**PHYS 715 (Lasers and Quantum Optics)** **Course Information**

Objective: To gain basic knowledge in the fields of optical electronics and photonics, including beam optics, Fourier optics and photonic crystals. The course will also cover some selected topics in laser physics and quantum optics, including atom-field interaction, stimulated emission, semi-classical laser theory, coherent states, and nonlinear optics.

Instructor: Zhigang Chen. Office: 526 Thornton Hall
Phone: 338-3876, Email: zhigang@sfsu.edu

Meeting Time and Place:

T, Th 09:35-10:50 TJ1 Office hour (Th, noon-1pm. Th526)

Textbook:

Primary reference:
*Fundamentals of Photonics*, 2nd Edition, by Saleh and Teich (John Wiley, 2007)
(The course will cover only selected chapters, as well as materials from other reference books and other sources).

Other references:
*Optical Electronics in Modern Communications*, 5th edition,
by AmnonYariv (Oxford Univ. Press, 1997)
*Lasers*, by Milonni and Eberly (John Wiley, 1988)
*Quantum Electronics*, 3rd edition, by Yariv (John Wiley, 1989).

Grading:

| | |
|---|---|
| Homework | 20% |
| Class Discussion/Presentation | 20% |
| Midterm Exam | 30% |
| Final Exam/Research Paper | 30% |

About Homework:

Homework is an important part of learning. You should work independently at first, and them you can discuss and collaborate with others. Solving problems with others will enhance your understanding and extend your retention. However, what you submit must be your own work. No late submission will be accepted.
See http://www.physics.sfsu.edu/policy/plagiarism.pdf for department policy.

About Seminar Presentation:

There are many interesting subjects in the fields of laser physics, optical electronics and nonlinear optics. Normally each field requires one semester of learning. In this course, we will try to cover some selected topics in each field. After learning the theory of light-matter interaction, laser oscillation and basic laser technology, you are required to do independent study and then do class presentation on a few selected topics based on your reading. The purpose of this requirement is to give you experience in independent literature research and in presenting your work to scientific or public community. Therefore, you need to prepare the notes carefully for each of your presentations. A final research paper can be submitted in lieu of final examination.

**PHYS 715** **Course Schedule**

Week 1 Rays Optics (Chap 1)
Ray optics, lens waveguides, matrix optics

Week 2 Electromagnetic Theory and Wave Propagation (Chap 5)
E & M waves (Review)
wave propagation in isotropic media
(power transport, storage & dissipation)
wave propagation in anisotropic crystals
(index ellipsoid, birefringence)

* Intro to Metamaterials (Chap 5.7)

Week 3 Propagation of Gaussian Beams (Chap 3)
Gaussian beam theory

Week 4 Hermite-Gaussian, Laguere-Gaussian, and Bessel Beams (Chap 3.3-3.4)

Week 5 Intro to Fourier Optics (Chap 4)

Week 6 Optical Resonators (Chap 10)

Fabry-Perot Etalon
stable and unstable cavities
resonant frequencies
laser longitudinal modes

Week 7 Intro to photonic crystals and bandgap materials (Chap 6)

* Coherence and statistical optics (Chap 11)

Week 8, 9 Interaction of Light and Atomic Systems (Chap 12-14)

Atomic susceptibility
spontaneous and induced transitions (Einstein's model)
Lamb's semi-classical laser theory (Maxwell-Bloch equation)
homogeneous and inhomogeneous broadening, gain saturation

Week 10 Laser Oscillation and Some Specific Lasers (Chap 15)

laser oscillation condition,
oscillation frequency
specific laser systems

* Semiconductor optics, LED and laser diodes (Chap 16-17)

**Midterm Exam**

Week 11 Laser Technology (Chap 15)

Mode-locking, Q-switching, Pulse shaping

Week 12 Intro to Nonlinear Optics (Chap 21)

Second-harmonic generation and frequency conversion
Phase conjugate and photorefractive beam coupling

Week 13-15 Other Selected topics /Research Presentations

Topics may include atom optics, photonic/meta/plasmonic materials, EIT and photo storage, fast and slow light, quantum information and computing, optical solitons, bio-optics, etc. (Details will be discussed in class and more information will be provided later in the semester about topics for presentations).

**Research Paper or Final Exam**

Students with disabilities who need reasonable accommodations are encouraged to let the instructor know. The Disability Programs and Resource Center is available to facilitate the reasonable accommodations process. The DPRC, located in SSB 110, can be reached by telephone at 338-2472 (voice/TTY) or by e-mail at dprc@sfsu.edu. Special accommodations will be provided only with a formal request letter from DPRC