College of Optics & Photonics

Fall 2016

OSE-5203 Geometrical Optics and Imaging Science

Time: Monday and Wednesday 1:30 PM – 2:45 PM
August 22, 2016 – December 12, 2016

Location: CREOL-A214

Credit Hours: 3 hours

Prerequisite: Graduate standing or consent of instructor

Catalog Description: Fundamentals of Geometrical Optics, Geometrical Theory of Image Formation and Aberrations.

Course Description:
Optical rays. Fermat's principle. Reflection and refraction from planar and curved surfaces. Imagery by a single surface and multiples surfaces. Gaussian and Newtonian imaging equations. Magnification. Cardinal points. Stops and pupils. Vignetting. Field of view. Numerical aperture. Radiometry and Photometry. Chromatic dispersion and chromatics aberrations. Monochromatic aberrations. Seidel Third Order Primary and the Seidel Sums. Elementary optical systems; the eye, microscopes, telescopes, projectors.

Learning Outcomes:

- Upon completion of this course, students should understand the basic principles of modern geometrical optics.
- The students should also be able to solve analysis and design problems for basic optical systems:
- The students should be able to perform an exact ray tracing and evaluate the system aberrations.

Instructor: Dr. Jim Moharam, Professor

- Office CREOL – 274
- **Email:** moharam@creol.ucf.edu

Office Hours: Monday and Wednesday 3:00 PM - 4:00 PM or by appointment

Class Website:

- Course materials (syllabus, notes, problem sets, solutions, and old exams) will be available on https://webcourses.**ucf**.edu/
- Lectures are "video streamed" through the **PANOPTO** system.

Reference Materials:

- Class notes
- E. L. Dereniak and T. D. Dereniak, "Geometrical and Trigonometric" Cambridge University Press 2008. (could be useful but not required)

Course Requirements and Grading Policy:

- **Problem sets: 10%**
  - Problem sets are to be submitted before the beginning of the class on the due date in person or by e-mail.
  - Late homework will not be accepted.
  - You may work with others but the submission must be all yours.
- **Midterm Exam I: 25%**
  - Monday, October 3, 2016 1:30 PM -2:45 PM
- **Midterm Exam II: 25%**
  - Monday, November 7, 2016 1:30 PM -2:45 PM
- **Final Exam: 40%**
  - Monday, December 12, 2016 1:00 PM -3:50 PM

Exams are comprehensive and are closed book and notes.
All exams are held in CREOL A-214.

Make up Work/Exam Policy:

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

Grading Scale:

Plus and minus grades will be used.

(%)	Rubric Description
$A \geq 90$	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.
$90 > B \geq 70$	Good, has a strong understanding of most or all of the concepts and is able to apply them to stated and defined situations.
$70 > C \geq 60$	Average, has a basic understanding of the major concepts of the course and is able to apply to basic situations.
$60 > D \geq 50$	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.
$F < 50$	Demonstrates no understanding of the course content

Calendar:

August (3)		September (8)		October (8)		November (8)		December (1)	
				3 (MT)	5		2		
		5 (H)	7	10	12	**7 (MT)**	9		
		12	14	17	19	14	16	**12 (F)**	
22	24	19	21	24	25	21	23 **(C)**		
29	31	26	28	31		28	30		

- **National Holiday-University Closed** September 5, 2016
- **Withdrawal deadline** October 31, 2016
- **Class Cancelled** November 23, 2016

General Information:

- Students in the on-campus sections are required to attend the class in person.
- Your e-mail of record at UCF will be used for communication.
- My preferred method of communication (other than in person) is e-mail. It is checked regularly including on weekends.
- If you have questions, out of office hours. E-mail me and I will get back to you within a reasonable time.

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 by e-mail (pdf format preferred). Graded problem sets and exams will be e-mailed back.

Financial Aid and Attendance:

- Students' academic activity at the beginning of each course must be documented. In order to document that you began this course, student must complete the ***academic participation verification question*** *posted on* ***Webcourses*** no later than week after the first class. Failure to do so will result in a delay in the disbursement of financial aid.

Class Attendance:

- Regular class attendance is necessary for students to fully grasp the course concepts. If you miss a class session, it will be your responsibility to find out the materials that were covered.

Professionalism:

- 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. You should be present in class before the lecture begins.

Ethics:

- As in all university courses, “The Golden Rule of Conduct” will be applied. 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) for further details. Violation of these rules will result in a record of the infraction being placed in your file and additional sanctions may be applied.

Students with Special Testing/Learning Needs:

- Students with documented special needs and requiring special accommodations must be registered with UCF Student Disability Services (www.sds.sdes.ucf.edu) or at (407) 823-2371 prior to receiving those accommodations. Students must inform the instructor of their special needs as early as possible in the first week of classes.

Course Outline:

- **The Foundations of Geometrical Optics**
  Waves, wave fronts, and rays
  Propagation of wave fronts, reflection, refraction
  Fermat's principle
  Irradiance and the inverse-square law
  The basic postulates of geometrical optics
- **Elementary Ray Optics**
  Plane surfaces
  Curved surfaces: focusing
- **Imagery by a Single Surface and a Thin Lens**
  The sign convention
  The paraxial approximation
  Imagery by a single surface
  Imagery by a thin lens
  Imagery of an extended object
  Magnification: longitudinal, angular, and visual magnifications
  Imagery of a volume
- **Gaussian Optics**
  The paraxial height and angle variables
  Paraxial ray tracing for systems of many surfaces
  Principal planes and back and front focal planes
  Thick lenses: power and location of principal planes
  Nodal points, measurement of focal length
  Newtonian imaging equation
- **ABCD Matrix Transformation**
  Matrix formulation for refraction and for translation
  The conjugate matrix
  Object and image planes
- **Real ray tracing**
  Ray transfer between spherical surfaces
  Refraction of a general ray
  Meridional and skew rays
- **Stops and Pupils**
  System stop and entrance and exit pupils
  Marginal and edge rays
  Vignetting
  Optical invariant
  Field stop and entrance and exit windows
  Field of view
  Numerical aperture and number
  Depth of focus and depth of field
- **Radiometry and Photometry**
  Light flux transmission through optical systems

Solid angle and projected area
Radiant flux, irradiance, radiance, Lambertian sources
Radiometry of imaging systems
Extended sources, distant sources

- **Aberrations**
  Optical material dispersion
  Chromatic aberrations
  Chromatic aberrations correction -Achromats
  Monochromatic aberrations
  The wave aberration function and classification of aberration
  The Seidel aberration coefficients
  Longitudinal and transverse Focus shifts
  Primary aberrations: spherical, coma, astigmatism, distortion, field curvature
  The Seidel Sums
  Primary aberrations of a reflecting prism (plane parallel plates)
  Primary aberrations of a spherical mirror
  Thin lens central aberrations (stop at the lens)
  Thin lens aberration with a remote stop
- **Gaussian Optics of Optical Instruments and Components**
  Objectives, telescopes, microscopes, projection systems, the eye