Homework Assignment 6
Physics 212

Handed out: Monday, March 22, 1999
Due in class on: Monday, March 29, 1999

Problem 1: Helium Atom Energies

1. Ignoring the interaction between the electrons, calculate the ground state energy for the Helium atom.
2. Calculate the expectation value of the correction to the Helium atom ground state due to electron-electron repulsion. Show that

$$\langle U_{12} \rangle \equiv \frac{1}{4\pi\epsilon_o} \left\langle \frac{e^2}{|r_1 - r_2|} \right\rangle = \frac{5}{4a_o} \left(\frac{e^2}{4\pi\epsilon_o} \right).$$

3. Taking the ground state energy of the Helium atom to be the sum of the above two energies, estimate the ionization energy - the energy required to remove one electron. Hint: Calculate the ground state energy of the He+ ion and subtract it from the estimated He g.s. energy.
4. Extra Credit: What is the 2nd ionization energy of Helium?

Problem 2: Problems in Griffiths

1. Problem 5.1 on page 178.
2. Problem 5.11 (b)-(e) on page 191.

Problem 3: Anti-symmetric Wavefunction for Three Electron Atom

Let the eigenfunction of the three-electron atom be written as a Slater determinant:

$$\psi(1,2,3) = \frac{1}{\sqrt{3!}} \begin{vmatrix} \psi_\alpha(1) & \psi_\beta(1) & \psi_\gamma(1) \\ \psi_\alpha(2) & \psi_\beta(2) & \psi_\gamma(2) \\ \psi_\alpha(3) & \psi_\beta(3) & \psi_\gamma(3) \end{vmatrix}.$$

Demonstrate the exchange anti-symmetry of this form and show that $\psi(1,2,3)$ satisfies the exclusion principle. Also verify the normalization of this function.