EELE 582 & 481 Optical Design - Syllabus

Montana State University, Spring 2015

Instructor: Dr. Joseph Shaw, Professor (994-7261; jshaw@ece.montana.edu)

Course Objectives: In this course you will learn to design and analyze optical systems using geometrical optics and wave aberration theory. The primary goal is to **gain conceptual understanding of optical imaging systems, aberrations, and computer-aided design** using optical design software.

Time & Location TR 10:50 am – 12:05 pm, EPS 110

Class website: http://www.coe.montana.edu/ee/jshaw/classes/opticaldesign_s15.html

Required textbook: J. M. Geary, *Introduction to Lens Design with Practical ZEMAX Examples* (Willmann-Bell, 2002).

583 students only: J. Sasian, *Introduction to Aberrations in Optical Imaging Systems* (Cambridge Press, 2013)

Recommended text: J. E. Greivenkamp, *Field Guide to Geometrical Optics* (SPIE Press 2004).

Other references:
W. J. Smith, *Modern Optical Engineering,*4th ed. (McGraw-Hill, 2007).
W. J. Smith, Modern Lens Design (McGraw-Hill, 2004)
R. Fischer, B. Tadic-Galeb, & P. R. Yoder, *Optical System Design*, 2nd ed. (SPIE Press 2008)
K. Kasunic, *Optical Systems Engineering* (McGraw-Hill, 2011)
W. J. Smith, *Practical Optical System Layout* (McGraw-Hill, 1997)
Mouroulis & Macdonald, *Geometrical optics & Opt. Design* (Oxford 1997)
M. Laikin, *Lens Design, 3rd ed.* (Marcel Dekker 2001)
W. T. Welford, *Aberrations of optical systems* (Adam-Hilger Press, 1989)
R. R. Shannon, *The Art and Science of Optical Design* (Cambridge 1997)

Grading:

Homework	25%
Mid-term exam	25%
Design Project	25%
Final exam	25%

Homework will focus on design problems chosen to help you learn basic principles or techniques of optical design. Full credit will be earned by:

- demonstrating reasonable effort;
- meeting assigned design goal and providing meaningful discussion of the significant variables or methods required to do so;
- (or) coming close to the design goal and providing meaningful discussion of what is limiting the performance of your design.

For each homework assignment, you will turn in a **design summary** explaining your design objectives and summarizing the steps taken to meet them. Your summary should include sufficient graphs, tables, etc., to support your claims.

Additional requirements for students in EELE 582

This class is taught as a co-convened senior-level and graduate-level class. There are extra requirements for students in the graduate version of the course.

Homework
Students in EELE 582 will be required to complete additional homework problems focused on deepening your theoretical understanding of optical systems and aberrations.

Exams
Each exam will include one additional question that is to be completed by students in EELE 582. These questions will be designed to assess your understanding of the material covered in the extra homework problems. Exams in this class are conducted primarily outside of class because of the need to use the ZEMAX program in your work; however, the extra EELE 582 exam questions may be completed in a closed-book exam session.

Class policies:
1. Without prior arrangement, late homework is accepted with 10% penalty until next due date.
2. I encourage everyone to share ideas on optical design and effective use of the optical design codes, but cheating or plagiarism will be dealt with according to MSU policy: http://www.montana.edu/policy/student_conduct/#academicmisconduct
3. Discussion about homework is encouraged, but each student must submit their own work.
4. On exams, collaboration with anyone is prohibited.

Topics to be covered in this class

- Optical surface shape and conventions; paraxial ray tracing & y-nu ray trace method.
- System parameters from ray tracing: margin and chief rays, stops and pupils, optical invariant.
- Wave-front and ray aberration theory.
- Automated optimization of optical designs (solves, merit functions, Gaussian quadrature…).
- Interferometric testing of optical surfaces, components, and systems.
- Calculating aberration coefficients from ray-trace data.
- Lens shape & aberration balancing.
- Use of symmetry to reduce off-axis aberrations; flattening curved wave fronts.
- Chromatic variation of aberrations (sphero-chromatism; achromats, aplanats, apochromats…).
- Optical Transfer Function and estimation of image contrast and resolution (Strehl ratio).
- Optical effects of windows, field lenses, mirrors, and corrector plates.
- Telescope design using spherical & aspherical mirrors.
- The Hubble space telescope, its famous optical problems and how it was fixed.
- Tolerancing of optical systems (determining sensitivities of a design to parameter changes).
- Nonsequential ray tracing (increasingly common and powerful method).
- Design projects of your own choice.