Birzeit University
Faculty of Science-Department of Physics
Quantum Mechanics II, Phys4332
Spring 2018
Homework 2: Due date Mar. 20th 2018

1.

2. A spin-$\frac{1}{2}$ particle of mass m moves in spherical harmonic oscillator potential $V = \frac{1}{2}m\omega^2 r^2$ and is subject to an interaction $\lambda\sigma \cdot r$. The net Hamiltonian is therefore:

$$\begin{aligned} H &= H_0 + H_1 \\ H_0 &= \frac{P^2}{2m} + \frac{1}{2}m\omega^2 r^2 \\ H_1 &= \lambda\sigma \cdot r \end{aligned}$$

   (a) What is the shift in energy for the ground state through first order in perturbation H_1.

   (b) Compute the shift of the ground state energy through second order in the perturbation H_1.

3. Let $\vec{s}_1$ and $\vec{s}_2$ be the spin operators of two spin 1/2-particles. Then $\vec{S} = \vec{s}_1 + \vec{s}_2$ is the spin operator for this two-particle system.

   (a) Consider the Hamiltonian $H_0 = \frac{1}{\hbar^2}(S_x^2 + S_y^2 - S_z^2)$. Determine the eigenvalues and eigenvectors of this Hamiltonian.

   (b) Consider the perturbation $H_1 = s_{1x} - s_{2x}$. Calculate the eigenvalues of $H_0 + \lambda H_1$ in first-order perturbation theory.

4. Suppose that a hydrogen atom is exposed to a uniform electric field, $\vec{\varepsilon}$, and a parallel, uniform magnetic field, $\vec{B}$. Consider the first excited energy level, corresponding to n = 2, neglect the spin .

   (a) Show that in general the level is split into four nondegenerate energy levels.

   (b) For what values of ε and B are there instead only three levels, and what are the degeneracies of these levels?

   (c) For what values of ε and B are there only two levels, and what are the degeneracies of these levels?