Physics 622

**Problem set 2 (due February 5)**

Sakurai and Napolitano problems (each problem is 10 points):

5.1, 5.3, 5.11(a,b)

A1. **Second order perturbation theory correction to the eigenstate**: Derive the second order correction \( |n^{(2)} \rangle \) to the eigenstate in non-degenerate perturbation theory. Then answer the question in SN 5.2.

A2. **Anharmonic oscillator**: The Hamiltonian of a slightly anharmonic oscillator is given by the following Hamiltonian:

\[
\hat{H} = \frac{\hat{p}^2}{2m} + \frac{m\omega^2 x^2}{2} + \alpha x^3 + \beta x^4 .
\]

Calculate the correction to the energy of \( n \)th state to the first non-vanishing orders in \( \alpha \) and \( \beta \). Determine the range of values of \( \alpha \) and \( \beta \), for which the perturbation approach is valid.

A3. **A bound particle in the electric field**. A particle with charge \( q \) and mass \( m \) is in ground energy state inside a one-dimensional infinite square well with width \( 2a \), centered at \( x=0 \). Find the first- and second-order shifts of the ground level, if this particle is placed inside a uniform electric field \( E \).