PHY 339– Problem Set # 4

Complete reading of Chapter 2 of Griffiths.

1. Consider a neutral hydrogen atom having a proton with charge density \( e_0 \delta^3(r) \) and an electron in its ground state having a density

\[
\frac{e_0}{\pi a_0^3} e^{-2r/a_0},
\]

where \( a_0 \) is the bohr radius (0.529177249 Å). (Here we have denoted the elementary charge as \( e_0 \) in order distinguish it from the natural number \( e = 2.7182818... \)) Show that the electrostatic potential associated with this atom is given by

\[
V(r) = \frac{e_0}{4\pi \epsilon_0 r} \left( 1 + \frac{r}{a_0} \right) e^{-2r/a_0},
\]

using the following two methods:

(a)

\[
V(r) = \frac{e_0}{4\pi \epsilon_0} \int \frac{\rho(r')}{|r - r'|} d^3r'.
\]

(b) \( \nabla^2 V(r) = -\rho(r)/\epsilon_0. \)