Quantum Mechanics, Physics 531
Homework Assignment 3, due March 10, 2008

Problem 1. Problem 3.14.

Problem 2. Problem 3.27.

Problem 3. Problem 3.38.

Problem 4. Problem 4.18.

Problem 5. A particle in a spherically symmetric potential is in an eigenstate $|l, m\rangle$ of $\hat{\mathbf{L}}^2$ and $\hat{L}_z$ with eigenvalues $l(l+1)$ and m, respectively. Prove that the expectation values are given by

$$\langle l, m|\hat{L}_x|l, m\rangle = \langle l, m|\hat{L}_y|l, m\rangle = 0$$

and

$$\langle l, m|\hat{L}_x^2|l, m\rangle = \langle l, m|\hat{L}_y^2|l, m\rangle = \frac{l(l+1) - m^2}{2}.$$

Interpret this result in the limit $l \gg 1$.

Problem 6. Consider a charged rotator in a magnetic field B with the total angular momentum $l = 1$, described by the Hamiltonian

$$\hat{H} = \frac{\hat{\mathbf{L}}^2}{2J} + \mu \mathbf{B}\hat{\mathbf{L}}.$$

Calculate time dependence of the expectation values $\langle\chi(t)|\hat{L}_x|\chi(t)\rangle$, $\langle\chi(t)|\hat{L}_y|\chi(t)\rangle$, and $\langle\chi(t)|\hat{L}_z|\chi(t)\rangle$, if at $t = 0$ the state $|\chi(t)\rangle$ was described by

$$|\chi(t)\rangle = c_+|l = 1, m = +1\rangle + c_0|l = 1, m = 0\rangle + c_-|l = 1, m = -1\rangle$$

and $\mathbf{B} = \{0, 0, B_z\}$. Hint: use the result of problem 4 above for operators $\hat{L}_\pm$.