

**Physics 480
Laser Physics
Fall 2011**

Instructor: C. Durfee

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Class: Meyer 357, 11-12:15

Office hours: M 1-3, W 1:30-4:30

Summary:

In this course we will discuss many aspects of laser physics, from theory to design. Starting with an overview of how lasers work, we'll work through the origin of gain in different media, rate equations for continuous-wave and pulsed lasers, Gaussian beams, resonators. We'll also discuss more advanced topics such as laser stabilization, getting lasers to make short pulses (Q-switching and mode-locking), and laser amplifiers.

General Approach:

This is a good course for anyone who is interested in lasers. It is not just for people who plan to specialize in optics – anyone who might be using lasers in their work will benefit from a good understanding of how they work (and how to make them do what you want). As a more advanced, seminar-style class, this course has room to be tailored somewhat to the interests of the students. We will occasionally go to the ultrafast optics laboratory in the GRL to see different lasers at work. PHGN 462 (EM Waves and Optical Physics) or the equivalent is a co-requisite, PHGN 320 (Modern Physics 2 /Introduction to quantum mechanics) is a prerequisite. While this course is listed as a senior-level course, it is also appropriate for graduate students (required for Applied Optics MS students). I can work with anyone who would like to treat a topic in more depth.

Textbook and other reading:

The main textbook is *Principles of Lasers* (5th edition), by O. Svelto. Since there is ongoing research in this area, there may be some reading from journal articles in addition to the textbook.

There are several books that are also quite good. The best two are:

Lasers, Anthony Seigman. Comprehensive, slightly more advanced than Svelto.

Solid State Laser Engineering, Walter Koechner (latest edition). This is the bible for laser builders, and included everything from laser theory to power supplies and cooling.

The quantum theory of light, Rodney Loudon. Very good early chapters on the connection between classical and quantum interactions of light with matter. Later chapters on lasers from a quantum (QED) point of view.

Another useful book, though a little less accessible is:

Quantum Electronics, Amnon Yariv. Good sections on Gaussian beam propagation and nonlinear optics.

Course website:

Most of the class information will be organized and distributed through the course website which will be on the Physics Wiki system. A good fraction of class notes and Mathematica demos will be posted on the website: http://ticc.mines.edu/csm/wiki/index.php/PHGN-480_Fall-2011

Computation:

Most of the modeling and calculations will be done with Mathematica. Let me know if you are not comfortable with the program. There may also be some commercial demo programs that I will distribute if we need them.

Lab work:

This year we will do some work on building HeNe lasers. Some of this will be done during class time, some outside of class, preferably during office hours.

Grading:

Homework (40%): Due once a week. These may include lab exercises.

Midterm (20%)

Final project/presentation (40%): This will be a report on a type of laser of interest to the student, and will include representative design calculations. Each student will write a report and make a short presentation to the class.

Syllabus (subject to modification)

- Laser gain and atom-EM wave interactions
 - Absorption, spontaneous and stimulated emission, Einstein A and B coefficients
 - Line-broadening
 - Saturable absorbers and gain saturation
- Examples of gain in molecular, solid state and semiconductor systems
- Pumping lasers and rate equations
 - Pumping with lasers, flashlamps, arc lamps: solid-state (Nd:YAG, Ti:sapphire) and dye lasers
 - Electrical discharge pumping: ion, HeNe and eximer lasers
- Continuous-wave (CW) lasers
 - Rate-equations and threshold conditions for 3- and 4-level systems
 - Oscillator modeling and optimization
- Ray and wave propagation
 - Gaussian beams and ABCD matrices
- Resonators
 - Mode selection
 - Frequency stabilization
 - Fiber lasers
- Pulsed laser systems
 - Q-switching, gain-switching
 - Regenerative amplifiers and cavity dumping
 - Mode-locking
- Ultrafast optics and amplifiers
 - Special topics: chirped-pulse amplification, nonlinear frequency conversion, laser damage/B-integral.