

ROCHESTER INSTITUTE OF TECHNOLOGY
Rochester, New York

COLLEGE of SCIENCE
CHESTER F. CARLSON CENTER for IMAGING SCIENCE

Revised Course: OPTICS FOR IMAGING - SIMG 303

1.0 TITLE: OPTICS FOR IMAGING I
DATE: 2 Feb. 2005
CREDIT HOURS: 4
PREREQUISITE(S): 1017-313

COREQUISITE(S): none
COURSE PROPOSED BY: Roger L. Easton, Jr.
REVISED BY: Joel Kastner

2.0 COURSE INFORMATION:

	Contact Hours	Maximum Students / Section
Classroom	3	30
Lab	3	10
Studio	n/a	n/a
Other	n/a	n/a

QUARTER(S) OFFERED:

Fall Winter Spring Summer

STUDENTS REQUIRED TO TAKE THIS COURSE:

Imaging Science, 2nd year

STUDENTS WHO MIGHT ELECT TO TAKE THE COURSE:

Applied Mathematics, Physics, Imaging and Photographic Technology,
Environmental Science

3.0 GOALS OF THE COURSE:

- 3.1 Determine locations and sizes of images produced by optical systems with multiple elements
- 3.2 Understand the concepts of aberrations
- 3.3 Design, characterize, and optimize simple imaging systems

4.0 COURSE DESCRIPTION:

1051-303

Optics for Imaging I

This course introduces the description of optical imaging systems based on the ray model of light. Topics include refraction, reflection, imaging with lenses, stops and pupils, and optical system design using computer software.
(1017-313) **Class 3, Lab 3, Credit 4 (W)**

5.0 POSSIBLE RESOURCES:

- 5.1 *The Geometrical Optics Workbook*, D. Loshin, Butterworth-Heinemann
- 5.2 *Optics*, E. Hecht, Addison-Wesley.
- 5.3 *Seeing the Light*, D. Falk, D. Brill, and D. Stork, Harper and Row.
- 5.4 OSLO lens design software (Lambda Research Corp.)

6.0 TOPICS:

- 6.1 Wave and ray representation of light
 - 6.1.1 Review of wave properties (wavelength, frequency, period, etc)
 - 6.1.2 Huygen's Principle
 - 6.1.3 Rays: sign conventions
 - 6.1.4 Concept of vergence
 - 6.1.5 Pinhole camera & shadows
- 6.2 Laws of reflection & refraction
 - 6.2.1 Refractive index, dispersion
 - 6.2.2 Fresnel's Law
 - 6.2.3 Snell's law: derivation
 - 6.2.4 Critical angle
 - 6.2.5 Fermat's Principle; optical path length
 - 6.2.6 Refraction through multiple surfaces; apparent thickness
- 6.3 Prisms
 - 6.3.1 Definitions (apical angle; incident, internal, emergent angles; etc)
 - 6.3.2 Relationship between internal, external, apical, and ray deviation angles
 - 6.3.3 Limitations on refraction and deviation through prisms; reflecting prisms
 - 6.3.4 Dispersive power of prisms
- 6.4 Curved refracting surfaces
 - 6.4.1 Radius and sag; sagittal approximation
 - 6.4.2 Radius and surface power
 - 6.4.3 Reduced vergence
 - 6.4.4 Vergence equation (aka Gaussian Image Eqn); derivation via paraxial approx.
 - 6.4.5 Focal points, lateral magnification, extrafocal distance
 - 6.4.6 Ray tracing for positive & negative refracting surfaces
- 6.5 Thin lenses
 - 6.5.1 Thin lens power ("lens maker's equation")
 - 6.5.2 Vergence eqn. for thin lenses
 - 6.5.3 Focal points; "thin lens equation"
 - 6.5.4 Real & virtual images; location & magnification; symmetrical planes
 - 6.5.5 Ray tracing for positive & negative lenses
 - 6.5.6 Chromatic aberration
- 6.6 Thick lenses & thin lens combinations
 - 6.6.1 Telescopes & microscopes: intro to multi-element ray tracing
 - 6.6.2 Equivalent power
 - 6.6.3 Thick lenses

- 6.6.3.1 Surface & net powers and thick lens focal lengths
 - 6.6.3.2 Principal planes, nodal points
 - 6.6.4 Thin lens combinations
 - 6.6.4.1 Thick lenses as thin lens combinations
 - 6.6.4.2 Ray tracing: element-by-element method
 - 6.7 Plane and curved mirrors
 - 6.7.1 Plane mirrors: ray deviation, image formation
 - 6.7.2 Mirror curvature, power, and focal points
 - 6.7.3 Vergence equation for curved mirrors
 - 6.7.4 Image-object relationships: size & orientation
 - 6.7.5 Spherical aberration; parabolic mirrors
 - 6.7.6 Using mirrors at grazing incidence
 - 6.8 Stops and pupils
 - 6.8.1 Practical definitions of aperture & field stops, entrance/exit pupils
 - 6.8.2 Aperture and Depth of field
 - 6.8.3 Aperture and radiometry
 - 6.8.4 Diffraction limit
 - 6.9 Introduction to the MTF
 - 6.9.1 Concept of modulation transfer function
 - 6.9.2 Aberrations and MTF
 - 6.9.3 Diffraction limit and MTF
 - 6.10 Optical raytracing software
 - 6.9.1 Computer-aided optical system design
 - 6.11 Laboratory Experiments
 - 6.11.1 Pinhole camera: geometry and blur
 - 6.11.2 Snell's law, dispersion, and prisms
 - 6.11.3 Methods of measuring lens power (two-part lab)
 - 6.11.4 Thin-lens combinations & telescopes
 - 6.11.5 Measurement of aberrations
 - 6.11.6 Lens design using OSLO
 - 6.11.7 Optical systems: simulated vs. real (using OSLO; "final project")
- 7.0 INTENDED LEARNING OUTCOMES AND ASSOCIATED ASSESSMENT METHODS OF THOSE OUTCOMES:
- 7.1 Determine locations and sizes of images produced by optical systems with multiple elements. (HOMEWORK ASSIGNMENTS, EXAMS, LABORATORIES)
 - 7.2 Understand the concepts of aberrations (HOMEWORK ASSIGNMENTS, EXAMS, LABORATORIES)
 - 7.3 Design, characterize, and optimize simple imaging systems. (HOMEWORK ASSIGNMENTS, LABORATORIES)
- 8.0 PROGRAM OR GENERAL EDUCATION GOALS SUPPORTED BY THIS COURSE:
- 8.1 The student will have the basic understanding of the means and limitations of optical systems when used to create images.
 - 8.2 The student will be prepared for the upper-level required and elective courses in imaging science that require understanding of these concepts.

9.0 OTHER RELEVANT INFORMATION:

- 9.1 Course must be scheduled in a classroom equipped with a high-resolution projector (1280×1024) for classroom instruction

10.0 SUPPLEMENTAL INFORMATION: none