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

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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. Classical limit. Hamiltonian. Schrodinger equation. Probability current density. Stationary states. Properties of the wave functions.

2. **Matrices. Representation theory.** Wave function in the momentum space. Operators and matrices. Transformation of matrices. Quantum oscillator problem in matrix representation approach. Schrodinger, Heisenberg, and interaction representation of operators.

3. **Schrodinger equation.** Bound states and energy quantization. The variational principle. Reflection and transmission coefficients. Wave packets. Phase and group velocities. *Semi-stable states and resonances. Periodic potential and Brillouin zones.* Motion in 3d. Degeneracy.

4. **Angular momentum. Spin.** Orbital angular momentum. Commutation relations. Eigenfunctions. Spin. Spinors. Addition of angular momentum. Spin in magnetic field. Bosons and fermions. Particle indistinguishability and symmetry of the wave function. Many-particle systems. *Second quantization.*

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

6. **The atom.** *[Hydrogen atom.]* Fine structure. Stark effect. Zeeman effect. Hyperfine splitting. Helium atom. Thomas-Fermi atom.

7. **Quasiclassical approximation.** The wave function in quasiclassical approximation. Boundary conditions. Bohr and Sommerfeld's quantization rule. Tunneling in quasiclassical approximation.

8. **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.

9. **Motion in a uniform magnetic field. Landau levels.**

10. **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.

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

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

13. **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.