Spring 2014 **Syllabus**

Physics 622: Quantum Mechanics II

TTh 11:00-12:20 in Small Hall room 235

Prerequisite: PHYS 621

Instructors

Prof. Seth Aubin
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Fancher: Monday 2-3pm.

Course Objectives

The primary purpose of this course is to cover quantum mechanics and related calculation methods as applied to atomic, molecular, optical, solid state, particle, and many-body systems.

The course will cover the following topics:

- Hydrogen-like atoms, fine and hyperfine structure
- Stark effect and Zeeman effect
- Time-independent perturbation theory
- Variational method
- Time-dependent perturbation theory
- 2-level systems, 3-level systems, Rabi flopping
- Symmetries: Parity, time-reversal, lattice translation
- Identical particles
- Multi-electron atoms
- Scattering theory: from particle physics to cold atoms
- Second quantization, many-body systems
- Quantization of the electromagnetic field
- Relativistic quantum mechanics, Dirac equation

Course Materials

Text: Most of the course materials and problem sets will be taken from the following required text for the course:

Modern Quantum Mechanics, by J. J. Sakurai and J. Napolitano (2nd ed., 2011).

Some course materials will also be taken from the following texts:

Quantum Mechanics, by L. D. Landau and E. M. Lifshitz (3rd ed., 2003).

Quantum Mechanics, by C. Cohen-Tannoudji, B. Diu, and F. Laloë (1st ed., 1992).

Quantum Mechanics, by L. I. Schiff (3rd ed, 1968).

Evaluations

Your final grade for the course will be determined from the following grading weight distribution:

Problem sets:	45%
Participation:	10%
Midterm:	15%
Final Exam:	30%

Problem sets: The problem sets are the main evaluation of learning for the course and also serve as a significant means of learning the material. Students are expected to do the problems on their own (not as a team effort with other students), though discussion and limited oral consultation with other students is encouraged.

Participation: The classroom presentation of course material will involve class discussions. All students are expected to participate in these discussions, since they will help elucidate the course material. Participation also reflects class attendance and the occasional quiz.

Midterm: The midterm will cover course material from the first half of the course.

Final exam: The final exam will cover all the material in the course, but with an emphasis on the second half of the course.

Weekly Schedule (tentative)

Week 0: 1/16 **Hydrogen atom review**
Hamiltonian, energy levels, electronic states, additional corrections.

Week 1: 1/21-23 **Perturbation theory (time-independent)**
Basic theory, 2-level systems, Van der Waals interactions.

Week 2: 1/28-30 **Degenerate perturbation theory**
Basic theory, no-crossing theorem, spin-orbit coupling

Week 3: 2/4-6 **Fine, hyperfine, and nuclear structure**
Spin-orbit coupling, nuclear spin, and nuclear structure.

Week 4: 2/11-13 **Zeeman and Stark effects**
Atoms in electric and magnetic fields, Wigner-Eckart theorem

Week 5: 2/18-20 **Variational method**
Ground state approximations, Ritz theorem, mini-max theorem, oscillation theorem.

Week 6: 2/25-27 **Time-dependent quantum systems**
2-level systems, Landau-Zener transitions, Rabi flopping.

------------------------------- Spring Break --------------------------------

Week 7: 3/11-13 **Midterm, time-dependent perturbation theory**
Fermi golden rule, Wigner-Weisskopf theory of excited state decay.

Week 8: 3/18-20 **Discrete symmetries**
Parity symmetry (and parity violation), time-reversal symmetry.

Week 9: 3/25-27 **Identical particles and multi-particle systems**
Bosons, Fermions, multi-electron atoms, second quantization, quantization of EM field.

Week 10: 4/1-3 **Lattice translation symmetry**
Tight binding model, Bloch theorem, basic band theory, Bloch oscillations.

Week 11: 4/8-10 **Scattering theory I**
Partial wave expansion, scattering length, quantum statistics.

Week 12: 4/15-17 **Scattering theory II … Dirac Equation I**
Born approximation, Lippman-Schwinger, Klein-Gordon equation, Dirac equation

Week 13: 4/22-24 **Dirac Equation II**
Symmetries, Dirac equation for a central potential

May 1, 2014, 14:00-17:00 **Final Exam**