OPTI 571L: Optical Physics Computation Lab
Effective Fall 2021
Course Modality: In-person

Course Description:

This course introduces students to using computers for solving quantum mechanics and optical physics problems of relevance to optical physics. Through this course, it is expected that students will (i) develop a deeper understanding of several topics in 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) develop skills constructing computer algorithms that relate to problems beyond optical physics, and that will potentially be useful throughout their career; and (iv) become comfortable solving problems numerically. These skills will be particularly useful to PhD students who are specializing in optical physics, and who are interested in enhancing their research tool set with computational methods.

Pre-requisites:

The OPTI 571L labs involve quantum mechanics and optical physics topics discussed in OPTI 570 and OPTI 544. While it is nominally expected that students taking OPTI 571L will have taken these two other courses, alternative graduate-level preparation in quantum mechanics (such as PHYS 570A and PHYS 570B) should be sufficient. Introductory quantum mechanics as taught at the undergraduate level or in OPTI 511R may be sufficient for some students; a student with this level of preparation should discuss the suitability of enrolling in OPTI 571L with one of the instructors at or prior to the beginning of the course. Preparation at this level may limit the lab options available.

It is also assumed that students have familiarity with and access to MATLAB. The use of MATLAB is required in this course. Students with no familiarity with MATLAB should talk with one of the instructors as soon as possible; alternative approaches may be considered. If it seems suitable and agreeable, a student can engage in an accelerated independent learning of MATLAB basics during the first couple of weeks of the course if the student's schedule permits this additional time expenditure.

Number of Units/ component:

Number of units: 1

Class component: 1 hour lecture each week, with weekly computer-based lab projects to be completed independently by students under instructor guidance.

Locations and Times:

TBA

Instructor Information:

The course instructor is:

Prof. Ewan M. Wright
Meinel 636
621-2406
ewan.wright@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: a graduate-level quantum mechanics textbook such as Quantum Mechanics, by Cohen-Tannoudji, Diu, Laloe. An undergraduate-level quantum mechanics textbook should suffice as reference material for some of the labs offered.

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 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 may also evolve from year to year, and a complete listing of projects that will be available in any given semester is subject to modification. Students may also come up with their own projects in consultation with the professors. Because of this, a student may repeat this course a second time for credit as long as the student selects an entirely different set of labs to complete.

The projects consist of computational exploration of the following projects. Typically, a student is expected to complete 4-5 labs over the course of the semester, depending on the labs selected. Labs 1 and 6 are required of all students at the beginning of the semester. After that, a student can choose which labs to work on:

Quantum Mechanics

1. Basic MATLAB for quantum mechanics
2. Bloch vector dynamics

Quantum Optics

3. Visualization of quantum states
4. Quantum anharmonic oscillator
5. Damped quantum harmonic oscillator

Particle Trapping and Manipulation

6. Atom trapping and interference I.
7. Atom trapping and interference II.
8. Optical trapping

Physical Optics

9. Novel laser beams
10. Raman-Nath and Bragg scattering
11. Second-harmonic generation

Laser Physics

12. Optical resonator modes
13. Laser pulse generation

Condensed matter physics

14. Quantum motion in periodic potentials

Number of Exams and Papers:

There are no exams or papers required for this course.

Course Policies:

Grading Policy

Grades will be based entirely upon the weekly computational lab assignments. Students should expect to work on their computer code on a weekly basis, and will need to show results to the professors upon completion of each lab or if the student has difficulties with a lab. More specific requirements will depend upon the laboratory work undertaken by the student. Grades will be determined based on the timeliness of completing assignments, 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). 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.