OPTI 370. Lasers and Photonics (3). Principles of lasers; properties and manipulation of laser light; physical effects and operating principles of photonic components and devices including light modulators and optical fibers; elements of photonic telecommunications. P, OPTI 240, MATH 223, OPTI 310.

Class homepage   http://fp.optics.arizona.edu/binder/OPTI370

Course Objectives:

- Understanding of the basic principles of lasers (not including semiconductor lasers)
- Understanding of the basic principles of photonic devices, including various components used in optical and optoelectronic communication systems

Course requirements and grading policy

Grades: There will be weekly homework assignments, two written in-class closed-book closed-notes midterm exams (date and time to be announced), and one in-class closed-book closed-notes final exam (see UA Catalog for time and date). ***The grades will be based 30% on the homework and in-class quizzes, 15% on the first midterm exam, 20% on the second midterm exam, and 35% on the final exam.***

The University's exam regulations for the final exam week apply, http://www.registrar.arizona.edu/schedule091/exams/examrules.htm

Class Homepage: Announcements and homework assignments can be found on the class homepage, http://fp.optics.arizona.edu/binder/OPTI370 No paper copies of the announcements and homework assignments will be distributed.

Homework: Late homework will not be accepted. You may not be given credit for problems that are not legible. Submitted pages must be (i) Letter-size (8.5" x 11"), (ii) stapled (if more than one page), and (iii) your name, course number and homework assignment number must appear on the first page. A well prepared assignment will include: all intermediate steps, formulas written neatly (use a ruler for long fractions if necessary), symbols and lines not overlapping, high

contrast between ink or pencil and the background paper color. Points will be deducted for sloppy preparation and homework assignments which exhibit an overall sloppy appearance may be returned without a grade and the student receiving zero credit for that assignment.

Attendance: You are responsible for any information given in class, posted on the class homepage, or sent by email from your instructor. Notify the instructor in advance if you must miss class, arrive late to class, or leave early from class.

Electronic devices: Cell phones and computers must be switched off during class. Texting is absolutely prohibited during class. If you want to use your computer to take notes, you need an individual permission from the instructor. You are expected to behave in accordance with the UA Student Code of Conduct at http://deanofstudents.arizona.edu/policiesandcodes

Textbook (required):

- B.E.A. Saleh and M.C. Teich, *Fundamentals of Photonics*, Second Edition 2007 (Third Printing, January 2009) (Wiley-Interscience)

Recommended texts (not required):

Books on electrodynamics, quantum mechanics and mathematics:

- J.D. Jackson, *Classical Electrodynamics*, 1975 (Wiley)
- D.J. Griffiths, *Introduction to Electrodynamics*, 1999 (Prentice Hall)
- D.J. Griffiths, *Introduction to Quantum Mechanics*, 1995 (Prentice Hall)
- D. Hughes-Hallet et al., *Calculus*, 2005 (Wiley)

Other books on optoelectronics and lasers:

- S.O. Kasap, *Optoelectronics and Photonics – Principles and Practices*, 2001 (Prentice Hall)
- Wilson and Hawkes, *Optoelectronics: An Introduction*, 3rd edition 1998 (Prentice Hall)
- W.T. Silfvast, *Laser Fundamentals*, 2004 (Cambridge University Press)

Topics Covered:

(The following list is meant to serve as a guideline. Changes to the list may be made without prior notification. Some topics will be discussed in detail, while others are only covered briefly. The numbers in parenthesis refer to the chapters in the text book by Saleh/Teich)

Brief review of wave optics (2.1)
Brief review of monochromatic waves, Helmholtz equation (2.2 A)
Brief review of planes wave and dispersion relation (2.2 B)
Brief review of interference of two waves (2.5 A)

Fourier Transform (Appendix A)
Pulsed light, quasi-monochromatic pulses (2.6 A)

Brief review of Maxwell's equations and wave equation (from 5.1, 5.2)
Irradiance (intensity) of monochromatic plane waves (5.4)
Susceptibility, absorption coefficient and refractive index (5.2)

Planar-mirror resonators (10.1 A)
Brief review of Gaussian beams (2.2 C and 3.1)
Spherical-mirror resonators (10.2)

Coherent vs. random light, temporal coherence function, coherence length, spectral width (11.1 A,B)

Brief summary: Schrödinger equation, energy levels (13.1 excluding semiconductors)
Thermal equilibrium distribution (13.2 A)

Interaction of photons with atoms, transition cross section, stimulated emission rate, photon flux, lineshape function, spontaneous emission rate (13.3)

Laser amplification, gain coefficient (14.1)
Rate equations, steady-state inversion, four-level pumping, three-level pumping (14.2)

Laser oscillation, small signal gain coefficient, saturated gain coefficient, threshold gain condition (15.1)
Laser output, number of modes, mode selection, Brewster window (15.2)

Examples of lasers and laser media: He-Ne, Nd^{3+}:YAG, Nd^{3+}:Glass, Ti:Sapphire, Er^{3+}:Silica fiber (13.1, 14.3 and 15.3)

Mode locking (15.4)

Polarization optics, linearly and circularly polarized light, propagation along principal axes in uniaxial crystals (6.1)

Phase retardation, half-wave retarder, quarter-wave retarder, light intensity control, polarizers, polarizing beam splitters (6.6)

Optical activity, rotatory power, Faraday effect, optical isolator (6.4)

Optical interconnects, wavelength-division multiplexers (23.2), circulator, add-drop multiplexer (20.3)

Electro-optics, Pockels effect, anisotropic nonlinear refractive indices, phase retardation, retardation half-wave voltage, Pockels cell intensity modulator, waveguide Mach-Zehnder interferometer (20.1)

Brief overview: optical fiber, step-index multi-mode fiber, step-index single-mode fiber (9.1)
Brief overview: dispersion-shifted fiber, dispersion-flattened fiber, dispersion-compensating fiber (9.3)

Group velocity and group velocity dispersion (5.6)

Brief overview: optical fiber attenuation and dispersion, WDM channels, channel separation (24.1, 24.3)