University of Central Florida-

College of Optics & Photonics

Spring 2014

OSE-3053 Electromagnetic Waves for Photonics

Time: **Tuesday and Thursday** 1:30 PM – 2:45 PM

Location: CREOL-A-214

Credit Hours: 3 hours

Prerequisite: OSE3052 or C.I.

Description: Electromagnetic theory of light, Fresnel reflection and refraction, polarization and crystal optics, metallic and dielectric waveguides.

Learning Outcomes:

Upon completing this course, the students will:

- Know the electromagnetic foundation of optics and the need for an electromagnetic description of light, as opposed to scalar waves or rays.
- Know the basics of polarization optics and the difference between different states of polarization (linear, circular or elliptical).
- Know how reflection at a boundary can change polarization.
- Be able to design simple systems that control the polarization of light.
- Know how reflection at a boundary can change polarization.
- Know the concept of surface and evanescent waves.
- Know the difference between guided waves in metallic and in dielectric planar waveguides.
- Know the concept of guided modes and cut-off conditions in waveguides.

Instructor: Dr. Jim Moharam, Professor
Office CREOL – 274
Email: moharam@creol.ucf.edu
My preferred method of communication (other than in person) is e-mail. It is checked regularly including weekends.
Your e-mail of record at UCF will be used for communication.

Office Hours: Monday and Wednesday 3:00 PM - 4:00 PM or by appointment.

- 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.
- Otherwise a time will be arranged to meet at my office.

Course Materials: Class materials, notes, and problem sets are posted on:
https://webcourses.ucf.edu **(modules section)**
Please check before every lecture.

Reference Book:

M. F. Iskander, "Electromagnetic fields and waves" 2nd Ed., Waveland Press, 2013 (ISBN 978-157766-783-4).

Course Requirements and Grading Policy:

Homework 20% - Late homework not accepted

- Problem sets are to be submitted by class time on the due date.
- You may work with others on the homework but the submission must be all yours.

Mid Term I	20% - Tuesday, February 11, 2014	1:30 PM -2:45 PM
Mid Term II	20% - Tuesday, March 31, 2014	1:30 PM -2:45 PM
Final Exam	40% - Tuesday, April 29, 2014	**1:00 PM -3:50 PM**

- Exams are closed book and notes.
- The final exam is comprehensive.

Excusal from Course Assignments and Course Examinations

- If an emergency arises and a student cannot submit assigned work on or before the scheduled due date or cannot take an exam on the scheduled date, the student MUST give notification to the instructor NO LESS THAN 24 HOURS BEFORE the scheduled date and NO MORE THAN 48 HOURS AFTER the scheduled date.

Class Attendance and Participation

- Regular class attendance is strongly advised and is necessary for students to fully grasp many of the course concepts.
- Please be on time to class.
- If you miss a class session, it will be your responsibility to find out the materials that were covered.
- Students in attendance are expected to be active participants in the course. This participation includes: contributing to class discussions, providing insight into the class discussion topics, raising questions, and relating class material to personal experiences and other course topics.

Grading Scale (%) Interpretation

- Plus and minus grades will be used.

85 -100	A,A-	Excellent, exceeds average understanding as evidenced in course work and goes well beyond the basics.
75 - 85	B,B+	Above average, fully meets average understanding as evidenced in course work and fully understands the basics and can deal with concepts somewhat beyond that level.
60 -75	C-,C,C+,B-	Average, meets minimum expectations and satisfies course requirements
50 - 60	D+,D,D-	Below average, meets many minimum expectations and satisfies all or most course requirements.
0 - 50	F	Fails to meet minimum expectations in understanding and course work as evidenced by performance and submission of graded elements

Professionalism and Ethics

- Academic dishonesty in any form is not acceptable and 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.

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

Calendar:

January (8)		**February (8)**		**March (7)**		**April (6)**	
		4	**6 (R)**	**4 (SB)**	**6 (SB)**	1	3
7	9	**11 (MT)**	13	11	13	8	10
14	16	17	20	17	20	15	17
21	23	24	27	24	**27 (R)**		
28	30			**31(MT)**		**29 (F)**	

Spring Break March 2-7, 2014
Withdrawal deadline March 18, 2014

Topics:

Vector Analysis: (3 lectures)

- Vector algebra, coordinate systems, vector representation, and vector coordinate transformation
- Vector integration: The divergence theorem and Stoke's theorem
- Vector differentiation: Gradient of scalar function, divergence of vector field, curl of vector function, Laplacian of a scalar function, and vector Laplacian of vector function

Electromagnetic Theory and Maxwell's Equations: (3 lectures)

- Electric and magnetic fields- permittivity and permeability of free-space
- Lorentz force equation
- Gauss's, Ampere's, and Faraday's Laws; displacement current
- Maxwell's equations in integral form
- Maxwell's equations in differential form
  - Continuity equation and the displacement current
- The Poynting's theory and electromagnetic power
- Time harmonic fields and their representations
- Time harmonic Maxwell's equations

Electromagnetic Fields in Materials: (3 lectures)

- Electromagnetic properties of materials:
  - Conductor and conduction current - Conductivity
  - Dielectric materials and their polarization - Permittivity
  - Magnetic materials and their magnetization – Permeability
  - The constitutive relations between the field intensity and the flux density in materials
- Maxwell's equations in material regions
  - The concept of complex permittivity
- Electromagnetic field boundary conditions at the interface between two layers

Review and First Midterm: (2 lectures)

Plane Wave Propagation in Materials: (4 lectures)

- The wave equation in source free region
- The time harmonic wave (Helmholtz) equation in source free region
  - Plane wave solution of the Helmholtz equation
- Plane wave propagation in materials
  - The concept of refractive index
  - Characteristics of planes waves: Propagation vector, phase velocity, wavelength, the concept of refractive index, relationship between the propagation vector and electric and magnetic fields
- The Poynting's theory and electromagnetic power for a plane wave
- Polarization of plane waves: Linear, circular, elliptical

Normal Incidence Plane Wave Reflection and Transmission at Planar Boundaries: (2 lectures)

- Normal incidence plane wave reflection and transmission at plane boundary between two media
  - Normal incidence plane wave reflection at perfectly conducting plane
- Reflection and Transmission at multiple interfaces
  - Quarter and half-wave transformers
  - Applications include anti-reflection coating

Oblique Incidence Plane Wave Reflection and Transmission at Planar Boundaries: (3 lectures)

- Oblique incidence plane wave reflection and transmission at plane boundary between two media
  - Parallel (TM) and perpendicular (TE) polarizations
  - Reflection and transmission coefficients
  - Brewster angle and total transmission, the critical angle and total reflection
  - Surface and evanescent waves
- Oblique incidence plane wave reflection at a perfectly conducting plane

Review and Second Midterm: (2 lectures)

Crystal Optics: (2 lectures)

- Anisotropic media such as crystals
- Propagation of light through anisotropic media
  - Retardation and retardation plates
- Polarization devices – wave plates, polarization rotators, amplitude modulators
  - Application: Liquid crystal displays

Metallic and dielectric planar waveguides: (4 lectures)

- Guide modes in metallic waveguides
  - TEM modes in two plate planar waveguides – cut-off condition
  - TM and TE modes in rectangular waveguides – cut-off condition
  - Guided modes and cut-off condition
- Guide modes in dielectric waveguides
  - Symmetric waveguides
  - TM and TE modes in rectangular waveguides – cut-off condition
  - Single mode waveguides
  - Asymmetric waveguides