photographic systems; viewfinders and focusing aids; autofocus systems; autocollimator; scanners.

Optical Materials and Dispersion

18. Materials; glass properties; Abbe number; other optical materials.

19. Dispersing prisms; minimum deviation; index measurement;

20. Thin prisms; combinations of thin prisms; achromatic prism; direct vision prism.

21. Chromatic effects; longitudinal chromatic aberration; thin lens achromat.

Other Optical Systems

22. Radiometric Transfer; AΩ product; camera equation.

23. Illumination systems; diffuse illumination; projection condenser system; Kohler illumination; critical illumination; slide projector.

23A. Light Sources; integrating sphere and bars; practical considerations; dark field and Schlieren systems; overhead projector; Fresnel lenses.

24. Optical fabrication techniques; grinding and polishing; spherometer