Physics 751 Midterm II Review Sheet

The best strategy is to read through my web notes, the last four sets posted, review all the answers to homework problems, then read your own notes from class and/or Shankar on Angular Momentum.

Simple Harmonic Oscillator: know

$$x = \sqrt{\hbar/2m\omega}\left(a^\dagger + a\right), \quad p = \sqrt{m\omega\hbar/2}\left(a^\dagger - a\right), \quad \langle n+1|a^\dagger|n\rangle = \sqrt{n+1}, \quad \langle n-1|a|n\rangle = \sqrt{n}.$$

Know the definition of the **propagator**, and be able to derive the free particle propagator.

Be familiar with the **Heisenberg representation**, know how to find the equation of motion for an operator in that representation, and know the connection with Ehrenfest's theorem.

Memorize the result $e^{A+B} = e^A e^B e^{-\frac{1}{2}[A,B]}$, know for what operators it is valid, and be able to use it for normalizing coherent states, etc.

Know what the ***P*-basis** is, and when it's useful.

Angular Momentum

From class notes: be able to show, if the operator $\vec{J}$ is defined by $|\psi\rangle \to e^{-\frac{i}{\hbar}\hat{\vec{J}}.\vec{\theta}}|\psi\rangle$ under a rotation defined by $\vec{\theta}$, then from our knowledge of *classical* rotations, $\left[J_i, J_j\right] = i\hbar\varepsilon_{ijk}J_k$, and know this formula by heart! Be able to derive from this the commutation relations among $J^2, J_z, J_\pm$. Be able to derive the matrix elements of these operators for the common eigenkets of J^2, J_z, and know how to prove that $2j$ is an integer. In fact, you should *memorize*:

$$J_\pm|j,m\rangle = \hbar\sqrt{j(j+1) - m(m\pm 1)}\,|j, m\pm 1\rangle.$$

Orbital angular momentum: know the formulas for the components L_i in Cartesian coordinates. From the formula you've memorized above, be able to construct the matrix operators corresponding to rotations of an orbital angular momentum equals one state about the x, y or z axes.

Know what L_z is in spherical polar coordinates, and what its eigenstates are. (We won't do Legendre polynomials on this test.)