1. A variational wavefunction of the helium atom is
\[ \psi(1, 2) = \frac{1}{\pi} \xi^3 e^{-\xi(r_1 + r_2)} \]
\[ E = -(Z - \tfrac{5}{16})^2 \]  
Using the virial theorem, calculate \( \langle T \rangle \), \( \langle V \rangle \), the kinetic and potential energies, respectively.

2. From perturbation theory, we have the result that if
\[ H = H^{(0)} + \lambda H^{(1)} \]
then
\[ E_n = E_n^{(0)} + \lambda E_n^{(1)} + \lambda^2 E_n^{(2)} + \ldots \]
Use the Hellmann-Feynman theorem in the \( \lambda = 0 \) limit to show that
\[ E_n^{(1)} = \langle \psi_n^{(0)} | H^{(1)} | \psi_n^{(0)} \rangle \]

3. Suggest a derivation of the second order Moller-Plesset energy correction,
\[ E_n^{(2)} = \sum_{b=a+1}^{\infty} \sum_{a=n+1}^{n} \sum_{j=1}^{n-1} \sum_{i=j+1}^{j+1} \left| \langle ab | r_{12}^{-1} | ij \rangle - \langle ab | r_{12}^{-1} | ji \rangle \right|^2 \]
\[ \epsilon_i + \epsilon_j - \epsilon_a - \epsilon_b \]
\[ \langle ab | r_{12}^{-1} | ij \rangle = \int d1d2 \phi_a^*(1) \phi_b^*(2) r_{12}^{-1} \phi_i(1) \phi_j(2) \]
noting the limits in the sums, the energy denominator and the overlap numerator. Is \( n \) the number of electrons or orbitals?