PHYS 622
Problem set # 10 *(due April 22)*
Each problem is 10 points.

A1 Consider an attractive delta-shell potential
$V(r) = -\frac{\hbar^2\lambda}{2\mu}\delta(r-R)$.
Calculate the phase shift $\delta_\ell(k)$, where ℓ is the angular momentum quantum number.

A2 Find the s-wave phase shift δ_0 and the scattering amplitude a_S for the "spherical well" potential
$V(r) = -V_0$ for $r < R$, and $V = 0$ for $r > R$. At which conditions the scattering length becomes infinite, and what is their physical significance?

A3 Same as A2, but for the attractive delta-shell potential. You can (and should) use the results in A1.

A4 Consider the scattering of a particle by a distribution of scattering centers. Each scatterer is located at a point $\vec{r}_i$ and scatters with a given potential $V_0(|\vec{r}-\vec{r}_i|)$. Write down the scattering amplitude in the Born approximation. Consider the case of cube of side L with the scatterers placed at its eight vertices, and an infinite cubic lattice of a lattice spacing L.

Q1 The lowest excited states of the He atom have electron configuration $(1\mathrm{s})^1(2\mathrm{s})^1$. These include a spin singlet and a spin triplet. Which one (singlet or triplet) has the lower energy? Explain. Using single-electron wave functions $\psi_{1s}(\mathbf{r})$ and $\psi_{2s}(\mathbf{r})$, write down the expression for the energy difference. (You do not have to write down the actual forms of $\psi_{1s}(\mathbf{r})$ and $\psi_{2s}(\mathbf{r})$, which are of course similar to hydrogen wave functions but with $Z = 2$).