UCF **College of Optics & Photonics**

OSE 6111 – Optical wave propagation (3 credit hours)

Spring 2018

Place & Time: CREOL-102, Tue and Thu, 4:30 PM – 5:45 PM From Jan 8 to May 1, 2018

Prerequisites: Graduate standing or consent of instructor.

Description: OSE 6111 is a core requirement for the Ph.D. degree in Optics. 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 periodic arrangements of dielectric layers, and in planar waveguides. The material treated in this course is propaedeutic to the study of more advanced topics in photonics.

Objectives: At the end of the course the students should be able to formulate the appropriate field equations and boundary conditions for the propagation of optical waves in linear dielectric media, to find their analytic solutions, to interpret them in physical terms, and to indicate their limits of applicability.

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

Office Hours: Mondays and Wednesday 2:00 – 3:00 pm, or by appointment.

Webcourses: Course materials, homework assignments, solutions, notes and announcements will be posted on Webcourses. Lectures are "video streamed" through the PANOPTO system. A link to the lectures will be available 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) (Chapters 3, 5, 6, 7, and 8 of this book cover most of the topics of the course).
- *Optics*, 5th Edition, by E. Hecht (Pearson, 2017) (Chapters 2-4, 7, 8 are a nice reference for some topics of the course).
- *Classical Electrodynamics*, 3rd Edition, by J. D. Jackson (Wiley, 2001) (Fundamentals of EMT from the perspective of a physicist. Useful for consultation)

Grading scale: Grading will be done over a scale from 0 to 100, with letter grades distributed as: A (100-90), B (89-75), C (74-60), D (59-50), and F (49-0). Pluses and minuses will be used. The overall grade will be based on:
- Homework assignments (**12%**),
- Mid-term exam #1 (**20%**)
- Mid-term exam #2 (**28%**)
- Final exam (**40%**).

Homework: Homework will be assigned on an approximately weekly basis. It is anticipated that there will be 8 total assignments, two for the introductory part of the course, three for the second, and three for the third part (HWA1-2, HWB1-3, HWC1-3). 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. Solutions that do not conform to these requirements will be penalized. Late homework will receive zero points.

Exams: The provisional schedule for the mid-term exams is **Thursday February 8th** and **Thursday March 22nd**, during normal lecture time (4:30 PM – 5:45 PM). The final exam will be on **Thursday April 26th**, from 4:00 PM to 6:50 PM. Exams are comprehensive and closed book. During the mid-term and final exams, each student will be allowed to use only a *printed and individual* cheat sheet (**CS1** for MT1, **CS2** for MT2, **CSF** for the final) of his/her own making. The cheat sheets **CS1**, **CS2**, and **CSF** must comprise no more than 1, 2, and 3 single-face pages, respectively, and they must be uploaded to webcourses, as a separate pdf document before the exam (See calendar). 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.

Calendar: The codes HWA1-2, HWB1-3, HWC1-3, indicate the 8 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**	
Jan 9	Jan 11	Feb 13	Feb 15	Mar 27 **HWC1**	Mar 29
Jan 16	Jan 18	Feb 20 **HWB1**	Feb 22	Apr 03 **HWC2**	Apr 05
Jan 23 **HWA1**	Jan 25	Feb 27 **HWB2**	Mar 01	Apr 10 **HWC3**	Apr 12
Jan 30 **HWA2**	Feb 01	Mar 06 **HWB3**	Mar 08	Apr 17	Apr 19
Feb 06, **CS1**	**Feb 08 (MT1)**	SPRING BREAK		Study Day	**Apr 26 FINAL**
		Mar 20, **CS2**	**Mar 22 (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. The instructor shares the same commitment. Students with disabilities who need accommodations must be registered with Student Disability Services (SDS) before requesting accommodations from the instructor. Students who are registered with SDS and need accommodations to attend OSE6111 classes must contact the instructor at the beginning of the semester to discuss needed accommodations. No accommodations will be provided until the student has met with the instructor to request accommodations.

Attendance: Mandatory (it will be taken). University excuses absences only for religious observances, intercollegiate 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 (13.5h)

A1: Mathematical Background (3h):
Complex numbers. Vectorial quantities and vector operations. Vector fields, differential vector operators, divergence theorem, Green's identities, Stokes's theorem. Fourier series and Fourier transform in linear systems.

A2: Review of Electromagnetic Theory (4.5h):
Electromagnetic fields. Integral and differential time time-dependent Maxwell equations. Constitutive relationships and permittivity, permeability, and conductivity. Power and Energy and the Poynting's theorem. Complex harmonic Maxwell equations. Boundary conditions and field matching at interfaces.

A3: Electromagnetic Propagation in Linear Isotropic Homogenous Media (6h):
The wave equation and Helmholtz equation. Plane wave propagation. Power flow density. Electromagnetic field polarization: linear, circular, and elliptical.

PART B. Propagation across boundaries and in anisotropic media (13.5h)

B1: Reflection and Refraction at Planar Interfaces (6 h):
Phase Matching. Propagating, surface, and evanescent waves. TE and TM polarizations. Reflection and transmission coefficients. Brewster angle, critical angle, total internal reflection. Reflection and refraction in multi-layered structures.

B2: Light polarization and propagation in anisotropic media (7.5 h):
Dielectric tensor classification of anisotropic media. Dispersion relation and light propagation in uniaxial and biaxial media. Power flow in anisotropic media. Refraction and reflection at anisotropic interface. Jones's calculus and retardation plates. Index ellipsoid. Optical activity, Faraday rotation.

PART C. Optical propagation through periodic materials and waveguides (12h)

C1: Optical Propagation in Periodic Media (4.5h)
Periodic field spatial harmonics. Generalized phase-matching condition and the grating equation. Propagation and evanescent diffracted orders.

C2: Planar Dielectric Waveguides (7.5h)
TE and TM guided modes in planar-mirror waveguides and planar dielectric waveguides.
Dispersion relations for TE and TM modes. Cut-off conditions and single mode waveguide. Symmetric and asymmetric planar waveguides. Field distribution in planar waveguides, power flow. Mode orthogonality and mode excitation.