OPTI x85: Illumination Engineering

Spring 2017: three credit hours. Project-based course.

Instructor
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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; OSC 305
Software Lab: M 2.00 - 2.50 pm; OSC 307
You are expected to be in class, using only the videos to supplement the lectures.

Office Hours:
Open / by appointment (most individuals in the AP Office can schedule)

Distance Learning:
OPTI 585 is available via the College's distance-learning program. You are to hand in materials by the specified dates and times. There are no exams in this course.

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 the 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**

Without written/email approval, there will be a score reduction of 10% per day (or portion thereof) late for any submission. The due date is till end of the given day (Tucson time); therefore, for example, one day late will begin at midnight and last till the end of the day following the due date. All submissions will be reviewed for originality.

**Undergraduate (OPTI 485) - all dates tentative:**

• **Project Proposal:**
  o 10%, due Friday, 3 February 2017
  o Paper (2+ pages, with references and pictures)

• **Preliminary Design Review (PDR):**
  o 20%, written due Friday, 10 March 2017
  o Paper (5+ pages text with references, graphics are additional)
  o Note: there will be an assignment of a short video of your PDR that you will provide to me and the other students in the class. This video will be due around 31 March 2017. It is not formally part of the PDR.

• **Critical Design Review (CDR):**
  o 35%, due final couple weeks
  o Poster /Oral presentation (15%)
    ▪ Poster (on-campus students: Friday, 28 April 2017 (during class session)
    ▪ Oral (DL students): during class sessions and potential extra session
  o Paper (20%; 10+ page report, with references and pictures), due Monday, 8 May 2017

• **Class/Project Day Participation:**
• 10%, attending lectures, asking questions during lectures or on D2L, and asking questions during presentations (DL students: send questions or post on D2L)
• Homework / Lecture Quizzes:
  o 25%; weekly lecture “quiz” and other assignments

Graduate (OPTI 585) – all dates tentative:
• Project Proposal:
  o 10%, due Friday, 3 February 2017
  o Paper (3+ pages, with references and pictures)
• Preliminary Design Review (PDR):
  o 20%, written due Friday, 10 March 2017
  o Paper (7+ pages text with references, graphics are additional)
  o Note: there will be an assignment of a short video of your PDR that you will provide to me and the other students in the class. This video will be due around 31 March 2017. It is not formally part of the PDR.
• Critical Design Review (CDR):
  o 35%, due final couple weeks
  o Poster /Oral presentation (15%)
    ▪ Poster (on-campus students: Friday, 28 April 2017 (during class session)
    ▪ Oral (DL students): during class sessions and potential extra session
  o Paper (20%; 13+ page report, with references and pictures), due Monday, 8 May 2017
• Class/Project Day Participation:
  o 10%, attending lectures, asking questions during lectures or on D2L, and asking questions during presentations (DL students: send questions or post on D2L)
• Homework / Lecture Quizzes:
  o 25%; weekly lecture “quiz” and other assignments

D2L is used throughout the class for providing the lectures, assignments, and so forth. You can hand in assignments in hardcopy format, but it is preferred if you use D2L.
**TEXTS**

**Required Textbook:**
- 2016 Notes provided by instructor via D2L.

**Suggested Textbooks:**
- R. J. Koshel, Ed., *Illumination Engineering: Design with Nonimaging Optics*, Wiley (2013). (This is an awesome book that can be found online via UA Libraries)

I will be bringing many other books to class to show to you. These other books tend to be in specific areas of illumination. Please talk to me about which books are good for your interests.

**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

COURSE GRADE

Components: as per previous section

• Project proposal: 10%
• PDR: 20%
• CDR presentation: 15%
• CDR report: 20%
• Participation: 10%
• Homework/Quiz: 25%

Without written approval, there will be a score reduction of 10% per day late for any submission. The due date is till midnight of the given day.

Final Grade:

• A 90% - 100%
• B 80% - 90%
• C 70% - 80%
• D 60% - 70%
• E < 60%
For Undergraduates (406):
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

For Graduates (506):
A: Excellent - has demonstrated a more than acceptable understanding of the material; exceptional performance; exceeds expectations
B: Good - has demonstrated an acceptable understanding of the material; adequate performance; meets expectations
C: Average - has not demonstrated an acceptable understanding of the material; inadequate performance; does not meet expectations
D: Poor - little to no demonstrated understanding of the material; exceptionally weak performance
E: Failure - usually reserved for non-attendance
ACADEMIC INTEGRITY

Academic Integrity at the University of Arizona is the principle that stands for honesty and ethical behavior in all homework, tests and assignments. All students should act with personal integrity and help to create an environment in which all can succeed.

Dishonesty will not be tolerated in this course. This includes, but is not limited to, cheating, plagiarizing, fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. Students who are found to be dishonest will be reported to the Dean of Students Office and receive a sanction, such as a failing grade on the assignment, exam, and/or in the course. Students should refer to the UA Code of Academic Integrity if they have questions. The Code can be found at: [http://deanofstudents.arizona.edu/codeofacademicintegrity](http://deanofstudents.arizona.edu/codeofacademicintegrity).

ACCESSIBILITY AND ACCOMMODATIONS

At the University of Arizona we strive to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, you are welcome to let me know so that we can discuss options. You are also encouraged to contact Disability Resources (520-621-3268) to explore reasonable accommodation.

Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

You may learn more at: [http://drc.arizona.edu](http://drc.arizona.edu)

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