

PHYSICS 633 Spring 2006 SAMPLE Midterm problems

1) $H_0 = \omega_0 S_z$, $H_1 = \omega_1 S_x \theta(t) \theta(\tau - t)$. If the particle starts in its ground state, what is the probability that its spin will flip in leading time-dependent perturbation theory when $t > \tau$?

2) H_0 is the Coulomb hamiltonian for hydrogen. $H_1 = -eE_0 z \theta(t) e^{-t/\tau}$. What is the probability a hydrogen atom will make a transition from its ground state to any $n = 2$ state as $t \rightarrow \infty$.

3) $H_0 = \omega_0 S_z$, $H_1 = \omega_1 S_y \theta(t) e^{-t/\tau}$. If the particle starts in its excited state, what is the probability that its spin will flip in leading time-dependent perturbation theory as $t \rightarrow \infty$? Comment on when this first-order approximation will be invalid.

4) $V(x) = -\alpha (a - |x|^2)$ for $|x| < a$ and is zero everywhere else. Choose trial wave functions with one free parameter for which you can complete all integrals you need to estimate the ground state energy and the first excited state energy. Compute both estimates.

5) $V(x) = \frac{1}{2} kx^2 + \delta x^4$. Use a gaussian trial wave function to put an upper bound on the ground state energy. Choose a related trial wave function and find a bound for the first excited state energy. Compare your ground state estimate with first-order perturbation theory for the shift from harmonic oscillator energies coming from δx^4 .