College of Optics & Photonics

Spring 2022
OSE-5203 Geometrical Optics

Time: Tuesday and Thursday 1:30 PM – 2:45 PM
January 11, 2021 – May 3, 2022

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:

- The students should understand the basic principles of modern geometrical optics.
- The students should also be able to analysis and design 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-234
- **Email:** moharam@creol.ucf.edu
- **Office Hours:** Monday and Wednesday 3:00 PM - 4:00 PM or by appointment on Zoom

Class Website:

- Course materials (syllabus, notes, problem sets, solutions, and old exams) will be available on https://webcourses.**ucf**.edu/.
- Lectures are recorded on Zoom and the link to the lectures is available on Webcourses.

Reference Materials:

- Class notes.
- P. Mouroulis and J. MacDonald, "Geometrical Optics and Optical Design" Oxford University Press 1997. (not required)
- E. L. Dereniak and T. D. Dereniak, "Geometrical and Trigonometric" Cambridge University Press 2008. (not required)

Course Requirements and Grading Policy:

- **Problem sets: 10%**
  - Problem sets are to be submitted by the due date either in person in class or by email in PDF format: (Last Name-HW#.PDF).
  - Late homework will not be accepted.
  - You may work with others but the submission must be all yours.
- **Midterm Exam I:** **25%** Thursday, February 17 1:30 - 2:45 PM
- **Midterm Exam II:** **25%** Thursday, March 31 1:30 - 2:45 PM
- **Final Exam:** **40%** Tuesday, May 3th 1:00 - 3:50 PM

  Exams are comprehensive and are closed book and notes.

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 or 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. 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:

January (6)		**February (8)**		**March (8)**		**April (6)**		**May**	
		1	3	1	3				
		8	10	**8 (SB)**	**10 (SB)**	5	7	**3 (F)**	
11	13	15	**17 (MT)**	15	17	12	14		
18	20	22	24	22	24	19	21		
25	27			29	**31 (MT)**				

- National Holiday-University Closed January 17, 2022
- Spring Break – No Classes March 6-13, 2022
- Withdrawal deadline March 25, 2022

General Information:

- Students in the on-campus section 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 Student in the Remote Section:

- The exams will be administered remotely under the honor code. External materials of any form (book, notes, electronic, information on the web, etc.) as well as discussing or seeking or receiving assistance on the exam from others are not allowed. Procedures will be announced.

Financial Aid and Participation Verification:

- Students' academic activity at the beginning of each course must be documented. Student must complete the ***academic participation verification question*** *posted on* ***Webcourses*** no later than week after the first class. Failure to do so may 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.

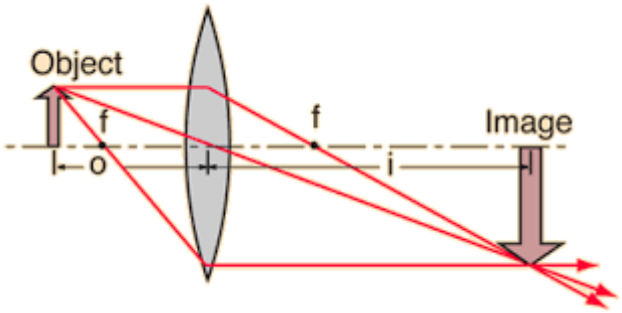
Ethics:

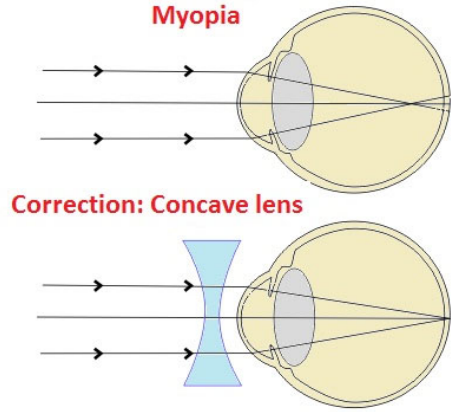
- As in all university courses, "The Golden Rule of Conduct" will be applied. If you are uncertain as to what constitutes academic dishonesty, please consult "The Golden Rule" in the UCF Student Handbook (www.goldenrule.sdes.ucf.edu) for further details. Violation of these rules will result in a record of the infraction being placed in your file and additional sanctions may be applied.

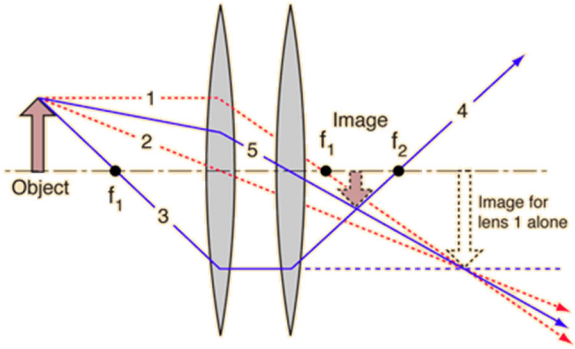
Students with Special Testing/Learning Needs:

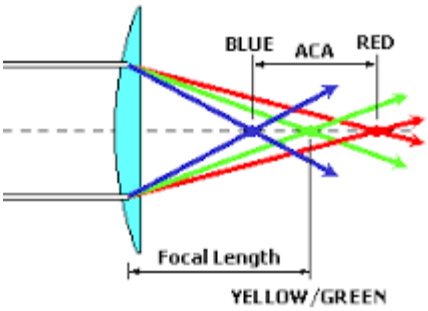
- Students with documented special needs and requiring special accommodations must be registered with UCF Student Disability Services (www.sds.sdes.ucf.edu) or at (407) 823-2371 prior to receiving those accommodations. Students must inform the instructor of their special needs as early as possible in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

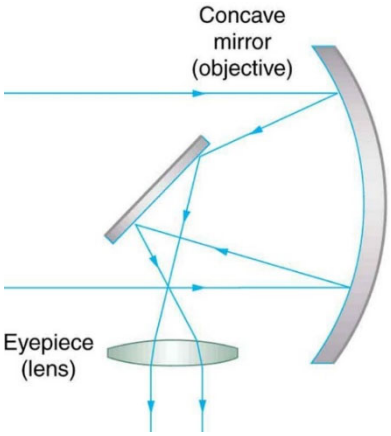
Optical Imaging System:

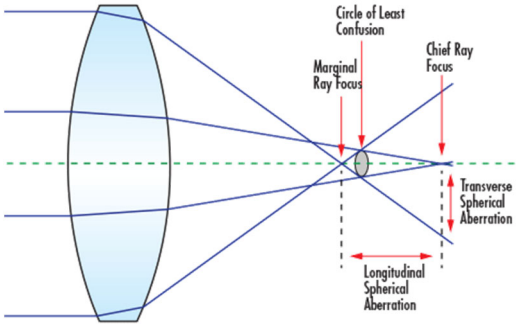


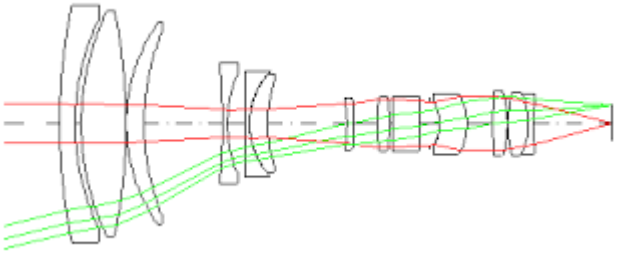












Infinity-sa.com. sciencedirect.com, hyperphysics.astr.gsu.edu, edmondoptics.com

Course Outline:

- **The Foundations of Geometrical Optics**
  Waves, wavefronts, and rays
  Irradiance and the inverse-square law
  Propagation of wave fronts, reflection, refraction
  Snell's Law
  Fermat's principle
  The basic postulates of geometrical optics
- **Elementary Ray Optics of Planar Surfaces**
  Reflection and refraction
  Image parity and handedness upon reflection
  Plates –ray lateral displacement and image longitudinal shift
  Mirrors
  Prisms –refraction and reflection
- **The Paraxial Approximation for Curved Surfaces**
  Spherical and Parabolic surface
  Small angle approximation
  Ray height and sign convention
  Thin lens approximation
  Primary and secondary focal points
  Real and virtual image
  Optical power
  Graphical ray tracing
- **Imagery by a Single Surface and a Thin Lens**
  Imagery by a single surface
  The conjugate equation
  Optical power and the effective focal length
  Primary and secondary focal distances
  Imagery by a mirror
  Imagery by a thin lens
  Image size and location
  Magnification: longitudinal, angular, and visual magnifications
  Imagery of an extended object
- **Gaussian Optics**
  Paraxial ray tracing for systems of many surfaces
  Gaussian ray tracing equation.
  Magnification by a multi-surface system
  Primary and secondary principal planes
  Frond and back focal planes
  Imagery by a thick lens
  Nodal points, measurement of focal length
  Newtonian imaging equation
  Optics of the eye

- **ABCD Matrix Transformation**
  Matrix formulation for refraction and for translation
  The conjugate matrix
  Principal and focal planes
  Object and image planes
- **Apertures in Optics systems**
  System aperture stop and entrance and exit pupils
  Marginal and chief 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
- **Chromatic Aberration**
  Optical material dispersion
  Chromatic aberrations
  Chromatic aberrations correction –Achromats
- **Real ray tracing**
  Ray transfer between spherical surfaces
  Refraction of a general ray
  Meridional and skew rays
- **Monochromatic Aberration**
  Ray aberration and wavefront aberration
  The wave aberration function and classification of aberration
  The Seidel aberration polynomial
  Seidel primary aberrations
  Longitudinal and transverse focus shifts
  Primary aberrations: spherical, coma, astigmatism, distortion, field curvature
  The Seidel Sums
  Primary aberrations of a 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