

# OPTI 513R / Optical Testing

**Instructor:**

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**Office Hours:** Email for appointment

**Prerequisites:** OPTI 505

**Course Description:**

Review of paraxial properties of optical systems; optical material qualification; optical aberrations; interferometry; distance/slope measuring optical sensors/instruments; deflectometry; measurement of surface shape, mid-spatial frequency error and micro roughness; testing concave/convex optics; testing of spherical surfaces and lenses; freeform/aspheric surface metrology; dynamic/instantaneous metrology.

**Learning Objectives:**

1. Test/measure optical components and systems.
2. Evaluate optical system performance.
3. Explain basic interferometry, deflectometry, and optical sensors for optical testing.
4. Better specify optical components and systems.
5. Determine if an optics supplier can actually supply the optics you are ordering.
6. Design/produce higher-quality optical systems.

**Grading:**

1. You will be given a mid-term exam and a final exam during the semester. (All exams will be in-class, closed book exams.)
2. The homework will be due by the "beginning of class" on the date stated on each assignment sheet. Credit will be reduced 25% for each day a homework assignment is late.
3. The final grade in the course will be calculated as follows: homework - 30%; mid-term exam - 30%; and final exam - 40%.

**Special Acknowledgement:**

The 513R course materials were originally prepared/created by Dr. James C. Wyant and generously handed over to Dr. Dae Wook Kim for the continuing educational mission.

**Course References:**

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|----------------------------------|--|
| 1. Optical Society of America    | Optics Infobase                                |
| 2. SPIE                          | Digital Library                                |
| 3. D. Malacara, Ed.              | Optical Shop Testing, Third Edition            |
| 4. E. P. Goodwin and J. C. Wyant | Field Guide to Interferometric Optical Testing |
| 5. W. Smith                      | Modern Optical Engineering                     |

**Lecture Outline:**

*(Note: It is a "live" outline and schedule. In order to cover more up-to-date technologies and emerging topics, as necessary, this schedule and topic list could be changed during the semester.)*

1. Review of Paraxial Properties of Optical Systems
  - 1.1 Thin Lenses
  - 1.2 Thick Lenses
  
2. Qualification of Optical Material
  - 2.1 Internal Defects
  - 2.2 Measurement of Refractive Index
  - 2.3 Strain
  - 2.4 Mechanical and Thermal Properties
  
3. Optical Aberrations
  - 3.1 Sign Conventions
  - 3.2 Aberration Free Image
  - 3.3 Spherical Wavefront, Defocus, and Lateral Shift
  - 3.4 Angular, Transverse, and Longitudinal Aberration
  - 3.5 Seidel Aberrations
  - 3.6 Zernike Polynomials
  - 3.7 Peak-Valley and RMS Wavefront Aberration
  - 3.8 Strehl Ratio
  - 3.9 Chromatic Aberrations
  - 3.10 Aberrations Introduced by Plane Parallel Plates
  - 3.11 Aberrations of Simple Thin Lenses
  - 3.12 Conics
  - 3.13 General Aspheres/Freeform Surfaces
  
4. Interferometry for Optical Testing
  - 4.1 Two Beam Interference
  - 4.2 Pioneer Fizeau Interferometer
  - 4.3 Twyman-Green Interferometer
  - 4.4 Fizeau Interferometer – Laser Source
  - 4.5 Mach-Zehnder Interferometer
  - 4.6 Typical Interferograms

- 4.7 Interferograms and Moiré Patterns
- 4.8 Classical techniques for inputting data into computer
- 4.9 Direct Phase Measurement Interferometry
- 4.10 Vertical Scanning (Coherence Probe) Techniques
  
- 5. Distance/Slope Measuring Optical Sensors/Instruments
  - 5.1 Distance Measuring Sensors
  - 5.2 Laser Trackers
  - 5.3 Scanning Pentaprism Test
  
- 6. Deflectometry for Optical Testing
  - 6.1 Deflectometry Concept
  - 6.2 Visible Deflectometry
  - 6.3 IR Deflectometry
  - 6.4 Deflectometry and Fringe Projection Technique
  
- 7. Measurement of Surface Quality/Micro Roughness
  - 7.1 View transmitted or reflected light
  - 7.2 Mechanical Probe – Stylus Profilometry
  - 7.3 AFM– Atomic Force Microscope or SPM – Scanning Probe Microscope
  - 7.4 Lyot Test (Zernike Phase Contrast)
  - 7.5 FECO – Fringes of Equal Chromatic Order
  - 7.6 Nomarski Interferometer - Differential Interference Contrast (DIC)
  - 7.7 Interference Microscope
  
- 8. Testing Flat Surface Optical Components
  - 8.1 Mirrors
  - 8.2 Windows
  - 8.3 Prisms
  - 8.4 Corner Cubes
  - 8.5 Diffraction Gratings
  
- 9. Testing of Curved Surfaces and/or Lenses
  - 9.1 Radius of Curvature
  - 9.2 Surface Figure
  
- 10. Metrology for Aspherical/Freeform Surfaces
  - 10.1 Aspheric Surfaces
  - 10.2 Null Test
  - 10.3 Non-Null Test