OPTI503 Optical Design and Instrumentation II

Spring 2018

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College of Optical Sciences
University of Arizona

Objective: This course moves beyond the first-order treatment of optical system design to discuss other topics important to optical engineering. The effects of aberrations on the performance of imaging systems will be studied. The concepts of wavefront and ray aberrations will be introduced, and the individual third-order aberration terms will be examined. The course will continue with a detailed discussion of image quality criteria. Colorimetry will also be discussed. The principles of geometrical optics and linear systems theory will then be applied to electronic imaging systems.

Recommended Texts: None

Grading and Exams:

Homework & Projects	40%
Midterm – In Class	30%
Final – In Class	30%

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 end of the semester 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 two weeks, and it will usually be due in one week. Completion of the homework is important to fully master this material. Collaboration and discussion of the homework is encouraged.

A student may only turn in their own homework. No electronic submissions are permitted.

Late Homework Policy for On-Campus Students:

- HW should be turned in to TA before the class on the due date.
- Late HW that is turned in on the due date will receive a 20% 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 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).

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.

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. Please include your phone number in any emails. 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.

This schedule will permit prompt grading and submission of the course score.

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.

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OPTI503 Syllabus

Optical Design and Instrumentation II (3). Aberrations of Optical Systems: wave fans and ray fans, spot diagrams, wavefront expansion, effects of aberrations on image quality, image quality criteria, aberration balancing, principle of lens design; Color: colorimetry, chromaticity, color gamut, additive and subtractive colors; Digital Imaging Systems: resolution and aliasing, color filter arrays, aliasing suppression, image displays and projectors; Optical Thin Film: Fundamentals, materials, coating with dielectric layers, multiple cavity filters, coating with metallic layers, and special filters

Prerequisite: Opti502.

Aberrations

1. Frist-order optics, tangential and sagittal rays, ray tracing.
2. Transverse and longitudinal ray aberrations, wave aberrations.
3. Monochromatic aberration: defocus, wavefront tilt, spherical aberration, coma, field curvature, Petzval surface, astigmatism, and distortion.
4. Chromatic aberration.
5. Seidel aberration coefficients.
6. Stop-shift effects, aspherical surfaces.

Image quality

1. Spot diagram
2. Image quality metrics, Rayleigh criterion, and wavefront variance.
3. PSFs with wavefront errors, influence of aberrations on PSFs.
4. Strehl ratio, encircled and ensquared energy.
5. Modulation transfer functions, influence of aberrations on MTFs.
6. Resolution and test targets.
7. Image simulation.

Optical design

1. Principle of optical design.
2. Correction of monochromatic aberrations.
3. Optical materials and correction of chromatic aberrations.

Color

1. Visual color perception, basic color concepts (spectrally pure, hue, saturation).
2. Colorimetry, sources and color temperature, trichromatic theory of color, color matching functions.
3. CIE RGB and XYZ chromaticity values, x-y chromaticity diagram.
4. Dominant and complementary wavelengths, color addition, additive color, color gamut, sRGB color system for digital images.
5. Subtractive color, other color systems, gamma correction, calibration.

Digital Imaging Systems

1. Imaging chain modeling
2. Sampled imaging systems, resolution, and aliasing.
3. Two-dimensional sampling and Nyquist domains, color filter arrays, reciprocal sampling grids.
4. Optical low-pass filters, sharpness-aliasing tradeoff.

Optical Thin film

1. Fundamentals and materials.
2. Coating with dielectric layers
3. Multiple cavity filters
4. Coating with metallic layers
5. Special filters