Physics 512 **Winter 2003**

Homework Set #5 – Due Friday, February 14

1. This problem is essentially Merzbacher, Chapter 18, Problem 4 [or Sakurai, Chapter 5, Problem 1]. Consider a one-dimensional harmonic oscillator perturbed by a constant force

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2 - Fx$$

   a) Show that the first order perturbation in the energy levels vanishes
   b) Now calculate the eigenenergies E_n up to second order in the perturbation.
   c) Show that the second-order perturbation result gives the exact eigenenergies (which may be obtained by completing the square in H). Explain why this happens.

2. Sakurai, Chapter 5, Problem 2. In nondegenerate time-independent perturbation theory, what is the probability of finding in a perturbed energy eigenstate $|\psi_n\rangle$ the corresponding unperturbed eigenstate $|\psi_n^{(0)}\rangle$? Solve this up to terms of order g^2.

3. Consider the $2p$ levels of hydrogen ($m = 0, \pm 1$) subject to a perturbation

$$V = Ax^2 + By^2 - (A+B)z^2$$

   a) Write V in terms of components of a rank-2 spherical tensor.
   b) Neglecting electron spin, find the "correct" zeroth-order eigenstates and their corresponding energies. It is sufficient to give the energies in terms of a reduced matrix element $\langle 2p||T^{(2)}||2p\rangle$.
   c) Show that the expectation value of L_z vanishes in each eigenstate found above.

4. Merzbacher, Chapter 18, Problem 14.