PHYSICS 633 Spring 2005 April 21 midterm

Name:_____

In all problems, $H = H_0 + H'$.

1a) A spin-1/2 particle has $H_0 = \omega_0 S_z$, $H' = \omega_1 S_x$. Compute the first order shifts in the energies of the spin-up and of the spin-down states using first-order perturbation theory. Compute the exact eigenvalues and compare with your perturbative result.

1b) $H_0 = \omega_0 S_z$, $H' = \omega_1 S_x \theta(t)\theta(\tau - t)$. If the particle starts in its ground state, what is the probability that its spin will flip in leading time-dependent perturbation theory when $t > \tau$?

2a) H_0 is the Coulomb hamiltonian for hydrogen. $H' = -eE_0 z$. Compute the first-order energy shift for the $n = 1$ state and for a complete set of $n = 2$ states.

2b) H_0 is still the Coulomb hamiltonian for hydrogen. $H' = -eE_0 z\theta(t)e^{-t/\tau}$. What is the probability a hydrogen atom will make a transition from its ground state to any $n = 2$ state as $t \to \infty$.

3) [extra credit] H_0 is the 2-dimensional well, with $0 < x < a$ and $0 < y < a$. $H' = \alpha\delta(x - a/2)\delta(y - a/2)$. (a) Compute $E^{(1)}_{mn}$. (b) Demonstrate whether $E^{(2)}$ is finite or not.