Problem 10.1

Griffiths Chapter 6. Problem 21.

Problem 10.2

Use perturbation theory to estimate the first order correction to the ground state energy of Hydrogen due to the finite size of the proton. To do this, assume that the proton is a uniformly charged sphere of radius $b = 1 \cdot 10^{-15}$m. The electric potential is thus

$$V(r) = \begin{cases} \frac{e}{4\pi\epsilon_0 b}\left(\frac{3}{2} - \frac{r^2}{2b^2}\right) & r \leq b \\ \frac{e}{4\pi\epsilon_0 r} & r > b \end{cases}$$

As this problem only asks for an estimate you may expand your expressions to lowest non-vanishing order in the dimensionless quantity b/a_0 where a_0 is the Bohr radius. Compare the magnitude of your answer to the fine- and hyperfine corrections. How does your estimate change if the proton has all its charge on its surface?

Problem 10.3

Consider the electron-electron interaction as a perturbation, and compute the ground state energy of Helium correct to first order. Plug in numbers and compare your answer to that obtained in class using the variational method.

Hint: We calculated a very similar integral in class, and it is also given in Griffiths. You may use the result for this problem without any explicit calculation.