Homework 5

1. (20 points) For Hydrogen atom calculate \( \langle \phi_{nl}^{jm} | V | \phi_{nl}^{jm} \rangle \) using Virial theorem

2. (40 points) Rederive the Fine Structure correction to the Energy Levels of Hydrogen atom

use the following expressions for the derivation:

\[
\langle \phi_{nl}^{jm} | \frac{1}{r^3} | \phi_{nl}^{jm} \rangle = \frac{\alpha^3 m^3}{n^3} \frac{1}{l (l+1) (l+\frac{1}{2})}
\]

\[
\langle \phi_{nl}^{jm} | V^2 | \phi_{nl}^{jm} \rangle = \frac{\alpha^4 m^2}{n^3} \frac{1}{(l+\frac{1}{2})}
\]

3. (10 points) Calculate the magnitudes of fine structure splittings for \( \Delta j = 1 \) in the case of \( n = 2 \) and \( n = 3 \)