

**Fundamentals of Ultrafast Optics**  
**OSE 6445 (3 Credits)**

**Time:** Tuesday, Thursday 4:30-5:45

**Place:** CREOL 103

**Instructor:** P. J. Delfyett, CREOL 272, 823-6812, [delfyett@creol.ucf.edu](mailto:delfyett@creol.ucf.edu)

**Office Hours:** Open door policy or from 3:00-4:30pm Tuesdays and Thursdays; Rm 272

**Webcourse:** Each student is REQUIRED to complete an assignment on Webcourse by the end of the first week of class.

**Course Goals:** To have students become proficient in understanding state of the art technical literature (i.e., scientific journal publications) in technical areas that use picosecond and femtosecond photonic technologies and applications.

**Course Description:**

Introductory Concepts (The following are the necessary fundamental quantities that are required in understanding the generation, transmission, detection and manipulation of ultrafast optical signals).

Definition of Electric Fields, Intensity, Spectral Field & Intensity, Temporal and Spectral Phase, Instantaneous Frequency & Group Delay, Dispersion & Dispersion Engineering (Computer Project of Linear Pulse Propagation).

Ultrafast Optical Signal Generation (The techniques described in this portion of the course are the primary methods of generating ultrafast optical signals with temporal durations in the picosecond and femtosecond regime. The students gain practice in using the fundamental definitions in interpreting the temporal and spectral characteristics of optical signals generated by these methods).

Mode-locking (active, AM&FM, passive via saturable absorber/saturable gain, Kerr lensing, other nonlinear effects), Gain Switching, Direct Modulation, Attosecond pulse generation (Computer Project – Numerical Simulation of Passive Mode-locking w/ Gain Saturation, Optical Frequency Combs and Stabilization).

Ultrafast Signal Detection (Methodologies are discussed for detecting, measuring and characterizing optical signals that are sufficiently fast and beyond the capabilities for conventional electronics).

Ultrafast photodetectors (PIN, avalanche, photoconductive), streak camera, nonlinear optical correlation techniques, joint time-frequency measurements, and multi-heterodyne detection between 2 ultrafast lasers (computer simulation of autocorrelation, spectrogram & SHG FROG).

Ultrafast Optical Signal Transmission (Students learn about linear and nonlinear pulse propagation and the mathematical procedures, e.g., split-step Fourier, for predicting the characteristics, both temporal and spectral, owing to nonlinear effects).

Optical fibers, pulse compression, soliton propagation, Bragg reflectors, saturable absorption, gain saturation, group delay dispersion (Computer project: nonlinear pulse propagation/solitons; pulse compression).

Ultrafast Optical Signal Processing (Methods for manipulating and processing of ultrafast optical signals. These are critical techniques for future optical communication networks, computer interconnects and advanced ultrahigh speed signal processing).

Pulse shaping, arbitrary waveform generation (optical and RF), optical sampling, optical analog to digital converters, computing and logic, nonlinear switching, photonic network architectures (OTDM, DWDM, OCDMA), and matched filtering.

### **Course Requirements:**

Students are required to have a background, or have covered courses in the following areas: physical optics (including coherence, interference, wave propagation), differential equations (including Fourier transforms, wave equations), and lasers. Nonlinear optics is desired but not required. It is desired that students should have completed the optics core curriculum, but it is not required.

### **Reference Materials**

1. **Ultrashort Laser Pulse Phenomena, J. C. Diels & W. Rudolph, Academic Press, 2006, ISBN 13: 978-0-12-215493-5.**
2. **Ultrafast Optics, A. M. Weiner, Wiley, 2009, ISBN 978-0-471-41539-8.**
3. Laser Electronics, 3<sup>rd</sup>. Ed., J.T. Verdeyen, Prentice Hall, 1995, ISBN 0-13-706666-X
4. Ultrashort Laser Pulses & Applications, W. Kaiser, Ed., Springer Verlag, (1988).
5. Principles and Applications of Optical Communications, M. K. Liu, IRWIN, 1996, ISBN 0-256-16415-0.
6. Fundamentals of Photonics, B. Saleh & M. Teich, J. Wiley (1991)
7. Optical Fiber Communications V:A & V:B, I. P. Kaminow, T. Li, A. Willner, Academic Press (1997) ISBN 978-0-12-374171-4.
8. Compact Sources of Ultrashort Pulses, I. Duling, Ed., Cambridge University Press (1995) ISBN 0-521-46192-8.
9. Ultrafast Lasers, Technology & Applications – M. Fermann, et al., Marcel Dekker (2003) ISBN 0-8247-0841-5.

**Evaluation:**

2exams (1 Midterm, 1 Final Exam – scheduled as per the registrar – no exceptions).

Homework (Assigned problems and projects MUST be handed in when due – no exceptions!).

***An emphasis of the evaluation will be on the computer based projects.***

**Plagiarism:** It is your responsibility to know the rules regarding academic honesty. Failure to comply with these rules may result in failing the course, as well as expulsion from the program.

**Final Exam:**

When: Exam will be held during the time set by the University Final Exam Schedule

Where:

Time: