College of Optics & Photonics

Spring 2015

OSE-6432 Guided Waves and Optoelectronics

Time: Tuesday and Thursday 10:30 AM – 11:45 AM
January 13, 2015 – April 22, 2015

Location: CREOL- A-214

Credit Hours: 3 hours

Prerequisite: Graduate standing and OSE6111 or consent of instructor

Description: Principles of guided wave optics; fiber optics, electro -optics, modulation, acousto-optics and optoelectronics.

Instructor: Dr. Jim Moharam, Professor
- Office CREOL – 274
- **Email:** moharam@creol.ucf.edu

Office Hours: Monday and Wednesday 1:30 PM - 2:30 PM or by appointment

Class Website:
- Course materials (syllabus, notes, problem sets, solutions, and old exams) will be available on https://webcourses.**ucf**.edu/.
- Lectures are "video streamed" through the ***Tegrity*** system.
- A link to the lectures on ***Tegrity*** is available on Webcourses.

Reference Materials:
- Class notes
- A Yariv and P. Yeh, "Photonics: Optical Electronics in Modern Communications," Oxford University Press, 6th edition, 2006.
- "Fundamentals of Optical Waveguides", K. Okamoto, Academic Press.
- "Fundamental of Photonics", Saleh and Teich, Wiley, 2007.

Prerequisites by Topics:

Electromagnetic field theory
- Maxwell's equations, Boundary conditions, and the Poynting theory.

Electromagnetic wave propagation in linear isotropic homogenous media
- Reflection and refraction at planar boundaries
- Total internal reflection and evanescent fields

Electromagnetic wave propagation in anisotropic media
- Ordinary and extraordinary waves.
- Optical retardation and Jones's Calculus
- Index ellipsoid

Course Requirements and Grading Policy:

- **Problem sets: 10%**
  - Problem sets are to be submitted before the beginning of the class on the due date in person or by e-mail.
  - You may work with others but the submission must be all yours.
  - Late homework is not accepted.
- **Midterm Exam I: 25%**
  Tuesday, March 3, 2015 10:30 AM -11:45 AM
- **Midterm Exam II: 25%**
  Thursday, April 9, 2015 10:30 AM -11:45 AM
- **Final Exam: 40%**
  Tuesday, May 5, 2015 10:00 AM -12:50 PM

Exams are comprehensive and are closed book and notes.

Make up Work/Exam Policy:

If an emergency arises and a student cannot submit assigned work by the due date or cannot take an exam on the scheduled date, the student must notify the instructor no less than 24 hours before and no more than 48 hours after the scheduled date.

Grading Scale (%) Interpretation:

Plus and minus grades will be used.

(%)	Rubric Description
$A \geq 90$	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.
$90 > B \geq 75$	Good, has a strong understanding of most or all of the concepts and is able to apply them to stated and defined situations.
$75 > C \geq 60$	Average, has a basic understanding of some of the major concepts of the course and is able to apply to basic situations.
$60 > D \geq 50$	Below average, has a marginal understanding of only the simple concepts and is able to apply to only a limited number of the basic situations.
$F < 50$	Demonstrates no understanding of the course content.

Calendar:

January (6)		**February (7)**		**March (7)**		**April (6)**	
		3	5	**3 (MT)**	5		2
		10	12	**10 (SB)**	**12 (SB)**	7	**9 (MT)**
13	15	17	19	17	**19 (T)**	14	16
20	22	24	26	24	26	21	23
27	29			31			

- **Withdrawal deadline** March 20, 2015
- **Spring Break** March 9-14, 2015 – no classes

General Information:

- Students in the on-campus sections are required to attend the class in person.
- Your e-mail of record at UCF will be used for communication.
- My preferred method of communication (other than in person) is e-mail. It is checked regularly including on weekends.
- If you have any questions, do not wait for office hours. E-mail me and I will get back to you within a reasonable time.
- If it is not possible to satisfactorily answer your questions, a time will be arranged to meet at my office.

Information for Distant Learning Students:

- Students in the distant learning section located within 150 miles from UCF must take the Midterms and the Final Exam with the students in the face-face section.
- It is extremely important to review the class videos in a timely manner.
- Problem sets are to be submitted by class time on the due date by e-mail (pdf format preferred). Graded problem sets and exams will be e-mailed back.

Financial Aid and Attendance:

Students' academic activity at the beginning of each course must be documented. In order to document that you began this course, students must complete the ***assignment posted on Webcourses*** no later than **January 20**. Failure to do so will result in a delay in the disbursement of financial aid.

Class Attendance:

Regular class attendance is necessary for students to fully grasp the course concepts. If you miss a class session, it will be your responsibility to find out the materials that were covered.

Professionalism:

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. You should be present in class before the lecture begins.

Ethics:

As in all University courses, The Golden Rule of Conduct will be applied. If you are uncertain as to what constitutes academic dishonesty, please consult The Golden Rule in the UCF Student Handbook (www.goldenrule.sdes.ucf.edu) for further details. Violations of these rules will result in a record of the infraction being placed in your file and additional sanctions may be applied.

Students with Special Testing/Learning Needs:

Students with documented special needs and requiring special accommodations must be registered with UCF Student Disability Services (www.sds.sdes.ucf.edu or at (407) 823-2371) prior to receiving those accommodations. Students must inform the instructor of their special needs as early as possible in the first week of classes.

Course Outline:

Guided Wave Optics (4.5 weeks)

- ***Planar slab waveguides (1.5 weeks)***
  - TE and TM guided modes in planar waveguides
  - Symmetric and asymmetric planar waveguides
  - Field distribution in planar waveguides
  - Cut-off conditions, allowed modes, single mode waveguide
  - Power flow in wave guides
  - Mode orthogonally and mode excitation
- ***Rectangular channel waveguides (1 week)***
  - Quasi TE and TM modes in channel waveguides
  - The effective index medium method
- ***Optical fibers (1.5 week):***
  - Electromagnetic waves in cylindrical coordinates
  - Step index fibers
  - Fiber V-number
  - Hybrid HE, EH, TE, and TM modes
  - Field distributions in optical fibers
  - Cut-off conditions, allowed modes, single mode fiber
  - Mode degeneracy and Composite LP modes
  - Numerical aperture
  - Power distribution in optical; fibers
- ***Propagation of Optical Pulses (1 week)***
  - Pulse propagation in non-dispersive media
  - Pulse propagation in dispersive media
  - Group velocity dispersion, differential delay, and frequency chirp
- ***Dispersion in Optical fibers (0.5 week)***
  - Waveguide dispersion, material dispersion, and modal dispersion

Electro-optics and Acousto-optics (4 weeks)

- **The linear electro-optic effect**
  - Index ellipsoid
  - Electro-optic induced retardation
  - Amplitude modulation and phase modulation
- **Bulk electro-optics modulator**
  - Longitudinal and transverse modulators
  - Design considerations
- **Integrated electro-optics modulator**
  - Optical coupling between waveguides and directional couples
  - Coupled-mode theory
  - Directional coupler switch
  - Single channel Mach-Zehnder modulators
  - Dual output Mach-Zehnder modulators

- **The quadratic electro-optic effect**
- **The photoelestic effect**

Optoelectronics (4.5 weeks)

- ***Photons in semiconductors (1 week)***
- Band Theory
- ***Photo Detectors: (1.5 weeks)***
  - Properties of semiconductor photoconductors
  - Quantum efficiency, responsitivity, response time
  - p-n junctions
  - Properties of semiconductor photoconductors
  - Quantum efficiency, responsivity, response time
  - Photodiodes
  - p-n and p-i-n, hetero structure photodiodes
  - Photodetector noise
  - Thermal and Shot noise
- ***Optical gain and condition for emission (1 week)***
  - Light emitting diodes and spontaneous emission
  - Laser diodes and stimulated emission
  - Net gain and gain spectrum
- ***Semiconductor lasers (1 week)***
  - Optical amplification and feedback
  - spectral and spatial distribution, mode selection
  - Laser confinement loss
  - Condition for lasing and threshold gain and threshold current