PHYS 394 - Light-Matter Interactions

Winter Term 2013

INSTRUCTOR: Donna Strickland, Room 257, Ext: 32724


COURSE OBJECTIVES: At the end of the course you should be able to:

- Illustrate laser properties using common applications
- Appraise the accepted definition of coherence in terms of laser radiation
- Explain how a laser works to generate coherent radiation above an oscillation threshold
- Solve specific laser design criteria
- Explain why nonlinear optics was not observed before the laser
- Assess multiple detection methods for various applications

TEXT: Principles of Lasers, Orazio Svelto
EXTRA READING: Lasers, A.E. Siegman
Lasers, P.W. Milonni J. H. Eberly

TOPICS COVERED IN COURSE:

Coherence:
- Classical description and how it applies to lasers
- temporal coherence - monochromaticity for CW lasers and transform limited bandwidth for pulsed lasers
- spatial coherence - collimation

Lasers:
- Laser Components: gain medium, pumping, laser cavity, output coupler
- laser properties - monochromaticity, collimation, coherence, Gaussian beam propagation

Gain Medium:
- semi-classical description of Absorption, Stimulated and Spontaneous Emission
- population rate equations - Laser Amplification
- types of pumping

Laser Cavities:
- Etalons, Confocal cavity, output coupler
- cavity modes; spatial and temporal
- cavity losses

Nonlinear and Electro-Optics
- Q-switching, mode-locking, frequency doubling

Radiation and Detectors
- Radiometry
- Types of Detectors
Light-Matter Interactions

Laser

Coherent beam

Nonlinear Optics

Detection

Gain medium

Mode-locker, Q-switch

Cavity modes

Spatial modes

Temporal modes

Gain medium

Stimulated emission
Absorption, Spontaneous emission

Gaussian beam

monochromatic spectrum, or short pulses

Frequency doubler

Photoconductor, Photovoltaic, Thermal, Pyroelectric...

Optical Pumping

Spatial modes

From prerequisites

Fourier Transforms

Maxwell's Equations

Quantum Mechanics

Temporal modes

Cavity modes

Spatial modes

Optical Pumping

From prerequisites

Maxwell's Equations

Quantum Mechanics
**Evaluation:** The course grade will be based on 5 assignments, one written report, a mid-term test and a final examination, which will be held during the Official Examination Schedule.

The breakdown is as follows:

- **Assignments:** 20%
- **Written report:** 20%
- **Mid-term Test:** 20%
- **Final Examination:** 40%

**Assignments:** There will be 5 assignments each worth 4%. The assignments will be assigned every other week and will cover the lecture topic covered in those two weeks.

**Rules for Group Work in Assignments:** Students can work in groups, but each student needs to submit his/her own version of the working and results.

**Assignment Deadline:** Assignments are to be handed in to the instructor during the Friday class of that week.

**Late Submissions:** If the TA has not completed marking, late assignments will be accepted. Assignments cannot be handed in after the solutions are posted on-line which will typically go up the following week.

**Pick up Marked Assignments:** Marked assignments will be picked up in class.

**Written Report:** The report will be your opportunity to display your understanding of laser properties as they relate to a common application of your choosing. The reports will be marked by the instructor. As this report is worth as much as the 5 assignments, it is expected that you will be working on this report during the weeks without assignments. You will be asked to choose your application by the 3rd week of class, show an outline of the report describing which laser properties are required for that application by week 7 and the final report will be due the 11th week.

**Academic Integrity, Grievance, Discipline, Appeals and Note for Students with Disabilities:** see [www.uwaterloo.ca/accountability/documents/courseoutlinestmts.pdf](http://www.uwaterloo.ca/accountability/documents/courseoutlinestmts.pdf) The text for this web site is listed below:

**Academic Integrity:** In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check [www.uwaterloo.ca/academicintegrity/](http://www.uwaterloo.ca/academicintegrity/) for more information.]

**Grievance:** A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, [www.adm.uwaterloo.ca/infosec/Policies/policy70.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm). When in doubt please be certain to contact the department’s administrative assistant who will provide further assistance.
Discipline: A student is expected to know what constitutes academic integrity [check www.uwaterloo.ca/academicintegrity/] to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about “rules” for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, www.adm.uwaterloo.ca/infosec/Policies/policy71.htm. For typical penalties check Guidelines for the Assessment of Penalties, www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.

Appeals: A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for Students with Disabilities: The Office for persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.

Geoff McBoyle
June 15, 2009 (updated November 2009)