Quantum Mechanics Qualifying PhD Exam Guidelines

Department of Physics, Southern Methodist University

Established in August 2014

History

- The majority of these guidelines were established in 2014.
- They were updated in 2017 to reflect the change in subject exam duration from 3 to 2 hours for academic year 2017-2018.

Exam Administration

The exam will consist of two longer questions (about 45 min each) and two shorter questions (about 15 min each). You will have two hours to work on the solutions. You are allowed one textbook of your choice, one math reference, and a calculator.

Exam Topics

The PhD qualifying exam will be at the *level* of the textbooks by Liboff, Griffiths, Shankar, etc. The exam questions will be on the following topics:

1. Principles of Quantum Mechanics like the superposition principle, definition of a quantum state, the probability interpretation, discrete and continuous symmetries, commuting operators and the uncertainty relation, etc.
2. The time-dependent and time-independent Schrödinger equation, bound state and unbound state exact solutions in 1, 2, and 3 dimensions, e.g. Square Well, Rectangular Box, Square Step, Harmonic Oscillator, Hydrogen atom, periodic potentials, delta-function potentials, etc.
3. Solving the Schroedinger equation, approximately
   a) Variational method
   b) WKB approximation
   c) Time-independent perturbation theory (degenerate and nondegenerate)
   d) Time-dependent perturbation theory
4. Angular Momentum
   a) SU(2), spin-1/2
   b) Addition of Angular Momenta and selection rules
5. Scattering
   a) Fermi's golden rule and quantum state transition rates, e.g. ionization of Hydrogen, Rutherford scattering.
   b) Familiarity with the non-relativistic scattering cross sections of half-integer spin

particles, e.g. symmetry constraints on the 2x2 scattering matrix, polarization, etc.

Note that some of these topics may or may not be covered in the books mentioned above.