**Optics 505 – Diffraction and Interferometry**

**Term:** Spring 2017

**Course #:** OPTI 505R

**Course Title:** Diffraction and Interferometry

**Instructor:** Tom D. Milster  
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University of Arizona  
Tucson, AZ 85721  
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**Email:** milster@optics.arizona.edu

**Web site:** [www.d2l.arizona.edu](http://www.d2l.arizona.edu)  
CLASS WEBSITE FOR ADDITIONAL MATERIAL

**Office Hours:** 1:00pm – 3:00pm Monday and Friday

**Recitation:** 2:30pm – 4:00pm Wednesday (Room 307)

**Course Time:** 9:30 – 10:45 AM  
**Dates:** Tuesday/Thursday  
**Location:** OPTI 307

**Prerequisites:** Optics (501), 512

**TAs:**  
Shu Yang ([shuyang@optics.arizona.edu](mailto:shuyang@optics.arizona.edu))  
Weichuan Gao ([weichuan@optics.arizona.edu](mailto:weichuan@optics.arizona.edu))  
TA office hours TBD.

**Course Description:**  
Interference and interferometry; diffraction theory; Fraunhofer and Fresnel diffraction; concepts of coherence; spatial frequency analysis of optical systems. (Holography and Speckle are presented in optional lectures).

**Homework, Grades, and Exams/Final**  
There are two take-home exams during the semester and a comprehensive final exam. An online mini quiz and homework are given most weeks. The final grade in the course is calculated as follows (100pts total):

<table>
<thead>
<tr>
<th>Component</th>
<th>Points</th>
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<tbody>
<tr>
<td>In-class exams</td>
<td>40pts</td>
</tr>
<tr>
<td>Comprehensive final</td>
<td>30pts</td>
</tr>
<tr>
<td>Online mini quizzes</td>
<td>24pts</td>
</tr>
<tr>
<td>Notes Pages</td>
<td>6pts</td>
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I do not grade on a curve. Grades are assigned by:

- A: 100-90pts
- B: 89-80pts
- C: 79-70pts
Class Notes: Class notes, homework solutions and other information are provided on the D2L website under the “Content” menu bar item.

Detailed online mini-quiz information: Twelve online mini-quizzes are given during the semester through the D2L website (Login at http://d2l.arizona.edu. Each quiz covers approximately one week of class material.) Quizzes are a combination of randomized multiple choice and true-false questions. You need a UA NetID in order to logon to the system and take quizzes. Quizzes are available at any time during the semester, once they are posted. Quizzes have a time limit of 15 minutes, once you start the quiz. You may use any resource, other than another person, in order to work the online mini-quizzes. They are based on the lectures and reading assignments from course notes. You are allowed three attempts to take each quiz. Your final score for each quiz is the highest score of all attempts. The online quizzes must be completed according to the schedule shown below. Note that you must finish each quiz by 5pm on the assigned day.

Notes Page: You will be responsible for three “Notes Page” summary sheets that accompany the three exams. Each Notes Page is an original one-side, one-page summary of course material appropriate for the associated exam. A copy of your Notes Page must be turned in via upload to D2L on midnight before the in-class exams and by May 4 for the final exam. The pages will be checked and approved for format (one side, one page) before each exam. You may bring your Notes Pages to the exams and use them during the exams, if they are approved. Zero credit is assigned for late submissions.

In-class exam information: The two in-class exams are problem oriented. Problems are similar to homework questions and appropriate sections of written comprehensive/qualifying exam questions. Calculators will be provided. Only the Notes Pages are allowed as reference material that can be used during the exams. Otherwise, the exams are closed book.

Final comprehensive exam: The final exam is administered at a time determined by the UA listing for final exams, as listed below. It is closed book and closed notes. Calculators are provided. The three exam questions are problem oriented and are variations of 505R Written Comprehensive/Qualifying Exam questions drawn from approximately the last 20 years.

Detailed homework information: Suggested homework problems are listed below according the course notes outline. Homework is not collected or graded. Solutions to all problems will be posted on D2L.

Recitation: Recitations are taped, and all students have access to the videos. These sessions are interactive, so I recommended that you attend. A discussion section is set up on the D2L website in order to post questions for the review sessions. Recitations are held Wednesday afternoons from 2:30pm until 4:00pm in room 307.

Discussion board: A discussion board is set up on D2L under the “Discussions” menu bar item. Both the TAs and Professor will monitor the discussion board on a regular basis in order to provide feedback. Student-to-student discussion is also encouraged.

Online lecture viewing for on-campus students: Permission will be granted to on-campus students by way of supplying an access password that is posted on the “News” items on the D2L class site.
Online demonstrations: Some in-class demonstrations performed in previous years are available online. Links to these short videos will be provided during the semester.

Optional Lectures: Several optional lectures are available on the video site and are available to all students. Example topics are Holography and Speckle.

Academic integrity: All students are expected to follow the University Of Arizona Code Of Academic Integrity. Violations will be immediately sanctioned, according to the guidelines found at: http://deanofstudents.arizona.edu/codeofacademicintegrity.

Attached you will find a tentative outline, schedule, and recommended texts.
Optics 505 – Diffraction and Interferometry

1) Introduction
   a) Administrative items
   b) Introduction to interferometry and diffraction
   c) Mathematical preliminaries

2) Waves and Polarization (LLE Chapter 3)
   a) Scalar, one-dimensional analysis
      i) Transverse waves
      ii) Linear superposition
      iii) Beats
      iv) Standing waves
   b) Plane waves
   c) Spherical Waves
   d) Polarization
      i) Linear polarization
      ii) Circular polarization
      iii) Elliptical polarization
      iv) Ellipticity
      v) Jones calculus
      vi) Stokes parameters and Mueller calculus
      vii) Degree of polarization

3) Interference and Interferometry (LLE Chapter 4)
   a) Basic two-beam interference
      i) Two plane waves
      ii) Two spherical waves
      iii) Plane wave and spherical wave
      iv) Plane wave and cylindrical wave
      v) Two cylindrical waves
   b) Classical two-beam interferometers
      i) Methods of beam division
      ii) Young’s double-pinhole interferometer (YDPI)
      iii) Young’s double-slit interferometer (YDSI)
      iv) Lloyd’s mirror
      v) Fresnel’s mirrors
      vi) Fresnel’s biperism
      vii) Twyman-Green
      viii) Mach-Zehnder
      ix) Michelson
      x) Fizeau and Newton’s rings
      xi) Plane parallel plate
      xii) Fizeau and Newton’s Rings
      xiii) Lateral shear
      xiv) Radial shear
      xv) Polarization splitters
      xvi) Diffraction gratings
   c) Multiple Beam Interference
      i) Airy’s formula
      ii) Absorbing coatings
      iii) Fabry Perot (plane and spherical)
   d) Multilayer Films (Separate notes)
      i) Theory
      ii) AR film
iii) High reflectance film

4) Scalar Diffraction (LLE Chapter 5)
   a) Introduction
   b) Mathematical Description of Diffraction
      i) Integral Theorem of Helmholtz and Kirchhoff
      ii) Diffraction by a plane screen
      iii) Huygens-Fresnel Principle
      iv) Derivation of a Huygens wavelet
      v) Transfer function of free space
      vi) Angular spectrum of plane waves
      vii) Talbot effect
      viii) Babinet’s principle
   c) Fresnel Diffraction
      i) Fresnel zones
      ii) Fresnel diffraction from apertures
      iii) Poisson’s spot
      iv) Fresnel zone plates
      v) Edge diffraction
      vi) Atlas of diffraction patterns in the near field
   d) Fraunhofer Diffraction
      i) Circular aperture
      ii) Exit pupil of an imaging system
      iii) Rectangular aperture
      iv) Diffraction from slits
   e) Theory of Gratings
      i) Geometric OPD theory
      ii) Fraunhofer diffraction from thin gratings
      iii) Thick gratings and Bragg diffraction

5) Coherence and fringe localization (LLE Chapter 6)
   a) The mutual coherence function
   b) Two-wavelength point source
   c) Power spectrum
   d) Basic temporal coherence
   e) Basic spatial coherence
   f) van Cittert – Zernike
   g) Coherence area
   h) Terminology
   i) Fringe localization

   a) Coherent imaging
   b) Incoherent imaging
   c) Microscopy and illumination*

7) Direct Phase Measurement (through additional lecture)
   a) Methods of phase shifting
   b) Algorithms

8) Holography (through optional lectures)
   a) Physical description
   b) Mathematical proof of reconstruction process
   c) Minimum reference beam angle to separate orders
   d) Recording and playback geometry
   e) Light sources and recording materials
   f) Volume holograms
g) Applications
9) Speckle (through optional lectures)
   a) Physical origin
   b) Applications

(*) denotes advanced topics that will be covered if time permits.
References – OPTI 505 – Diffraction and Interferometry

Primary
Online Class Notes

Secondary
Born & Wolf Principles of Optics
Goodman Introduction to Fourier Optics
Goodman Statistical Optics
Hecht Optics
Collier, Burckhardt, & Lin Optical Holography
Dainty Laser Speckle and Related Phenomena
Ditchburn Light
Francon Optical Interferometry
Francon & Mallick Polarization Interferometers
Francon et al. Atlas of Optical Phenomena and Supplement
Goodman Statistical Optics
Hariharan Optical Interferometry
Hariharan Optical Holography
Hariharan Basics of Interferometry
Jenkins & White Fundamentals of Optics
Jones & Wykes Holographic and Speckle Interferometry
Klein & Furtak Optics
Malacara Optical Shop Testing
Mertz Transformations in Optics
Möller Optics
Reynolds, DeVelis Physical Optics Notebook: Tutorials in Fourier Optics
Parent, and Thompson
Saleh and Teich Fundamentals of Photonics
Scott Introduction to Optics and Optical Imaging
Steel Interferometry
Stone Radiation and Optics
Tolansky Multiple-Beam Interferometry of Surfaces and Films
Vest Holographic Interferometry
Optics 505  
TENTATIVE SCHEDULE  
Diffraction and Interferometry

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* Indicates pre-tape, makeup or guest lecture class. The instructor might not be present.
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<td>1</td>
<td>Syllabus, Introduction, LLE Ch 3: 3.0 through 3.4.1.1</td>
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