BirZeit University
Faculty of Science-Department of Physics
Quantum Mechanics Phys635
Spring 2017
Final Exam, June. 7th 2017

1. A particle of mass m moves in one-dimensionally in the oscillator potential $V(x) = \frac{1}{2}m\omega^2 x^2$. Calculate the relativistic correction to the first order to nth state.

2. A quantum mechanical rigid rotor constrained to rotate in one plane has moment of inertia I about its axis of rotation and electric dipole moment μ (in the plane). This rotor is placed in a weak uniform electric field ε, which is in the plane of rotation. Treating the electric field as a perturbation, find the first non-vanishing corrections to the energy levels of the rotor.

3. Consider a one-dimensional simple harmonic oscillator whose classical angular frequency is ω_0. For t < 0 it is known to be in the ground state. For t > 0 there is also a time-dependent potential $V(t) = F_0 x cos(wt)$, where F_0 is constant in both space and time. Obtain an expression for the expectation value $< x >$ as a function of time using time-dependent perturbation theory to the second non-vanishing order.

4. The coherent states are defined to be an eigenvector of the annihilation operator.

$$a|\alpha >= \alpha|\alpha >$$

   (a) Show that $|\alpha >$ can be written as:

$$|\alpha >= e^{-|\alpha|^2/2} \sum_{n=0}^{\infty} \frac{\alpha^n}{\sqrt{n!}} |n >$$

   (b) If we define a state defined by the creation operator, will it be physical. Why or why not?

$$a^{\dagger}|\alpha >= \alpha|\alpha >$$

5. A spin 3/2 particle is placed in a uniform magnetic field pointing in the Z-direction. If at t=0, the x-component of the particle was measured and found to be $\frac{1}{2}$.
   (a) Write the wave function at any later time t.
   (b) At what times if S_z is measured we will get +3/2
   (c) Write a rotation matrix that can describe the physical situation.

6. Show that for harmonic oscillator that the eigenvalues of the number operator $\hat{N}$ are positive integers or zero.

Good Luck
$\ddot{\smile}$