**OPTI 571L: Optical Physics Computation Lab**
*Effective Fall 2014*

**Course Description:**

This course will introduce students to using computers for solving quantum mechanics and optical physics problems of relevance to optical physics. This computation lab course consists of weekly 1-hour lectures and weekly assignments to be completed independently by students and turned in for credit. The computational projects include topics that are discussed in OPTI 570, and topics that build from those covered in OPTI 570. The course is designed to be taken by students after completion of OPTI 570, rather than concurrently with OPTI 570.

**Pre-requisites:**

Students must have completed OPTI 570 or PHYS 570A or an equivalent course in graduate-level quantum mechanics. It is intended that the computational lab projects be completed with MATLAB. Previous experience with MATLAB will be helpful, but is not essential; an introduction to MATLAB will be offered for those students who have no familiarity with MATLAB. The use of other computational packages may be permitted on a case-by-case basis, but will be generally discouraged.

**Number of Units/ component:**

Number of units: 1

Class component: 1 hour lecture each week

Laboratory times will be decided upon on an individual basis. Students will be expected to utilize their lab time to complete the weekly computer-based lab project, under instructor guidance.

**Locations and Times:**

TBA

**Instructor Information:**

This course will have two instructors:

Brian Anderson  
Meinel 622  
626-5825  
bpa@optics.arizona.edu

Ewan Wright  
Meinel 626  
621-2406  
ewan@optics.arizona.edu
Expected Learning Outcomes:

After completion of this course, it is expected that students will have (i) developed a deeper understanding of several topics of quantum mechanics and optical physics through the ability to run their own numerical experiments; (ii) become comfortable solving problems of interest, or of relevance to their own laboratory or theoretical work in optical physics; (iii) developed skills constructing computer algorithms that relate to problems beyond optical physics, and potentially useful throughout their career; (iv) become more comfortable solving problems numerically. These skills will be particularly useful to PhD students who are experimentalists and theorists specializing in optical physics, and who are interested in enhancing their research toolset with computational methods.

Required Texts:

Required text: None. Recommended: Quantum Mechanics, by Cohen-Tannoudji, Diu, Laloe. Course lectures and projects will utilize the discussions in this recommended text as needed, but other equivalent graduate-level quantum mechanics textbooks should suffice.

Topics and/or general calendar:

The specific projects in this course are variable, and depend upon the interests and desired outcomes of the students. Thus there is currently not a specific timeline of subject matter. While it is possible for all students to undertake the same computational projects in a given semester, it is intended for students to be given some flexibility in choosing their projects. Laboratory projects will also evolve from year to year, and a complete listing of projects that will be available in any given semester is subject to modification. The projects can be expected to consist of computational exploration of a subset of the following projects or similar projects:

1. Basic MATLAB techniques in Quantum Mechanics
   Finding the eigenvalues and eigenvectors of matrix
   Numerically finding the eigenmodes of arbitrary potentials
2. Harmonic oscillators and coherent states
   Visualization in phase space
   Wigner representation
   Decomposition of wavefunctions into Hermite-Gaussian basis
   Squeezing: simulating dynamics of uncertainties and measurement outcomes
3. Two-level systems
   Rabi oscillations and dynamics on the Bloch sphere: visualization methods
   Squeezed states of two-level systems
4. Double-well potential
   Stationary Perturbation Theory: eigenstates of the double well
   Time-dependent Perturbation Theory: evolution in the double well
   Split-Step Evolution method: dynamics of a wavefunction in the double well
5. Angular momentum and atomic physics
   Calculating electric dipole transition matrix elements
Zeeman effect: calculating the response of an atom to a magnetic field
DC Stark effect: calculating the response of an atom to a DC electric field
AC Stark effect: calculating the response of an atom to an AC electric field
Computer-based visualization of atomic orbitals
Time-dependent Perturbation Theory: atomic transitions

6. Advanced topics
  Time-dependent Perturbation Theory: manipulating external potentials
  Evolution in time-dependent and stationary potentials that are classically chaotic
  Matter-wave diffraction and Interference
  Numerical evolution of the wavefunction with a nonlinear Schrodinger equation
  Morse potential

Number of Exams and Papers:

There will be no exams or papers required for this course.

Course Policies:

Grading Policy

Grades will be based entirely upon the weekly computational laboratory assignments. Students should expect to turn in their computer code and/or results on a weekly basis, although the specific requirements will depend upon the laboratory work undertaken by the student. Grades will be determined based on the timeliness of turning in required materials, the validity of the results (ie, are they correct), the independent completion of computer code (although working with other students may be permitted on a few projects), and the demonstration of independence and self-motivation in the pursuit of answers to problems not specifically assigned (ie, using computer code written for the lab projects to go beyond the specific questions of each project).

Computational Laboratory Assignments: 100%
Total: 100%

The grade will be determined according to the cumulative percentage earned such that 90-100% = A, 80-89% = B, 70-79% = C, 60-69% = D, below 60% = E.

Academic Integrity (http://web.arizona.edu/~studpubs/policies/cacaint.htm)

According to the Arizona Code of Academic Integrity, “Integrity is expected of every student in all academic work. The guiding principle of academic integrity is that a student’s submitted work must be the student’s own.” Unless otherwise noted by the instructor, work for all assignments in this course must be conducted independently by each student. Co-authored work of any kind is unacceptable. Misappropriation of exams before or after they are given will be considered academics misconduct.
Misconduct of any kind will be prosecuted and may result in any or all of the following:

- Reduction of grade
- Failing grade
- Referral to the Dean of Students for consideration of additional penalty, i.e. notation on a student’s transcript re. academic integrity violation, etc.

**Attendance Policy**

It is important to attend all classes, as what is discussed in class is pertinent to adequate performance on assignments and exams. If you must be absent, it is your responsibility to obtain and review the information you missed. This is especially important in this course where a substantial amount of course material will emerge through class discussion.

"All holidays or special events observed by organized religions will be honored for those students who show affiliation with that particular religion. Absences pre-approved by the UA Dean of Students (or Dean's designee) will be honored."

**Classroom Behavior**

The Arizona Board of Regents’ Student Code of Conduct, ABOR Policy 5-308, prohibits threats of physical harm to any member of the University community, including to one’s self. See: http://policy.web.arizona.edu/threatening-behavior-students.

**Students with Disabilities**

If a student is registered with the Disability Resource Center, he/she must submit appropriate documentation to the instructor if he/she is requesting reasonable accommodations. (http://drc.arizona.edu/instructor/syllabus-statement.shtml).

*The information contained in this syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.*