Examples of TH questions for the PHY1222 2007 course.

1. Discuss qualitatevely and quantitatevely one or more key experiments that showed the need of quantum description of nature at small scales (Examples: Photoelectric effect, Compton scattering, The spectral lines and the Bohr atom).

2. Present the principles of QM and the path integral formulation. Discuss the two-slit experiment. Derive the Schrördinger equation.

3. Position and momentum operators in position space. Eherenfest theorem.

4. Derive the time-independent Schrödinger equation and discuss the importance of the stationary states as a means to write the most general wave function $\psi(x,t)$ (Superposition principle). Give examples in the discrete spectrum case.

5. Density of probability and current. Derive the continuity equation and define the Transmission and Reflection coefficients for a general scattering problem. Discuss in detail one of the following applications:

   - Potential step and drop.
   - Tunnel effect.
   - The potential well (continuous spectrum). Resonances.

6. Solve and discuss the Schrödinger equation in a periodic potential.

7. Solve and discuss the Schrödinger equation for an attractive and repulsive delta-function potential. Build a model for a molecule.

8. Discuss the solution of the Schrödinger equation for the harmonic oscillator with operatorial methods.

9. Discuss the solution of the Schrödinger equation for the harmonic oscillator with the analytic method.

10. Discuss the superposition principle in the discrete spectrum and continuous spectrum cases.

11. Present in a concise way the most important formal features of an Hilbert space. List and prove the key theorems for Hermitian operators and their relation to QM.

12. Derive the uncertainty relation for two generic operators A and B. Find the form of the wave function in position space corresponding to the minimum uncertainty relation.

13. Discuss the Schrördinger equation for a free particle, the problem of normalizing the eigenstates of the momentum operator and its solution in terms of wave-packets. Discuss a gaussian wave packet in position space: its functional form and its time evolution.

14. Discuss the relation between time and energy in QM.

15. Present some of the most important features of QM using a two-state system: Time evolution for the eigenstates of an operator $\hat{A}$ which does not commute with the Hamiltonian $\hat{H}$; Sequential measurements; Time-energy uncertainty relation.