College of Optics & Photonics

OSE-3053 Electromagnetic Waves for Photonics

Spring 2019

Place & Time: CREOL-102, Mon, Wed, Fri, 8:30 AM – 9:20 AM From Jan 6 to Apr 27, 2020

Prerequisites: OSE3052 or consent of instructor.

Credit Hours: 3 hours

Instructor: Dr. Luca Argenti, Office: PSB 304, e-mail: luca.argenti@ucf.edu

Office Hours: Tuesday and Thursday 1:30pm – 3:00 pm, or by appointment.

Description: The course covers the foundation of electromagnetic optics, the propagation of optical plane waves within homogeneous, isotropic, and non-isotropic dielectric media, across planar boundaries between them, through dielectric layers, and in planar waveguides.

Learning Outcomes:

Upon completing this course, the student will be able to:

- Explain the concept of electromagnetic fields and Maxwell's equations.
- Apply Maxwell's equations to determine the electric and the magnetic fields and the power and their dependence on the medium electromagnetic properties.
- Analyze the propagation characteristics of plane waves including the propagation constants, electric and magnetic fields, and power flow.
- Determine the polarization state for a given field.
- Analyze the reflection and transmission of light at planar interfaces and the dependence on the incident wave polarization and angle of incidence.
- Analyze the reflection/transmission from a single film on a substrate and design a thin film AR coating.
- Explain the principles of crystal optics and analyze simple components that control the polarization and the intensity of light.
- Explain the principles of waveguides and determine the guided modes.

Webcourses: Course materials, homework assignments, solutions, notes and announcements will be posted on Webcourses. The preferred mode of communication is through the email within Webcourses. It is the student's responsibility to check the "coursemail" tool frequently. All communication between student and instructor and between student and student should be respectful and professional. The instructor will try to answer emails within 1 working day. If you need to directly write to the instructor at the @ucf.edu address, prepend the string "[OSE6111]" to the subject.

Reference Material:

- *Class Notes*
- *Fundamentals of Photonics*, 2nd Edition, by B. E. A. Saleh and M. C. Teich (Wiley, 2009)
- *Optics*, 5th Edition, by E. Hecht (Pearson, 2017)

Grading Policy:

- Engagement Quiz **(1%)**
- Homework assignments (**19%**),
- Mid-term exam #1 (**20%**)
- Mid-term exam #2 (**20%**)
- Final exam (**40%**)

Grading Scale (%) Interpretation: Plus and minus grades will be used

85-100	A, A-	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.
75 - 85	B+, B	Good, has a strong understanding of most or all of the concepts and is able to apply them to stated and defined situations.
60 -75	B-, Cx	Average, has a basic understanding of the major concepts of the course and is able to apply to basic situations.
50 - 60	Dx	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.
0 - 50	F	Demonstrates no understanding of the course content.

Homework: Homework will be assigned on an approximately weekly basis. It is anticipated that there will be 9 total assignments, three for each of the main three parts of the course (HA1-3, HB1-3, HC1-3). A typical assignment will comprise a list of exercises to be solved in writing. Students are free to interact outside class time and discuss homework assignments. However, the solutions must be worked out individually, *formulated in clear handwriting*, scanned, and uploaded *as a single legible pdf file* to the webcourse page. Late homework will receive zero points.

Exams: The provisional schedule for the mid-term exams is **Friday February 7th** and **Friday March 20th**, during normal lecture time (8:30 AM – 9:20 AM). The final exam will be on **Wednesday April 22nd**, from 7:00 AM to 9:50 AM. Exams are comprehensive and closed book; each student will be allowed to use a *printed and individual* single-page formula sheet of his/her own making.

Calendar: The codes HA1-3, HB1-3, HC1-3, indicate the 9 homework assignments. Each assignment will normally be due the week after it is made available on webcourses.

A: EM Field Theory			B: Electromagnetic Optics			C: OWP In layered media		
J6	J8	J10	F10	F12	F14	M23	M25	M27
J13	J15	J17 **HA1**	F17	F19	F21 **HB1**	M30	A1	A3 **HC1**
	J22	J24 **HA2**	F24	F26	F28 **HB2**	A6	A8	A10 **HC2**
J27	J29	J31 **HA3**	M2	M4	M6 **HB3**	A13	A15	A17 **HC3**
F3	F5	**F7:MT1**	SPRING BREAK			A20	**A22:FE**	
			M16	M18	**M20:MT2**			

Record of Academic Engagement: All faculty are required to document students' academic activity at the beginning of each course. Please, complete the activity online by the end of the first week of classes. Failure to do so may result in a delay in the disbursement of your financial aid.

Students with disabilities: UCF is committed to providing reasonable accommodations for all persons with disabilities. Students with disabilities who need accommodations must be registered with Student Accessibility Services (SAS) http://sas.sdes.ucf.edu/ (Ferrell Commons 185, sas@ucf.edu, phone 407-823-2371) before requesting accommodations from the instructor. Students who are registered with SAS and need accommodations to attend class must contact the instructor at the beginning of the semester to discuss accommodations that might be necessary and reasonable.

Attendance: Mandatory. University excuses absences only for religious observances, inter-collegiate activities and athletics, and university-verified family or medical emergency. Students are expected to notify the instructor in advance if they intend to miss class to observe a holy day of their religious faith. If you are a deployed active duty military student and feel that you may need a special accommodation due to that unique status, please contact your instructor to discuss your circumstances.

Make-up exams: Only given to students taking part in University-sanctioned activities. Authentic justifying documentation must be provided in advance. Exceptions are to be made for medical and family emergencies at the discretion of the instructor.

Plagiarism and cheating: Many incidents of plagiarism result from students' lack of understanding about what constitutes academic misconduct. However, students are expected to familiarize themselves with UCF's Golden Rule, which defines plagiarism as follows: ``whereby another's work is used or appropriated without any indication of the source, thereby attempting to convey the impression that such work is the student's own.'' Plagiarism and cheating of any kind on an exam or assignment will result in zero points (and may, depending on the severity of the case, lead to an "F" for the entire course) and may be subjected to appropriate referral to the Office of Student Conduct for further action. See the UCF Golden Rule for further information. Students are assumed to adhere to the academic creed of this University and maintain the highest standards of academic integrity. The instructor will also adhere to the highest standards of academic integrity.

Diversity and Inclusion: Diversity of students, faculty, and staff is a strength of UCF and a critical component of its educational mission. Dimensions of diversity can include sex, race, age, national origin, ethnicity, gender identity and expression, intellectual and physical ability, sexual orientation, income, faith and non-faith perspectives, socio-economic class, political ideology, education, primary language, family status, military experience, cognitive style, and communication style. Participants to OSE6111 are expected to contribute creating an inclusive and respectful classroom environment.

Content of the course:

PART A. Mathematical Background and Electromagnetic Field Theory

A1: Mathematical Background (4 lectures):

- Scalar and vector representation.
- Coordinate systems and vector coordinate transformation
- Vector algebra – Scalar and vector products.
- Vector integration: The divergence theorem and Stoke’s theorem
- Vector Calculus: Gradient, divergence, curl of vector function, and Laplacian.

A2: Electromagnetic Theory in Vacuum and in Materials (4 lectures):

- Coulomb’s Law, electric field intensity, electric flux density - permittivity of free-space.
- Biot-Savart Law, magnetic field intensity, magnetic flux density, and permeability of free-space.
- Lorentz force equation.
- 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.

A3: Maxwell’s Equations and Boundary Conditions (5 lectures):

- 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.
- Maxwell’s equations in material regions.
- The concept of complex permittivity.
- Electromagnetic field boundary conditions at the interface between two layers.

PART B. Propagation across boundaries and in isotropic media

B1: Plane Wave Propagation in Materials (5 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.
- The concept of refractive index.
- Propagation vector, phase velocity, wavelength.
- 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, and elliptical.

B2: Plane Wave Reflection and Transmission at Planar Boundaries: (6 lectures)

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

B3: Reflection and Transmission at multiple interfaces: (3 lecture)

- Quarter and half-wave transformers
- Applications include anti-reflection coating

PART C. Optical propagation through anisotropic media and waveguides

C1: Crystal Optics (5 lectures)

- Anisotropic media
- Propagation of light through anisotropic media
- Phase retardation and Jones' calculus
- Polarization devices – wave plates, polarization rotators, amplitude modulators

C2: Metallic planar waveguides (3 lectures)

- TEM, TE, and TM modes in two plate planar waveguides.
- Dispersion relation, cut-off condition, field distribution, and power flow.

C3: Dielectric planar waveguides (4 lectures)

- Symmetric waveguides
- TM and TE modes in planar waveguides.
- Dispersion relation, cut-off condition, field distribution, and power flow.
- Single mode waveguides