Physics 6400 **Quantum theory I** **Winter 2013**

Instructor: Sergei A. Voloshin, 345 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: D.J. Griffiths, *Introduction to quantum mechanics*, second edition.
A.P. French and E.F. Taylor *An Introduction to Quantum Physics*
Grading: 17% for each of two one-hour exams, 33% for the final, 33% for the homework.
Homework: assigned weekly and collected on a week later. Late homework will not be accepted.

Course outline

1. **Review of mathematics.** *Probability and probability density.* Normalization. Examples: Gaussian distribution. Expectation value, mean, variance and standard deviation. *Delta function. Matrices and vectors.* Eigenvectors and eigenvalues, characteristic equation. *Operators.* Transpose and hermitian conjugate operators. Examples: differentiation, parity operator, translation (finite shift) operator. Eigenvalue problem. Discrete and continuous spectra.

2. **Wave function.** Normalization.Position and momentum operators. Hamiltonian.(Properties of the operators corresponding to physical quantities. Hermitian operators and their eigenfunctions and eigenvalues. Completeness and orthogonality.) Superposition principle. Uncertainty principle.

3. **One-dimensional Schrodinger equation.** Stationary states. Time-independent Schrodinger equation. Bound states and energy quantization. *The infinite square well.* Boundary conditions. Parity and symmetry of the wave function. Nodes, standing waves. Commutator and uncertainty relations. *The finite square well.* Continuity of the first derivative of the wave function and boundary conditions. Energy levels. Shallow well. *Delta function potential* as a shallow well. Discontinuity of ψ'. *The harmonic oscillator.* Analytic method. Hermite polynomials. Algebraic method. Raising and lowering operators.

4. **1d Scattering.** *Free particle.* Probability current density. Wave packets. Phase and group velocities. The minimum uncertainty wave packet. *Scattering problem* in one dimension. Reflection and transmission coefficients. The scattering matrix. Examples: the delta function potential, square well and square barrier. Tunneling.

5. **Quantum mechanics in three dimensions.** Degeneracy. *Angular momentum.* Commutation relations. Eigenfunctions. Rigid rotator. *Hydrogen atom.* Separation of variables.*Spin.* Addition of angular momentum.

6. **Identical particles.** *Bosons and fermions. Exchange interaction. Symmetry of the wave function.*

7. **Important approximations.** *Time-independent perturbation theory.* First and second order corrections. *Quasiclassical approximation.* Tunneling. Bohr's quantization rule.

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.