

## PY 451: Quantum Physics I Problem Set 8

Due date: Friday, March 27 2009, by 5:00pm

1. (based on text 8-1 & 2) Consider a quantum particle in the three-dimensional square-well potential, in which  $V(\mathbf{r}) = 0$  for  $0 < |x|, |y|, |z| < a$  and  $V(\mathbf{r}) = \infty$ , otherwise. Extend the calculation started in lecture and compute, for the lowest 25 bound states: (i) the energies, (ii) the associated degeneracies, and (iii) the values of  $n_x$ ,  $n_y$ , and  $n_z$  for each bound state.
2. (based on text 8-3 & 4) Using the same reasoning as in problem 1, study the properties (energy values, degeneracies, and associated values of the quantum numbers) for the first 15 states of the three-dimensional harmonic oscillator potential  $V(\mathbf{r}) = \frac{1}{2}m\omega^2\mathbf{r}^2 = \frac{1}{2}m\omega^2(x^2 + y^2 + z^2)$ .
3. (text 7-2) Express the spherical harmonics for  $\ell = 0, 1, 2$  in terms of  $x, y, z$ .
4. (text 7-8) Calculate the commutators  $[x_i, L_j]$ , where  $x_i$  is the  $i^{\text{th}}$  component of the position operator and  $L_j$  is the  $j^{\text{th}}$  component of the angular momentum operator, for all  $i$  and  $j$ . (Note: There is a general pattern so that you do not need to calculate all 9 possible commutation relations.)