Optics 505 – Diffraction and Interferometry

Term: Spring 2019

Course #: OPTI 505R

Course Title: Diffraction and Interferometry

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Office Hours: 1:00pm – 3:00pm Monday and Wednesday

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

Prerequisites: Optics (501), 512

TAs: TBD

Course Description:

Waves and Polarization, Interference and interferometry; diffraction theory; Fraunhofer and Fresnel diffraction; concepts of coherence; optical transfer function (Holography and Speckle are presented in optional lectures).

Homework, Grades, and Exams/Final

There are six short section exams during the semester and a comprehensive final exam. Online mini quizzes accompany most lectures. The final grade in the course is calculated as follows (100pts total):

Section exams	60pts (10pts each)
Comprehensive final	12pts
Online mini quizzes	25pts (1pt each)
Homework Problems	3pts (0.5pt each)

I do not grade on a curve. Grades are assigned by:

A: 100-90pts
B: 89-80pts
C: 79-70pts
D: 69-60pts
E: Below 60pts

Class notes: Class notes, homework solutions and other information are provided on the D2L website under the "Content" menu bar item. The posted class notes are selected chapters from an upcoming book entitled "Laser Light Engineering." They are the primary reading resource for the class. Not all of the material contained in LLE chapters will be discussed in the lectures. Students are responsible only for the material covered in lectures.

In-class lectures: The primary lecture resource for the class is in the form of in-class lectures, which are also available as recoded videos shortly after the lecture is complete. Instructions for viewing the videos will be posted on the D2L web page "News" section and also distributed via email.

Detailed online mini-quiz information: Twenty-five online mini-quizzes (1pt each) are given during the semester through the D2L website (Login at http://d2l.arizona.edu). Each quiz covers one or two lectures of 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. Each quiz has four questions, which are worth 0.25pts each. 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 by 5:00pm on the day according to the schedule shown below. Distance students have an additional week to complete the mini quizzes.

Homework problems: Homework problems are listed in the course notes and schedule outline. Homework is uploaded into D2L and is checked for completeness by the grader. Late submissions are not accepted. Solutions to all problems are posted on D2L. Distance students have an additional week to turn in the problems.

Section exam information: The six section exams are problem oriented. Problems are similar to homework problems and appropriate sections of written comprehensive/qualifying exam questions. Calculators will be provided. The exams are closed book, no notes. Distance students have an extra week to complete the exams, with a proctor.

Final comprehensive exam: The final exam is administered at a time determined by the UA listing for final exams, as listed below. You are allowed one page of notes, single sided. Calculators are provided. The exam questions are problem oriented and are variations of 505R Written Comprehensive/Qualifying Exam questions drawn from approximately the last 20 years. Distance students have an extra week to complete the exam, with a proctor and approval of the note page.

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

TOPICAL LIST OF SUBJECTS

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 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)
   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 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
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
6) Optical Transfer Function – OTF (New notes for Spring 2018)
   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 – no exam questions)
   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 – no exam questions)
   a) Physical origin
   b) Applications

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

Class No:	Date:		Material Covered	
1	10-Jan	(Th)	Syllabus, Background, LLE Ch 3	
2*	15-Jan	(Tu)	LLE Ch 3	
3*	17-Jan	(Th)	LLE Ch 3	
	18-Jan	(F)		HW 1, MQ 1 and 2 (DUE 5:00 PM)
	21-Jan	(M)		**NO CLASS - MLK Holiday**
4	22-Jan	(Tu)	LLE Ch 4	
5	24-Jan	(Th)	LLE Ch 4	
	25-Jan	(F)		MQ 3 and 4 (5:00 PM)
	28-Jan	(M)		Section Quiz 1 – Ch 3 (5:30 PM)
6	29-Jan	(Tu)	LLE Ch 4	
7	31-Jan	(Th)	LLE Ch 4	
	1-Feb	(F)		MQ 5 and 6 (5:00 PM)
8	5-Feb	(Tu)	LLE Ch 4	
9	7-Feb	(Th)	LLE Ch 4	
	8-Feb	(F)		MQ 7 and 8 (5:00 PM)
10	12-Feb	(Tu)	LLE Ch 4	
11	14-Feb	(Th)	LLE Ch 4 – Review	
	15-Feb	(F)		HW 2, MQ 9 and 10 (5:00 PM)
	18- Feb	(M)		Section Quiz 2 – Ch 4 (5:30 PM)
12	19-Feb	(Tu)	LLE Ch 5	
13	21-Feb	(Th)	LLE Ch 5	
14	26-Feb	(Tu)	LLE Ch 5	
15	28-Feb	(Th)	LLE Ch 5	
	1-Mar	(F)		MQ 11 and 12 (5:00 PM)
	5-Mar	(Tu)		**NO CLASS – SPRING BREAK**
	7-Mar	(Th)		
16	12-Mar	(Tu)	LLE Ch 5	
17	14-Mar	(Th)	LLE Ch 5	
	15-Mar	(F)		HW 3, MQ 13 and 14 (5:00 PM)
	18-Mar	(M)		Section Quiz 3 – Ch 5A (5:30 PM)
18	19-Mar	(Tu)	LLE Ch 5	
19	21-Mar	(Th)	LLE Ch 5	
	22-Mar	(F)		MQ 15 and 16 (5:00 PM)
20*	26-Mar	(Tu)	LLE Ch 5	
21	28-Mar	(Th)	LLE Ch 5	
	29-Mar	(F)		HW 4, MQ 17 and 18 (5:00 PM)
	1-Apr	(M)		Section Quiz 4 – Ch 5B (5:30 PM)
22	2-Apr	(Tu)	LLE Ch 6	
23	4-Apr	(Th)	LLE Ch 6	
24	9-Apr	(Tu)	LLE Ch 6	
25	11-Apr	(Th)	LLE Ch 6	
				MQ 19 and 20 (5:00 PM)
26	16-Apr	(Tu)	LLE Ch 6, OTF	
27	18-Apr	(Th)	OTF	
	19-Apr	(F)		HW 5, MQ 21 and 22 (5:00 PM)
	22-Apr	(M)		Section Quiz 5 – Ch 6 (5:30 PM)
28	23-Apr	(Tu)	OTF	
29	25-Apr	(Th)	OTF	
	26-Apr	(F)		MQ 23 and 24
30	30-Apr	(Tu)	OTF	HW6 and MQ 25
	1-May	(W)		Section Quiz 6 – OTF (5:30 PM)

COMPREHENSIVE FINAL EXAM: Tuesday, May 7 at 9am in Room 307

Lecture numbers marked with (*) indicate that the lecture will be presented by video only.

OPTI 505R -
DRAFT - Homework Problems and Reading – S2019 version 110818

Lectures	Reading Suggestion	HW Problems
1	Introduction, LLE Ch 3: 3.0 through 3.3	
2	LLE: 3.4.1.1 through 3.4.1.3	
3	LLE: 3.4.1.4 through 3.4.3.2 (Exclude 3.4.2.7)	HW 1: 3-2, 3-3, 3-7, 3-11, 3-13, 3-22
4	LLE: 4.0 through 4.1.1.4	
5	LLE: 4.1.2 through 4.1.3	
6	LLE: 4.2.0 through 4.2.7	
7	LLE: 4.2.8	4-2, 4-9, 4-14
8	LLE: 4.2.9, 4.2.11 through 4.2.14	
9	LLE: 4.3.0 through 4.3.5	4-7,4-15, 4-18,
10	LLE: 4.3.6 through 4.3.6.4	
11	Thin Films Notes	4-26, 4-23, 4-16
12	MIDTERM EXAM	
13	LLE: 5.1 through 5.2.3	
14	LLE: 5.2.4 through 5.2.7	
15	LLE: 5.2.8 through 5.2.9	5-2, 5-4, 5-5
16	LLE: 5.2.9, 5.2.11 and Example 5.4	
17	LLE: 5.2.10, 5.3.1.1, 5.3.1.2, 5.3.2.1, and 5.3.2.2	5-8, 5-9, 5-10
18	LLE:5.3.2.3, 5.3.2.4 (including examples), and 5.3.4	
19	LLE: 5.3.4, 5.3.3 (Exclude Example 5.10), 5.3.5, 5.4 (intro) through 5.4.3, 5.4.5 (qualitative), and 5.4.6	5-13, 5-21, 5-22
20	LLE: 5.4.7, 5.5 (intro) through 5.5.1	
21	LLE: 5.5.2 through 5.5.3	5-30
22	MIDTERM EXAM	
23	LLE: 6.1 through 6.32	
24	LLE: 6.3.3	
25	LLE: 6.4.1 through 6.4.3	6-5, 6-6, 6-8
26	LLE: 6.4.4 through 6.4.6 and 6.6	
27	LLE: 8.1 through 8.2.2	6-9, 6-13, 6-15
28	LLE: 8.2.3 through 8.2.3.1	
29	LLE: 8.2.3.2	8-1, 8-7
30	LLE: 8.2.3.3	8-2