DUE: THURSDAY, NOVEMBER 19, 2009

1. Liboff, problem 12.16 on pages 594–595.

2. The hydrogen atom is placed in a weak uniform electric field of strength $\mathcal{E}$ pointing in the z-direction. The Hamiltonian describing the system is given by:

$$H = \frac{-\hbar^2}{2m}\vec{\boldsymbol{\nabla}}^2 - \frac{e^2}{r} - e\mathcal{E}z\,.$$

Compute the ground state energy of the system using the variational technique. Use the trial wave function

$$\psi(\vec{\boldsymbol{r}}) = N(1 + q\mathcal{E}z)\psi_{100}(\vec{\boldsymbol{r}})\,,$$

where $\psi_{100}(\vec{\boldsymbol{r}})$ is the ground state wave function of the hydrogen atom (in the absence of an external electric field), q is the variational parameter, and N is chosen such that the trial wave function is properly normalized. Ignore all spin effects (*i.e.*, ignore fine and hyperfine splittings). Since the external electric field is assumed to be weak, simplify your computations by expanding in $\mathcal{E}$ and keeping only the leading term. In particular, show that the first correction to the ground state energy of hydrogen is proportional to $\mathcal{E}^2$. Compare the coefficient of this term with the one obtained in class by the second-order perturbation theory calculation of the Stark effect.

HINT: You must first evaluate the normalization constant N, since it will depend on the variational parameter q.

3. Liboff, problem 13.43 on page 735.

4. Liboff, problem 13.44 on page 735.

5. Liboff, problem 14.7 on page 782. In working out this problem, you should obtain an explicit expression for the differential scattering cross-section as a function of the scattering angle.