Course Syllabus

OSE 3052 Introduction to Photonics, Spring 2016

M, W 3:00 –4:15 PM, CREOL 102

Instructor: Dr. David Hagan

Discussion period Mondays, 4:30 – 5:20 PM, CREOL 103

Discussion Instructor: Dr. Romain Gaume

Office: Room 209 CREOL Building, hagan@creol.ucf.edu

Web site: **Materials available on UCF Webcourses system**

Office Hours: **Monday, Wednesday 2:00 – 3:00 pm (before class).**
Thursday, 11:00 am – 12:30 pm. (This time may be rearranged to best meet the needs of students time. – Will be discussed in class.)

I will be in my office at these times, but of course I will be happy to discuss the material with you anytime. Often, I get questions via e-mail that can be quickly answered.

Catalog Description:

Introduction to light as rays, waves, and photons. Optical fibers. Interference and diffraction. Polarization. Image formation. LEDs and Lasers. Detectors. Optical systems (cameras, scanners, sensors).

Prerequisites: MAP 2302 Differential Equations

Also you will need to have competed PHY 2049C Physics for Engineers 2, and the other courses required for entry into the Photonic Science and Engineering major.

Laboratory course:

OSE 3052L, W 5:00 – 7:50 PM, CREOL A210, Instructor: Dr. Axel Schulzgen.

Photonics majors are required to take OSE 3052 and OSE 3052L concurrently. They are coordinated, but you must enroll separately in each class and they are graded independently.

Discussion section:

In the discussion section, in-class problems will be assigned and discussed. Your work will be turned in for grading each week and will count for up to 5% bonus to be added to your grade.

Detailed course description and learning outcomes:

Introduction:
Some of the main growth areas in the "high-tech" sector are centered on the branch of optics known as "Photonics", examples are; displays, data storage, telecommunication systems. This is not a temporary phenomenon. Continued growth of optics and photonics based industries means that there will be a growing and permanent need for engineers and scientists with some training in optics. Other areas of optics, such as bio-photonics, laser machining, laser marking, infrared

imaging, etc. are growing strongly also. These topics are covered in the other courses in the Photonic Science and Engineering degree program. This course provides students with the strong foundation in optics that will be needed for the subsequent courses. We will frequently make reference to applications as we go.

Content:
This course introduces the basic descriptions of light as rays (geometrical optics), waves (physical optics), and photons. Reflection and refraction of light rays and waves from planar and curved surfaces are introduced together with applications to basic optical systems such as single-lens imaging, microscopes, telescopes, scanning systems, concentrators, etc). Total internal reflection of rays is used to describe light propagation through optical fibers. Interference of optical waves is described along with interferometers and their applications to optical metrology and sensing. Diffraction of optical waves propagating through apertures is examined and the effects on the resolution of imaging systems and the spreading and focusing of optical beams are covered. Diffraction gratings and grating spectrometers. Polarization and polarization devices. Regarding light as photons, a brief introduction to absorption, emission, and luminescence phenomena is followed by a brief description of light emitting diodes, lasers and optical detectors. The electromagnetic properties of light are mostly postponed to the next course in the sequence: *OSE 3053 Electromagnetic Waves for Photonics*.

Learning outcomes:

Upon completion of this course, students should understand the basic principles of modern geometrical and physical optics and photonics. They should be able to read the specifications of commercial optical instruments such as a scanner for a laser printer, a telescope, or a spectrometer, and determine how these specifications impact the intended application. They should also be able to solve analysis and design problems for basic optical systems such as the following examples:

- Design an imaging system with prescribed magnification using a given lens, and determine the spatial resolution.
- Determine the critical angle for a given optical fiber and the angle of the cones of the incident and transmitted rays at the input and output of the fiber.
- Determine the changes in the Young's double-slit interference pattern that result from bringing the slits closer by some factor.
- Determine the changes in the Michelson interferogram that result from moving one of the mirrors or inserting a thin glass slab in one of the arms.

Topics: (A detailed schedule with dates follows at the end of this document.)

- Geometrical optics: Optical rays. Refractive index. Fermat's principle. Reflection and refraction from planar mirrors and boundaries between media of different refractive indexes. Total internal reflection. *Applications: single-lens imaging, microscopes, telescopes, prism scanning systems, concentrators, optical fibers.*
- Physical optics: Wave propagation. Planar and spherical waves. Reflection and refraction from planar mirrors and planar boundaries between media of different refractive indexes. Comparison between geometrical and wave optics.
- Interference of light and optical interferometers. *Applications: optical sensing and metrology.*

- Diffraction of light. *Applications: resolution of imaging systems. Angular spreading and focusing of optical beams.*
- Diffraction gratings and grating spectrometers.
- Polarization and polarization devices (polarizers, retarders, rotators).
- Light as Photons. Brief introduction to absorption, emission, and luminescence.
- Optical devices: detectors, LEDs, and lasers.

Textbook:
Introduction to Optics, 3rd ed., F. L. Pedrotti, L.S. Pedrotti and L. M. Pedrotti, Prentice-Hall, 2009. Chapters covered: 1 through 11; 13; 15.

Reference books:

Schaum's Outline of Theory and Problems of Optics, Eugene Hecht, McGraw Hill, 1975. Chapters covered: 1; 3; 4; 6; 7.
Optics, 4th ed., E. Hecht, Addison-Wesley.
Fundamentals of Photonics, B. Saleh and M. Teich, 2nd ed., Wiley, 2007.

Class Web site:

Materials used for classes will be available on UCF Webcourses for viewing or reading in advance of each class. If you want a hard copy of material that will be covered in a class, print them. These are only printed for you for the first class.

You are required to read or view materials prior to class. If you do not, you will not be able to do well in this class. See below.

Teaching vs. Learning

Most people learn things for themselves. As a teacher, my job is to help students to learn the material. In order to help you learn in depth, I plan to use a significant amount of class time for detailed discussion of concepts, and problem-solving. Credit will be given for these activities. These types of activities require that students actually carry out reading assignments prior to class. I will give in-class quizzes to ensure that students come to class prepared.

Professionalism and Ethics

Per university policy and plain classroom etiquette, mobile phones, etc. must be silenced during all classroom lectures, unless you are specifically asked to make use of such devices for certain activities.

Academic dishonesty in any form will not be tolerated. If you are uncertain as to what constitutes academic dishonesty, please consult The Golden Rule, the University of Central Florida's Student Handbook (http://www.goldenrule.sdes.ucf.edu/) for further details. As in all University courses, The Golden Rule Rules of Conduct will be applied. Violations of these rules will result in a record of the infraction being placed in your file and the student receiving a zero on the work in question AT A MINIMUM. At the instructor's discretion, you may also receive a failing grade for the course. Confirmation of such incidents can also result in expulsion from the University.

Students with Special Testing/Learning Needs

Students with special needs and require special accommodations must be registered with UCF Student Disability Services prior to receiving those accommodations. Students must have documented disabilities requiring the special accommodations and must meet with the instructor to discuss the special needs as early as possible in the first week of classes. UCF Student Disability Services can be contacted at http://www.sds.sdes.ucf.edu/, or at (407)823-2371.

Final Exam: Wednesday, May 04, 2016, 1:00 PM – 3:50 PM

Relationship of Course to ABET Criteria

ABET Criteria	Level of Emphasis During Course (Low, Medium, High)
(a) An ability to apply knowledge of mathematics, science, and engineering.	H
(b) An ability to design and conduct experiments, as well as to analyze and interpret data.	L
(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	L
(d) An ability to function on multidisciplinary teams.	L
(e) An ability to identify, formulate, and solve engineering problems.	H
(f) An understanding of professional and ethical responsibility.	L
(g) An ability to communicate effectively.	M
(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	L
(i) A recognition of the need for, and an ability to engage in life-long learning.	L
(j) A knowledge of contemporary issues.	M
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	H

Grading:

Activity	Grade weighting
Homework	20%
Quizzes	5%
In class work	10%
Two mid-terms, each worth 20% of total grade	40%
Final exam	25%
TOTAL	**100%**
In-class work from discussion section	**5% bonus**

Grading Scale (%)	Rubric Description
$100 \geq A > 93 \geq A^{-} > 90$	Excellent, has a strong understanding of all concepts and is able to apply the concepts in all and novel situations. Has full mastery of the content of the course.
$90 \geq B^{+} > 87 \geq B > 83 \geq B^{-}$	Good, has a strong understanding of most or all of the concepts and is able to apply them to stated and defined situations.
$80 \geq C^{+} > 77 \geq C > 73 \geq C^{-}$	Average, has a basic understanding of the major concepts of the course and is able to apply to basic situations.
$70 \geq D^{+} > 67 \geq D > 63 \geq D^{-}$	Below average, has a basic understanding of only the simple concepts and is able to apply to only a limited number of the most basic situations.
$60 \geq F$	Demonstrates little to no understanding of the course content.

Grade Objections: All objections to grades should be made **in writing within one week** of the grade being posted for the work in question.

OSE 3052 Introduction To Photonics, Spring 2016, Dr. David Hagan,
Daily Schedule (subject to change!)

Week	Date	Subjects covered	Textbook chapter
1	Monday, Jan 11	Course overview/Introduction to Photonics/Nature of light	1
	Wednesday, Jan 13	Waves, Photons and Radiometry	2
2	Monday, Jan 18	Martin Luther King Holiday (no classes)	
	Wednesday, Jan 20	Geometrical Optics: Laws of refraction and reflection; Total internal refraction and Fiber Optics;	2
3	Monday, Jan 25	Geometrical Optics: Imaging and spherical surfaces; Refractive Power and Magnification	2
	Wednesday, Jan 27	Geometrical Optics: Eyesight correction and introduction to optical instruments.	2,3
4	Monday, Feb 1	Optical Instruments: Stops and Pupils; Eyepieces	3
	Wednesday, Feb 3	Optical Instruments: Microscopes and telescopes	3
5	Monday, Feb 8	Waves and wave equations: representation of plane and spherical waves. Time and frequency domain representation.	4
	Wednesday, Feb 10	Superposition of waves	5
6	Monday, Feb 15	Recap	
	Wednesday, Feb 17	**Mid Term Exam 1**	
7	Monday, Feb 22	Properties of Lasers: Photons; Emission and Absorption; Light Amplification; Simple description of a laser.	6
	Wednesday, Feb 24	Lasers and LEDs	6
8	Monday, Feb 29	Interference of light: Two-beam interference; Young's Slits; Thin Film interference.	7
	Wednesday, March 2	Interference of light: Stokes relations and Multiple beam intereference	7
	Monday, March 7	Spring Break	
	Wednesday, March 9	Spring Break	

9	Monday, March 14 Wednesday, March 16	Interferometry: Michelson Interferometer, Fabry-Perot interferometer Optical quality inspection. Recap	8 8
10	Monday, March 21	**Mid Term Exam 2**	
	Wednesday, March 23	Coherence: Simple description of Spatial and temporal coherence; Temporal coherence and linewidth.	9
11	Monday, March 28	Fiber optics: Communication; Allowed modes, Bandwidth and data-rate	10
	Wednesday, March 30	Diffraction: Far-Field: Single slit; beam spreading, rectangular and circular apertures	11
12	Monday, April 4	Diffraction: Far-field: Double and many-slit diffraction;	11
	Wednesday, April 6	Diffraction gratings.	12
13	Monday, April 11	Diffraction: Near field: From Huygens' principle to Fresnel diffraction; Circular apertures and Zone plates. Babinet's principle	13
	Wednesday, April 13	Diffraction: Near field: Circular apertures Zone plates	13
14	Monday, April 18	Polarized light: types of polarized light	14
	Wednesday, April 20	Production and applications of polarized light-optical modulation	14,15
15	Monday, April 25	Recap	
	Wednesday, May 4, 2015, 1:00 PM – 3:50 PM	**FINAL EXAM**	

Note: Withdrawal Deadline is Wednesday, March 23, 2015 11:59 PM.

Financial Aid and Attendance:

Each semester, all faculty members are required to document students' academic activity at the beginning of each course. In order to document that you began this course, please complete and submit the first homework assignment by the due date of August 26, 5 pm. Failure to do so will result in a delay in the disbursement of your financial aid.