22.101 Applied Nuclear Physics

(Fall 2006)

Problem Set No. 3 **Due: October 2, 2006**

Problem 1

Derive the ℓ =0 (s-wave) radial wave equation from the time-independent Schrödinger wave equation for a particle in a spherical well of width r_o and depth V_o. Solve this equation for the ground state wave function and the corresponding bound-state energy. Sketch and discuss briefly your results and then indicate what changes would occur if the well were to become *very steep and very narrow*. Discuss the difference between this solution and the corresponding ground state solution in the one-dimensional problem.

Problem 2

In classical mechanics a particle incident upon a potential with range r_o at an impact parameter b would be scattered if $b < r_o$, but if b were greater than r_o then there would be no interaction. Use this simple picture to show that in the scattering of a neutron at low energy, by which we mean $kr_o << 1$, with $E = \hbar^2 k^2 / 2m$, *only the s-wave interaction is important*. Taking r_o = 1.5 F, what is the range of neutron energy where this approximation is valid?

Problem 3

Consider the one-dimensional problem of a particle of mass m and energy E incident upon a potential barrier of height V_o and width L ($V_o < E$) going from left to right. Derive the expression for the transmission coefficient in which you have introduced the wavenumber $\kappa = \sqrt{2m(V_o - E)} / \hbar$. Sketch the variation of T with κL. What physical interpretation can you give for the dimensionless quantity κL? For nuclear physics problems which is the more realistic limit between thin barrier and thick barrier (why)?