Physics 7400/7410 **Quantum Mechanics** **Fall 2014/Winter 2015**

Instructor: Sergei A. Voloshin, 349 Physics Bldg., ph:313-577-1630; fax:313-577-0711; e-mail: voloshin@wayne.edu
Office hours: 10:30am - 11:30am TF, and by appointment.
Texts: L.D. Landau and E.M. Lifshitz, "Quantum Mechanics"
J.J. Sakurai (and Jim Napolitano), "Modern Quantum Mechanics"
S. Weinberg, "Lectures on Quantum Mechanics"
Grading: 20% for each of two one-hour exams, 30% for the final, 30% for the homework/in-class quizzes.
Homework: assigned weekly and collected on a week later. Late homework will not be accepted.

Course outline

1. **Concepts of quantum mechanics.** Postulates of quantum mechanics. Superposition principle. Operators. Properties of the operators corresponding to physical quantities. Position and momentum operators. Hamiltonian. Stationary states. Heisenberg representation. Density matrix.

2. **Schrodinger equation.** Time-independent Schrodinger equation. Bound states and energy quantization. Properties of the wave function. The variational principle. Examples. Semi-stable states and resonances. Periodic potential and Brillouin zones. Motion in 3d. Degeneracy. Motion in a uniform magnetic field. Landau levels.

3. **1d Scattering.** Free particle. Probability current density. Wave packets. Phase and group velocities. Reflection and transmission coefficients.

4. **Angular momentum.** Orbital angular momentum. Commutation relations. Eigenfunctions. Spin. Spinors. Addition of angular momentum. Spin in magnetic field.

5. **Identical particles.** Bosons and fermions. Symmetry of the wave function. Many-particle systems. Second quantization.

6. **Motion in a central field.** Hydrogen atom.

7. **Quasiclassical approximation.** Tunneling. Bohr's quantization rule.

8. **Time-independent perturbation theory.** Non-degenerate perturbation theory. Degenerate perturbation theory.

9. **The atom.** Fine structure. Stark effect. Zeeman effect. Thomas-Fermi atom. Hyperfine splitting. Helium atom.

10. **Time-dependent perturbation theory.** Perturbation acting for a finite time. Periodic perturbation. Emission and absorption of radiation. Potential energy as perturbation. Green's function. Interaction representation.

11. **Scattering.** The general theory. Phase shifts and scattering length. Optical Theorem. Born's formula. Scattering of slow particles. Resonance scattering. Rutherford's formula. Electron scattering off atoms. Formfactors.

12. **Inelastic collisions.** Inelastic collisions of slow particles. Scattering near threshold. Glauber theory.

13. **Introduction to relativistic quantum mechanics.** Klein-Gordon equation. Dirac equation.

14. **Selected topics.** Berry's phase. Bell's theorem. Quantum computing. Path integral method.

Learning outcomes

- Understanding of the principles and concepts of Quantum Mechanics.
- Ability to solve problems and apply corresponding techniques for the material outlined above
- Ability to critically read and understand scientific texts related to Quantum Mechanics.

Homework:

- Write clearly.
- Explain notations, especially if different from those used in lectures.
- Do not refer to equations in the textbook (you may refer to lectures or to the equation sheet).
- Do not write anything irrelevant.
- If a computer program has been used, attach a print-out.