Quantum Mechanics, Spring 2004

Homework #9, Due 4/5/2004

1. Consider the low energy scattering from the potential $V(r) = V_0 e^{-\alpha^2 r^2}$.
(a) Calculate the scattering amplitude and differential cross section in Born approximation. Determine the range of validity of the approximation.
(b) Write down the expression for the next order term in the first order Born approximation. (No need to simplify).

2. (a) For a scattering potential $V(r)$, use the semiclassical approximation to determine an expression for δ_ℓ.
(b) A particle is scattered by a non-local potential

$$V(\vec{r}, \vec{r}') = -\frac{\hbar^2}{2m}\lambda u(r)u(r')$$

Show that only S-waves are affected by this interaction.

3. Sakurai Chapter 7, problem 3 (The spherically symmetric "rectangular" barrier/well potential)

4. Sakurai Chapter 7, problem 9 (The spherically symmetric attractive δ function potential)

5. A particle of mass m moves under the influence of a repulsive spherically symmetric potential: $V(r) = V_0$ for $r < a$, zero outside. If $\hbar^2 k^2/(2m) < V_0$, determine the S-wave phase shift.

6. (a) Consider the problem of finding the binding energy of deuteron (as discussed in Sakurai, pp 415–416). Determine the value of the effective range r_0 of the proton-neutron potential.
(b) A proton (938 MeV, spin 1/2) and a pion (140 MeV, spin 0) undergo scattering through a N (1440 MeV, spin 1/2) resonance. Calculate the cross section at the resonance in barns.

7. A nucleus with radius R absorbs all the neutrons incident on it. Let the de Broglie wavelength of the neutrons be smaller than the nuclear size. Determine the total (elastic) scattering cross section and the total (inelastic) absorption cross section.