Physics 829 Spring 2000
Dr. Herbst

FINAL EXAMINATION (In Class; Closed Book)
5 JUNE
(150 POINTS)

1. (40 pts) In the theory of the interaction of radiation with matter, consider the $W = -q/m\ P_z A_z$ interaction term. To solve the following problem, you may use either the semiclassical or the fully quantum formulation, whichever appeals to you more.

Using the first term in the exp(iky) expansion and first-order time-dependent perturbation theory, determine the possible final states of a hydrogen atom initially in its 1s state after resonance radiation is shone in upon it. You need not perform any integrations unless you desire to. In the absence of integrations, please explain your answer.

2. (30 pts) Prove the variational principle: $\langle H \rangle \geq E_0$.

3. (40 pts) A one-dimensional harmonic oscillator oscillating in the z-direction and in its ground state is suddenly placed in a static electric field E_z at t=0. You may assume the dipole operator $\boldsymbol{\mu}$ to be $1/2\ qZ^2/a$, where a is some length.

a) (20 pts) What would you expect the energy and the state vector to be as a function of time for t>0? Perform no integrations but determine the quantities that would go into the integrals.

b) (20 pts) Compute the actual probability that the system will remain in its ground state.

$$\psi_0(z) = \{\frac{\alpha}{\pi^{1/2}}\}^{1/2} \exp(-\alpha^2 z^2/2); \quad \alpha^2 = m\omega/\hbar$$

4. (40 pts)
a) (20 pts) Write out the electron configurations, term symbols, and wavefunctions with specific values of L and S for the 5 lowest states of the He atom. Order these states in terms of increasing energy.
b) (20 pts) Assuming electrons to be S=1 bosons, redo part a).