Homework #2.

5. In this exercise we will work out problems involving potentials which are given as delta functions. We will first focus on the 1D case.
(a) Calculate the binding energy of a particle if it is under the influence of an attractive delta potential $V(x) = -V_0 d(x)$ at x=0. Show that there is always only one bound state no matter how strong is V_0.
(b) Next consider the scattering problem. A particle with energy E is sent in from x<0 and is scattered off from the potential V(x), calculate the reflection coefficient R. Sketch R vs E.

Note: For simplicity you can assume m= $\hbar$ =1.

Hint: at the discontinuity the wavefunction is continuous but the derivative is not.

6. Next we consider a simplified H_2^+ molecule. Assume that an electron is moving in the field of two delta potentials at x=-R/2 and x=R/2, respectively. For simplicity in your calculation, set V_0=1 and m= $\hbar$ =1. Calculate the binding energies as a function of R. Find the range of R where there are two bound states. You would need to write a simple program to get the final answer and graph them.

Hint: The potential is symmetric, so your eigensolutions are either symmetric or antisymmetric.

7. Familiarize yourself with atomic hydrogen and its cousins.
(a) Calculate the difference in the binding energies of H(1s) and D(1s) in electron volts. You can just use the expression given in the textbook.
(b) What is the wavelength of the emitted radiation for an atomic hydrogen making transition from n=110 to n=109?
(c) The transition energy for n=2 to n=1 in atomic hydrogen is about 10 eV. What is the transition energy for a hydrogenic uranium (Z=92) for the same transition? What is the transition energy for a muonic hydrogen (electron is replaced by a negatively charged muon) for the same transition?
(d) The radius of the ground state of H is 0.5 ^{o}A. Calculate the radius of the hydrogenic uranium and the muonic hydrogen. For the muonic hydrogen, what is the probability that the muon will be found inside the nucleus. (This problem requires you to know a little bit of nuclear size, but just a little.)