Physics 355 - Problem Set #1, due Sept. 2, 2005

1. A rough criterion for the applicability of ordinary particle mechanics (Newtonian or relativistic) is that the de Broglie wavelength be much smaller than the characteristic linear dimension l of the system. When l is of the same order as the wavelength or is smaller than the wavelength, wave mechanics is needed. Apply these criteria to the following systems to determine whether quantum physics is required to describe them.

(a) An electron in the first Bohr orbit of the Hydrogen atom.

(b) A proton in the nucleus: assume a proton in a large nucleus (radius $\approx 10^{-12}$ cm) with a kinetic energy 10 MeV.

(c) Electrons in a TV tube. (kinetic energies of the order of 10 keV)

2. Assuming that the momentum of the electron in the Hydrogen atom would be of the order of the uncertainty in the measurement of the momentum, use the uncertainty principle to get an estimate for the ground state energy and the radius of the Hydrogen atom.

Hint: Get an expression for the total energy of the atom and find the radius for which this is a minimum.

3. Griffiths, problem 1.1.

4. Griffiths, problem 1.3.

5. Griffiths, problem 1.4.