Optical Design and Instrumentation I

Fall 2011

John E. Greivenkamp
College of Optical Sciences
University of Arizona

Class Notes

OPTI 502 **Optical Design and Instrumentation I**

Fall, 2011; Tues/Thurs 8:00-9:15

John E. Greivenkamp

Objective: This course will provide the student with a fundamental understanding of optical system design and instrumentation. The course begins with the foundations of geometrical optics, which includes the first-order properties of systems, and paraxial raytracing, continues with a discussion of elementary optical systems, and concludes with an introduction to optical materials and dispersion. A special emphasis is placed upon the practical aspects of the design of optical systems.

Instructor Notes: will be required and will be distributed at cost

Required Text:

Field Guide to Geometrical Optics 081945294-7	J. E. Greivenkamp

Reference:

Optics of the Human Eye	Atchison & Smith
Optical Instrumentation	Begunov at al
Radiometry and the Detection of Optical Radiation	Boyd
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
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
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
Introduction to Optics	Pedrotti & Pedrotti
Mirror, Mirror	Pendergrast
Applied Photographic Optics	Ray
Scientific Photography and Applied Imaging	Ray
Fundamentals of Photonics	Saleh & Teich
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 and Exams:

Homework	20%	
Midterm – In Class	35%	TBD (October)
Final – In Class	45%	Tuesday 12/13 8:00-10:00

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 that this type of calculator is also required for the Ph.D. Comprehensive Exam in Optical Sciences.

Please note the final exam date that has been assigned by the University – plan your holiday travel accordingly as the final exam will not be available prior to this date. If the dates have not yet been determined, they will be announced well in advance.

Homework: There will be approximately one assignment per week, and it will usually be due in one week. The solutions to the homework will be posted at the same time as the homework is assigned. 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 is due in the classroom on the assigned day. It must be turned in before the start of class. A student may only turn in their own homework.

Because the homework solutions are available as a resource during the completion of the assigned homework, the grading of the homework will be based upon verification that the homework problems have been completed and turned in. Approval for late homework must be obtained in advance.

Late Homework Policy for On-Campus Students:

- All late homework must be turned in to the instructor. Any HW turned in to the TA will receive zero credit. In the instructor's absence, you may turn in late HW to Cindy Gardner in Room 719.

- HW that is less than 24 hours late will receive a 20% penalty.
- HW that is between 24 and 48 hours late will receive a 50% penalty.
- HW more than 48 hours late will receive no credit.

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

Absence: It is expected that students will regularly attend class and be on time for class. Late arrivals to class are distracting to both the instructor and the other students. Attendance for this class is not part of the course grade (but please note the homework policies).

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.

Academic Integrity

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

Principle 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, 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.

Prohibited Conduct:

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.6, E.10, and F.1

2 Submitting an item of academic work that has previously been submitted without fair citation of the original work or authorization by the faculty member supervising the work.

3 Violating required professional ethics rules contained or referenced in the student handbooks (hardcopy or online) of undergraduate or graduate programs, or professional colleges.

4 Violating 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 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 any appeal to a University Hearing Board under this Code.

Further information can be found at http://dos.web.arizona.edu/uapolicies

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:

As a courtesy to the instructor and other students in the class, the use of cell phones, pagers, text messaging, personal music devices, etc. is prohibited during class. Computers are to be used only for class-related activities, such as note taking.

Students who are registered with the Disability Resource Center must submit appropriate documentation to the instructor if they are requesting reasonable accommodations: http://drc.arizona.edu/teach/syllabus-statement.html.

Students must abide by all aspects of the University's Student Policies, Procedures and Codes: http://dos.web.arizona.edu/uapolicies
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.

Instructor: John E. Greivenkamp
College of Optical Sciences, Rm. 741
University of Arizona
Tucson, AZ 85721
(520) 621-2942
greiven@arizona.edu

Office Hours: Monday 2:00-3:00

I also maintain an open door policy related to this course. Feel free to knock even if the door is physically closed. If the time is bad, we will set something up.

Course Web Page: www.optics.arizona.edu/ot/opti502

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

Teaching Assistant and Grader:

Sarmad Albanna
Sarmad.albanna@gmail.com

Tentative Office Hours:

M	3:00-4:00
Tu	2:00-3:00
W	3:00-4:00
Th	2:00-3:00

Special Instructions for Distance Learning Students

Send all correspondence to the address below. Do not send duplicate copies of homework or exams to me. This allows the material to be properly logged in and will decrease overall confusion. Be sure to include my name and the course number on all correspondence.

Send all correspondence to:

Cindy Robertson
College of Optical Sciences
Meinel Building Rm #419
University of Arizona
1630 E University Blvd
Tucson, AZ 85721
(520) 626-4719
(520) 626-4514 FAX
cindyr@optics.arizona.edu

Feel free to contact the TA or me with questions. This can be done via e-mail or phone. We will do our best to get you a quick answer. There are many people in this class, so try to start with the TA and then me if you need additional help.

Since there is often a delay between the date a lecture is given and the date you view it, there is some flexibility in the due dates for homework and exams. For your convenience, all of the homework sets and exams will be keyed to lecture numbers. Every attempt should be made for homework and exams to be received in Tucson within one week of the on-campus due date or exam date. The maximum allowable delay is two weeks behind the on-campus students – any course material received after this limit will receive zero credit. Please contact the instructor in advance if schedule issues arise. Once we receive your assignments, we will grade and return them as soon as possible.

All course materials (including the final exam) must be received in Tucson by Monday December 19, 2011. This will permit grading and submission of the course score prior to the holidays.

The final exam will not be available prior to the date scheduled by the University. Anything not received on time will receive a zero, and your grade will be computed accordingly.

I would also appreciate it if you would send me a brief paragraph about your job and educational background. I find it interesting to see the diversity of employment of our distance students.

OPTI-502 Syllabus

Optical Design and Instrumentation I -- 3 Credit Hours (29 Lectures)

Rays and Waves, Snell's Law, Mirror and Prism Systems, Gaussian Imagery and Cardinal Points, Paraxial Raytracing, Stops and Pupils, Radiometric Transfer, Vignetting, Elementary Optical Systems (Objectives, Telescopes, Illumination Systems, Projectors, Photographic Systems), Optical Materials, Dispersion, Achromats.

Foundations of Geometric Optics

1. Assumptions of geometrical optics; refractive index; optical path length; rays and wavefronts; Fermat's principle; Snell's law; refraction and reflection; critical angle; sign conventions.

2. Plane mirrors; systems of plane mirrors; parity and orientation.

3. Non-dispersing prisms and prism types; plane-parallel plate; tunnel diagrams; reduced thickness.

4. Imaging with a thin lens; focal length; conjugates; magnification; imaging equations.

5. Real and virtual images; negative lenses; thin-lens afocal system.

6. Gaussian optics; magnification; cardinal points and planes; focal length; Newtonian and Gaussian equations; conjugate planes; afocal systems; colinear transformation.

7. Object-image relationships and zones; longitudinal magnification.

8. Paraxial image formation; single refracting surface and its cardinal points; transfer between surfaces.

9. Two component systems; Gaussian reduction.

10. Single reflecting surface; thick lens; thin lens; systems of two thin lenses.

11. Paraxial ray tracing; cardinal points by raytracing; back focal distance; virtual objects.

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

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

14. Radiometric Transfer; AΩ product; camera equation.

15. Vignetting; real ray traces.

Elementary Optical Systems

16. Objectives; collimators; depth of focus and hyperfocal distance; Scheimpflug condition.

17. Zoom lenses; simple magnifier; magnifying power.

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

19. Image erection and relay systems; microscopes.

20. Telecentric systems; imaging properties of afocal systems.

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

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

23. Photographic systems; viewfinders and focusing aids; autofocus systems;

24. Eye; autocollimator; scanners.

Optical Materials and Dispersion

25. Optical fabrication techniques; grinding and polishing; spherometer

26. Dispersing prisms; minimum deviation; index measurement; glass properties; Abbe number; other optical materials.

27. Prism spectrometer

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

29. Longitudinal chromatic aberration; thin lens achromat.