



UNIVERSITY OF  
CENTRAL FLORIDA

## OSE6265: Optical System Design

CREOL, The College of Optics and Photonics  
3 Credit Hours

### Course Syllabus

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Instructor:	Dr. Zheyuan Zhu	Term:	Summer 2024
Office Location:	CREOL 235	Class Meeting Days:	Mon, Wed
Office Hours:	Tue 3:00 – 4:00 PM	Class Meeting Time:	10:00 – 11:40 AM
Phone:	4078236804	Class Location:	CREOL A214
Email:	<a href="mailto:zheyuan.zhu@ucf.edu">zheyuan.zhu@ucf.edu</a>	Course Modality:	P, M, ML

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**Additional notes:** I will be in my office during office hours, but of course I will be happy to discuss the material with you anytime. Please send me an email if you would like to schedule a meeting.

#### Course Description

**OSE6265 Optical System Design:** Design principles of lens and mirror optical systems; evaluation of designs using computer techniques.

This course is designed to provide a comprehensive foundation in design principles of optical systems, as well as the evaluation and optimization of designs using computer techniques. The lectures include an introduction to optical systems design, an introduction to the Zemax optical design software package, paraxial layout, raytracing, stops and pupils, lens design methods, optimization, achromatization, optical aberrations, and image quality metrics. Various classic lenses and optical systems will be studied using the theoretical and computing skills learned in class. Students will learn 1st and 3rd-order calculations, optical design code skills including optimization and image analysis, and optical design philosophy and practical skills.

#### Student Learning Outcomes

Upon completing this course, the students will be able to:

- Evaluate the performance for imaging optical system based on aberration theory.
- Understand common refractive and reflective optical instruments, design principle and performance evaluation criteria.
- Understand the major design constraints in manufacturing and properties in optical materials.
- Design basic optical systems using commercially available software (Zemax).

#### Enrollment Requirements

OSE5203 Geometric Optics or instructor consent.

#### Course Activities

Students are expected to participate in the class discussion, complete the assigned homework, midterm, and final project. Students should plan on at least four hours' worth of study and homework outside of class

each week (suggested two hours after each class session on reviewing class materials and completing homework). Topics covered in this course are listed below. Note: the schedule and topics covered in this course are subject to change.

Theme	Week	Lecture	Topics	Assignments
Geometric optics and imaging system through numerical tools (MATLAB/Zemax)	1	1	Review of geometric optics: Snell's law; multi-surface ray transfer (paraxial). Paraxial ray transfer (ABCD matrix). Course requirement, timeline, and software environment setup.	Attendance verification, software environment setup
		2	Exact ray tracing: sequential vs. non-sequential, sag, multi-surface ray transfer. Introduction to geometric optic software toolsets (Zemax). Properties of geometric optic system (cardinal point, principal plane, stop and aperture, entrance / exit pupil, marginal / chief ray, normalized P & H coordinates, optical invariants).	MATLAB exact ray tracing; system properties (MATLAB vs. Zemax)
	2	3	Properties of geometric optic system (continued). Examples of ray tracing and calculation of system properties using Zemax. From Maxwell's equation to geometric optics (wavefront).	
		4	From ray tracing to wavefront aberration (monochromatic). System performance evaluation (MTF, PSF). Calculation of system performance metric in Zemax.	WF, PSF, MTF (MATLAB vs. Zemax)
	3		Memorial Day break (no class).	
		5	Review of wavefront aberration (monochromatic) and 3 <sup>rd</sup> -order aberration coefficients. Fundamentals of gradient-based optimization, merit function and operands, numerical vs. analytical gradient, solvers and constraints.	Zemax optimization fundamentals
Optical design principles and evaluations	4	6	Optical design standard practice (sensor format, FOV, resolution (optics-limited or sensor limited), paraxial pre-design). Lens design principles. Stop shift; landscape lens.	Pre-design (mono sensor) + landscape lens
		7	Lens bending and aberration balancing (spherical aberration) Meniscus and lens shape factor; best-form lens; asphere.	Best-form lens design + ray-fan. Lens splitting.
	5	8	Lens splitting: from the perspective of seidel coefficients to practice. Replacing asphere with lens splitting.	
		9	Coma and astigmatism; symmetry. Periscope lens: symmetric and breaking symmetry.	Periscope lens + field flattener;
	6	10	Field curvature and F-theta distortion. Field flattener.	PETC curve

		11	Chromatic aberration and cemented achromats. Air-spaced achromats.	Predesign (Bayer sensor) + achromatic landscape lens
	7	12	Air-spaced achromats (continued). Achromats bending.	
		13	Forward and reversed geometry; the use of ideal lens model. Midterm project (open book and notes).	4X microscope objective
	8	14	Secondary color; apochromatic design. Material choice for achromats and apochromats. Chromatic focal shift curves.	APO primary lens (refractor telescope) + eyepiece
Optical system design examples		15	Afocal design; laser collimator; eyepiece.	
	9	16	Curved mirrors; reflector telescope. Coordinate break.	Reflector telescope design + decenter & tilt tolerance
		17	Field lens, windows, corrector plates (single element).	
	10	18	Reflector telescopes; tolerance (decentering and tilt, reflector telescope “collimation”).	
		19	Symmetric achromat. Celor lens.	Celor lens design
	11	20	Petzval lens.	Petzval design
		21	Triplet lens (tri-functional group lens)	Triplet (relay or telephoto) PSF, MTF, image simulation
	12	22	Imaging system performance metric and evaluation (MTF, resolution, Strehl ratio, depth of focus).	
		23	Final project.	

### **Important Dates**

First day of class	05/13/2024
Last day to add/drop class	05/17/2024
Midterm	06/26/2024
Final project due	08/02/2024

All homework submissions are due **one week** after they are assigned.

### **Assignment Submission**

Assignments should be submitted through [Webcourses@UCF](mailto:Webcourses@UCF). Upload a .zip file containing a document describing your design process and solution, as well as the associated code / Zemax files in your submission.

### **Final Exam**

Student will work on a final optical design project (open book and notes), due on or before 08/02/2024.

## Assessment and Grading Procedures

This course contains 12 homework sets, 1 midterm, and 1 final project. Students will be scored using a point-based grading system for each assignment. Additionally, in-class quizzes and participation will also be considered in the overall grade. Plus (+) and minus (-) grades will be used in the overall grade.

### Grading Methods

The weights of course activities are listed below.

Class activity	Overall weight
Quizzes & participation	10%
Homework (12 sets)	60%
Midterm	15%
Final project	15%
<b>Total</b>	<b>100%</b>

The following table describes the overall grading scales and rubrics.

Grading Scale	Rubric Description
100 $\geq$ A $>$ 85	Excellent, has a strong understanding of all concepts and is able to apply the concepts in all and novel situations. Has full mastery of the content of the course.
85 $\geq$ B $>$ 75	Good, has a strong understanding of most or all of the concepts and is able to apply them to stated and defined situations.
75 $\geq$ C $>$ 65	Average, has a basic understanding of the major concepts of the course and is able to apply to basic situations.
65 $\geq$ D $>$ 55	Below average, has a basic understanding of only the simple concepts and is able to apply to only a limited number of the most basic situations.
55 $\geq$ F $\geq$ 0	Demonstrates no understanding of the course content.

### Grade Objections:

All objections to grades should be made in writing within one week after the due date of the work in question. Objections made after this period has elapsed will not be considered – NO EXCEPTIONS.

### Make-up Exams and Assignments

If an emergency arises and a student cannot submit assigned work on or before the scheduled due date or cannot take an exam on the scheduled date, the student must give notification to the instructor no less than 24 hours before the scheduled date and no more than 48 hours after the scheduled due date.

### Attendance/Participation

All faculty members are required to document students' academic activity at the beginning of each course. In order to document that you began this course, please complete the attendance verification by the end of the first week of classes, or as soon as possible after adding the course, but no later than 05/17/2024. Failure to do so will result in a delay in the disbursement of your financial aid.

### Information for Distant Learning Students:

- Students in the distant learning section located within 150 miles from UCF must take the Midterms and the Final Exam with the students in the face-face section.
- It is extremely important to review the class videos in a timely manner.
- Problem sets are to be submitted by class time on the due date through Webcourses@UCF. Graded problem sets and exams will be e-mailed back.

### **Grade Dissemination**

Grades for all the assignments (homework, midterm, final project) will be posted on Webcourses@UCF.

### **Course Materials and Resources**

Lecture notes and other materials used for classes will be available on Webcourses@UCF for download before each class. The topics listed in this syllabus is subject to change without prior notice.

#### **Text (Strongly recommended):**

Introduction to Lens Design: with Practical ZEMAX Examples

Joseph M. Geary

William-Bell, Inc. (2002)

#### **Other recommended resources:**

Modern Lens Design, Warren J. Smith, McGraw Hill (1992)

Geometrical Optics and Optical Design, Mouroulis and Macdonald, Oxford University Press.

### **Policy Statements**

Per university policy and plain classroom etiquette, mobile phones, etc. must be silenced during all classroom lectures, unless you are specifically asked to make use of such devices for certain activities. Academic dishonesty in any form will not be tolerated! If you are uncertain as to what constitutes academic dishonesty, please consult The Golden Rule in the UCF Student Handbook ([www.goldenrule.sdes.ucf.edu](http://www.goldenrule.sdes.ucf.edu)) for further details. As in all University courses, The Golden Rule Rules of Conduct will be applied. Violations of these rules will result in a record of the infraction being placed in your file and the student receiving a zero on the work in question AT A MINIMUM. At the instructor's discretion, you may also receive a failing grade for the course. Confirmation of such incidents can also result in expulsion from the University.

### **Academic Integrity**

Students should familiarize themselves with UCF's Rules of Conduct at

<<https://scai.sdes.ucf.edu/student-rules-of-conduct/>>. According to Section 1, "Academic Misconduct," students are prohibited from engaging in

1. Unauthorized assistance: Using or attempting to use unauthorized materials, information or study aids in any academic exercise unless specifically authorized by the instructor of record. The unauthorized possession of examination or course-related material also constitutes cheating.
2. Communication to another through written, visual, electronic, or oral means: The presentation of material which has not been studied or learned, but rather was obtained through someone else's efforts and used as part of an examination, course assignment, or project.
3. Commercial Use of Academic Material: Selling of course material to another person, student, and/or uploading course material to a third-party vendor without authorization or without the express written permission of the university and the instructor. Course materials include but are not limited to class notes, Instructor's PowerPoints, course syllabi, tests, quizzes, labs, instruction sheets, homework, study guides, handouts, etc.
4. Falsifying or misrepresenting the student's own academic work.
5. Plagiarism: Using or appropriating another's work without any indication of the source, thereby attempting to convey the impression that such work is the student's own.
6. Multiple Submissions: Submitting the same academic work for credit more than once without the express written permission of the instructor.
7. Helping another violate academic behavior standards.
8. Soliciting assistance with academic coursework and/or degree requirements.

### *Responses to Academic Dishonesty, Plagiarism, or Cheating*

Students should also familiarize themselves with the procedures for academic misconduct in UCF's student handbook, *The Golden Rule* <<https://goldenrule.sdes.ucf.edu/>>. UCF faculty members have a responsibility for students' education and the value of a UCF degree, and so seek to prevent unethical behavior and respond to academic misconduct when necessary. Penalties for violating rules, policies, and instructions within this course can range from a zero on the exercise to an "F" letter grade in the course. In addition, an Academic Misconduct report could be filed with the Office of Student Conduct, which could lead to disciplinary warning, disciplinary probation, or deferred suspension or separation from the University through suspension, dismissal, or expulsion with the addition of a "Z" designation on one's transcript.

Being found in violation of academic conduct standards could result in a student having to disclose such behavior on a graduate school application, being removed from a leadership position within a student organization, the recipient of scholarships, participation in University activities such as study abroad, internships, etc.

Let's avoid all of this by demonstrating values of honesty, trust, and integrity. No grade is worth compromising your integrity and moving your moral compass. Stay true to doing the right thing: take the zero, not a shortcut.

### *Unauthorized Use of Websites and Internet Resources*

There are many websites claiming to offer study aids to students, but in using such websites, students could find themselves in violation of academic conduct guidelines. These websites include (but are not limited to) Quizlet, Course Hero, Chegg Study, and Clutch Prep. UCF does not endorse the use of these products in an unethical manner, which could lead to a violation of our University's Rules of Conduct. They encourage students to upload course materials, such as test questions, individual assignments, and examples of graded material. Such materials are the intellectual property of instructors, the university, or publishers and may not be distributed without prior authorization. Students who engage in such activity could be found in violation of academic conduct standards and could face course and/or University penalties. Please let me know if you are uncertain about the use of a website so I can determine its legitimacy.

### *Unauthorized Distribution of Class Notes*

Third parties may attempt to connect with you to sell your notes and other course information from this class. Distributing course materials to a third party without my authorization is a violation of our University's Rules of Conduct. Please be aware that such class materials that may have already been given to such third parties may contain errors, which could affect your performance or grade. Recommendations for success in this course include coming to class on a routine basis, visiting me during my office hours, connecting with the Teaching Assistant (TA), and making use of the Student Academic Resource Center (SARC), the University Writing Center (UWC), the Math Lab, etc. If a third party should contact you regarding such an offer, I would appreciate your bringing this to my attention. We all play a part in creating a course climate of integrity.

### ***In-Class Recording***

Students may, without prior notice, record video or audio of a class lecture for a class in which the student is enrolled for their own personal educational use. A class lecture is defined as a formal or methodical oral presentation as part of a university course intended to present information or teach enrolled students about a particular subject. Recording class activities other than class lectures, including but not limited to lab sessions, student presentations (whether individually or part of a group), class discussion (except when incidental to and incorporated within a class lecture), clinical presentations such as patient history, academic exercises involving student participation, test or examination administrations, field trips, private

conversations between students in the class or between a student and the faculty member, and invited guest speakers is prohibited. Recordings may not be used as a substitute for class participation and class attendance, and may not be published or shared without the written consent of the faculty member. Failure to adhere to these requirements may constitute a violation of the University's Student Code of Conduct as described in the Golden Rule.

### **Course Accessibility Statement**

The University of Central Florida is committed to providing access and inclusion for all persons with disabilities. Students with disabilities who need access to course content due to course design limitations should contact the professor as soon as possible. Students should also connect with Student Accessibility Services (SAS) <<http://sas.sdes.ucf.edu/>> (Ferrell Commons 185, [sas@ucf.edu](mailto:sas@ucf.edu), phone 407-823-2371). For students connected with SAS, a Course Accessibility Letter may be created and sent to professors, which informs faculty of potential course access and accommodations that might be necessary and reasonable. Determining reasonable access and accommodations requires consideration of the course design, course learning objectives and the individual academic and course barriers experienced by the student. Further conversation with SAS, faculty and the student may be warranted to ensure an accessible course experience.

### **Campus Safety Statement**

Emergencies on campus are rare, but if one should arise during class, everyone needs to work together. Students should be aware of their surroundings and familiar with some basic safety and security concepts.

- In case of an emergency, dial 911 for assistance.
- Every UCF classroom contains an emergency procedure guide posted on a wall near the door. Students should make a note of the guide's physical location and review the online version at <<https://centralflorida-prod.modolabs.net/student/safety/index>>.
- Students should know the evacuation routes from each of their classrooms and have a plan for finding safety in case of an emergency.
- If there is a medical emergency during class, students may need to access a first-aid kit or AED (Automated External Defibrillator). To learn where those are located, see <<https://ehs.ucf.edu/automated-external-defibrillator-aed-locations>>.
- To stay informed about emergency situations, students can sign up to receive UCF text alerts by going to <<https://my.ucf.edu>> and logging in. Click on "Student Self Service" located on the left side of the screen in the toolbar, scroll down to the blue "Personal Information" heading on the Student Center screen, click on "UCF Alert", fill out the information, including e-mail address, cell phone number, and cell phone provider, click "Apply" to save the changes, and then click "OK."
- Students with special needs related to emergency situations should speak with their instructors outside of class.
- To learn about how to manage an active-shooter situation on campus or elsewhere, consider viewing this video (<<https://youtu.be/NIKYajEx4pk>>).

### **Deployed Active Duty Military Students**

If you are a deployed active duty military student and feel that you may need a special accommodation due to that unique status, please contact your instructor to discuss your circumstances.

### **Title IX Policy**

Title IX prohibits sex discrimination, including sexual misconduct, sexual violence, sexual harassment, and retaliation. If you or someone you know has been harassed or assaulted, you can find resources available to support the victim, including confidential resources and information concerning reporting options at <https://letsbeclear.ucf.edu> and <http://cares.sdes.ucf.edu/>

