PHYS 622
Problem set # 9 *(due April 15)*
Each problem is 10 points.

Sakurai and Napolitano problems: 6.1

A1 Using the first-order Born approximation, calculate the scattering amplitude $f(\theta, \phi)$ and the total scattering cross-section σ_{tot} for the Coulumb potential $V(r) = Ze^2/r$. Discuss the behavior in the limit of slow and fast particles.

A2 Repeat problem A1 for the Yukawa potential $V(r) = \frac{\alpha}{r} e^{-r/R}$.

A3 Working in Born's approximation, express the scattering amplitude for two identical scatterers, separated by the distance a:
$V(\vec{r}) = V_0(r) + V_0(|\vec{r} + \vec{a}|)$
using the known scattering amplitude $f_0(\theta)$ for a single centrally-symmetric scatterer $V_0(r)$. Using this expression, discuss the connection between the differential scattering cross-sections of fast electrons on an atom and a diatomic molecule, consisting of the two identical atoms. For a more realistic result, the molecular cross-section must be averaged with respect to different orientations of the molecule (*i.e.* for different directions of $\vec{a}$). Find the ratio between the differential cross-sections for a diatomic molecule and a single atom for two limiting cases:
(a) $ka \ll 1$ (without posing limitations for kR, where R is the potential acting range).
(b) $kR \approx 1$ and $a \gg R$ (*i.e.* the distance between the scaterrers is much larger than the potential range of each of them).

Q1 Consider a one-dimentional potential with a step function component and an attractive delta function component just at the edge:
$V(x) = V_0\Theta(x) - \frac{\hbar^2 g}{2m}\delta(x)$.

(a) Compute the reflection coefficient for particles with mass m incident from the left with energy $E > V_0$.

(b) Consider the limit of highly energetic particles $E \to \infty$. Will it be possible to "detect" the presence of the δ potential component by analyzing the dependence of the reflection coefficient on the particle energy E? Explain your answer.