OPTI x85: Illumination Engineering

Spring 2013: three credit hours. Project-based course.

Instructor
John Koshel, OPTI 416 (old building), jkoshel@optics.arizona.edu

Course Goal
To learn basic skills in illumination design, especially the use of design software to carry out an individual project and present the results

Class Schedule
Lecture: F 9.00 am – 10.50 am; OPTI 305
Software Lab: M 2.30 pm – 3.15 pm; OPTI 305
You are expected to be in class, using only the videos to supplement the lectures

Office Hours:
Friday: 10.50 am – Noon (guaranteed)
Monday: 1 pm – 2.30 pm & 3.15 pm – 4.00 pm (guaranteed)
Appointment: just let me know when (email is the best way to find me, but cell: 520-591-9526). I prefer Mondays and Fridays. You may also stop by my off-campus office.

OPTI 485/585. Illumination Engineering (3). Fields: Illumination, Nonimaging, and Concentrators; Sources: Incandescent, Fluorescent, LED, HID, Modeling, and Experimental Measurement; Modeling: Ray Tracing, Radiometry and Photometry, Color, Polarization, and Scattering; Theory: Radiometry, Photometry, Étendue, Skew Invariant, and Concentration; Design Methods: Edge Ray, Flow Line, Tailored Edge Ray, Non-Edge Ray, and Imaging; Optics: Reflectors, Lightpipes, Couplers, Films, and Hybrids; Applications: Displays, Automotive, Solar, Sources, and Lighting; Special Topics: Software Modeling, Optimization, Tolerancing, and Rendering. Previous requirements: Undergraduate: permission from instructor (OPTI 201R, OPTI 340 or equivalent would suffice); Graduate: OPTI 502 or permission from instructor.

Course Objective:
● Complete a course project: software modeling, theory, public policy, etc.,
● Understand illumination-based modeling software,
● Understand the underlying design principles of nonimaging optics: étendue and edge ray, radiance/luminance, intensity, and illuminance/irradiance,
● Understand the components of an illumination system: source, optics, and target
● Know the limits of ray sampling in nonimaging systems,
● Gain knowledge of a number of applications: lighting, automotive, and displays,
● Gain knowledge of developing areas: optimization, tolerancing, and rendering,
● Learn how to present technical papers in both written (i.e., the professor) and oral (i.e., your peers and the professor) formats, and
● Potentially present and/or publish your work in an optics conference or journal.
GRADING

Undergraduate (OPTI 485) – all dates tentative:

- Project Proposal:
  - 10%, due Friday, 8 February 2013
  - Paper (2+ pages, with references and pictures)

- Preliminary Design Review:
  - 20%, written due Friday, 8 March 2013; short oral talk, Friday 29 March 2013
  - Paper (4+ pages, with references, pictures can be included but should also be in PPT file, see next bullet)
  - PPT (5+ pages of content)

- Final Design Review:
  - 40%, due final couple weeks
  - Presentation (15%; 15-minute oral presentation), last week of class
  - Paper (25%; 7+ page report, with references and pictures), due Friday 3 May 2013

- Class/Project Day Participation
  - 10%, attending lectures; and questions during presentations

- Homework:
  - 20%, Must complete 4 of the 5 assignments

Graduate (OPTI 585) – all dates tentative:

The project for graduate students will be decidedly more involved than that for undergraduates. Additionally, the final design review requirements are more extensive.

- Project Proposal:
  - 10%, due Monday Friday, 8 February 2013
  - Paper (3+ pages, with references and pictures)

- Preliminary Design Review:
  - 20%, written due Friday, 8 March 2013; short oral talk, Friday 29 March 2013
  - Paper (6+ pages, with references, pictures can be included but should also be in PPT file, see next bullet)
  - PPT (8+ pages of content)

- Final Design Review:
  - 40%, due final couple weeks
  - Presentation (15%; 25-minute oral presentation), last week of class
  - Paper (25%; 10+ page report, with references and pictures), due Friday 3 May 2013

- Class/Project Day Participation
  - 10%, attending lectures; and questions during presentations

- Homework:
  - 20%, Must complete 4 of the 5 assignments
TEXTS

Required Textbook:
- 2012 Notes on CD provided by instructor by second class.

Suggested Textbooks:

SCHEDULE

Course Outline: 2- hour lectures once per week, 1-hour laboratory to discuss software and projects

- Week 1: Introduction: course discussion, course survey, course project; types of optics, software modeling, radiometry, photometry, étendue, skew invariant, introduction to design methods and sources
- Week 2: Sampling: ray trace sampling, Rose Model, appearance modeling.
- Week 3: Sources: LEDs, incandescent, high-intensity discharge, daylight, Fluorescent, source measurement, source modeling, luminaires, lighting.
- Week 4: Étendue I: definition, conservation of étendue, examples.
- Week 5: Étendue II: concentration, skewness, examples
- Week 6: Nonimaging optics I: edge ray principle, compound parabolic concentrator, edge-ray concentrator, truncated CPC, tailored edge ray design, non-edge-ray design,
- Week 7: Nonimaging Optics II: flow line method, dielectric design, simultaneous multiple surfaces, hybrid optics.
- Week 8: Lightpipes: straight sections, bent sections, principal sections, parameterization, lightguides.
- Week 9: Displays I: backlit displays, wedged lightguide, microstructure, back reflector, diffusers, polarizers, source coupler, color modeling.
- Week 10: Displays II: polarization, microstructure design, brightness enhancement film, diffuser design, system modeling.
- Week 11: Short Oral Presentations/Displays III: projector displays, mixing rods, fly’s eye integrators, system modeling.
- Week 12: Optimization: methods, merit function, parameterization, non-uniform rational b-splines, fractional optimization, constraints, reflectors, hybrid optics, lightpipes.
- Week 13: Tolerancing: process error, system error, gross error, roughness error, BSDF/BRDF/BTDF, experimental measurement, source binning.
- Week 14: Applications/Introduction to stray light: solar energy, concentrators, photovoltaics, automotive, lightpipes, lightboxes, OLEDs; scatter, Fresnel reflections, total integrated scatter
- Week 15: Presentations

**ACADEMIC INTEGRITY**

According to the [Arizona Code of Academic Integrity](https://www.azcodes.com/an ACT edited), “Integrity is expected of every student in all academic work. The guiding principle of academic integrity is that a student’s submitted work must be the student’s own.” Unless otherwise noted by the instructor, work for all assignments in this course must be conducted independently by each student. Co-authored work of any kind is unacceptable. Misappropriation of exams before or after they are given will be considered academic misconduct.

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.

**STUDENTS WITH LEARNING DISABILITIES**

If a student is registered with the [Disability Resource Center](https://www.azcodes.com/an ACT edited), he/she must submit appropriate documentation to the instructor if he/she is requesting reasonable accommodations.

*The information contained in this syllabus may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.*