Optics 505 – Diffraction and Interferometry

Term: Spring 2009

Course #: OPTI 505R

Course Title: Diffraction and Interferometry

Instructor: Tom D. Milster
Optical Sciences Center, Rm. 729
University of Arizona
Tucson, AZ 85721

Phone: (520) 621-8280

Email: milster@arizona.edu

Web site: www.optics.arizona.edu/milster

Office Hours: 1:00 PM– 3:00 PM Wednesday

Recitation: 1:00 PM– 3:00 PM Fridays (TBD location)

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

Prerequisites: Optics 501, 512

TA: Anoop George

Course Description:

Interference and interferometry; concepts of coherence; diffraction theory; Fraunhofer and Fresnel diffraction; optical transfer function; holography; speckle.

Homework, Grades, and Exams/Final

You will be given three midterm exams during the semester, plus an oral exam. In addition, you will be required to write two essays. Midterm exams will be in class. You will be allowed one page of notes for the midterms. Otherwise, no other reference material can be used while taking the midterm exams. There is no final. Due to budgetary issues, there will be no assigned homework. However, there will be posted problems and solutions on the web site. The final grade in the course will be calculated as follows:

Three in-class exams	90% (30% each)
Oral exam	5% (During Final Exam week)
Essays	5% (2.5% each)

Attached you will find a tentative outline, schedule, and recommended texts.

Please use the message board on the class web site in order to post messages and questions about class notes and homework assignments. The message board will be monitored on a regular basis, and we will try to provide a quick response. There is a simple password for the message board. Please log on as 505Rstudent. The password is ‘student’.

Optics 505 – Diffraction and Interferometry

1) Introduction
   a) Administrative items
   b) Introduction to interferometry and diffraction
   c) Mathematical preliminaries
2) Maxwell's Equations
   a) Dielectric materials and polarization
   b) Maxwell's equations and the wave equation in absorbing media
   c) Power flow and the Poynting vector
   d) Beer's Law
   e) Single-photon absorption: the band model
   f) Frequency dependence of the refractive index and absorption
   g) Free-space wave equation
3) Solutions to the Wave Equation
   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
4) Interference
   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 biprism
      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)

5) Basic Diffraction
- a) Introduction
- b) Mathematical Description of Diffraction
  - i) Integral Theorem of Helmhotz 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

6) Coherence and fringe localization
- 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

7) Optical Transfer Function
- a) Coherent imaging
- b) Incoherent imaging
- c) Microscopy and illumination*

8) Multilayer Films
- a) Theory
- b) AR film
- c) High reflectance film

9) Direct Phase Measurement
- a) Methods of phase shifting
- b) Algorithms

10) Holography
    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
11) Speckle
    a) Physical origin
    b) Applications

(*) denotes advanced topics that will be covered if time permits.

References – OPTI 505 – Diffraction and Interferometry

Primary

Born & Wolf	Principles of Optics
Goodman	Introduction to Fourier Optics
Hecht	Optics

Secondary

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
Mertz	Transformations in Optics
Möller	Optics
Reynolds, DeVelis Parrent, and Thompson	Physical Optics Notebook: Tutorials in Fourier Optics
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

Lecture No:	Date:	Section Covered:	
1	15-Jan (Th)	1,2	
2	20-Jan (Tu)	2,3	
3	22-Jan (Th)	3	
4	27-Jan (Tu)	3,4	
5	29-Jan (Th)	4	
6	3-Feb (Tu)	4	
7	5-Feb (Th)	4	
8	10-Feb (Tu)	4	
9	12-Feb (Th)	4	
10	17-Feb (Tu)	4	
11	19-Feb (Th)	Test Sections 1-4	
12	24-Feb (Tu)	5	
13	26-Feb (Th)	5	
14	3-Mar (Tu)	5	
15	5-Mar (Th)	5	
16	10-Mar (Tu)	5	
17	12-Mar (Th)	5	
	17-Mar (Tu)		**NO CLASS – SPRING BREAK**
	19-Mar (Th)		**NO CLASS – SPRING BREAK**
18	24-Mar (Tu)	5	
19	26-Mar (Th)	5	
20	31-Mar (Tu)	5	
21	2-Apr (Th)	5	
22	7-Apr (Tu)	Test Section 5	
23	9-Apr (Th)	6	
24	14-Apr (Tu)	6	
25	16-Apr (Th)	6	
26	21-Apr (Tu)	6	
27	23-Apr (Th)	Test Section 6	
28	28-Apr (Tu)	7	
29	30-Apr (Th)	8	
30	5-May (Tu)	9*	
	6-May (W)		**LAST DAY OF CLASSES**
	9-16 May	Oral Exam (Sections 7-11) & Essays (Sections 10&11)	**FINAL EXAM WEEK**

* Indicates pre-tape, makeup or guest lecture class. The instructor might not be present.