

Write your name on the test booklet. Do NOT simply write an answer. Give a calculation and/or reasoning that supports your answer. Do all work and write all answers in the test booklet. Circle or clearly delineate all relevant work so that I do not take points off for errors in your scratch work.

1)  $H_0 = -\omega_0 S_z$ ,  $H_1 = \omega_1 S_x \theta(t) e^{-t/\tau}$ . If a particle starts in its ground state, what is the probability that its spin will flip in leading order time-dependent perturbation theory as  $t \rightarrow \infty$ ?

2)  $V(x) = \delta|x|$ . Use the trial state  $\psi(x) = e^{-ax^2}$  to find an upper bound on the ground state energy. Plot  $a$  as a function of  $\delta$  and discuss why it is reasonable, e.g. why it behaves as it does for very small  $\delta$  and very large  $\delta$ .

3)  $H_0 = \frac{P^2}{2m} - \frac{\alpha}{r}$ , the hamiltonian for hydrogen. At  $t = 0$  the proton's charge is turned off and slightly later at  $t = \tau$  it is turned back on. Find  $H_1(t)$  that will do this and compute the probability that a hydrogen atom starting in its ground state will make a transition to one of the  $n = 2$  excited states in leading order time-dependent perturbation theory.