PHYS 452 Quantum Mechanics II (Fall 2018)
Homework #3, due Tuesday Sep 25 in class

Perturbation theory, Stark effect

1. Consider a free electron in a magnetic field that is a combination of two uniform magnetic fields. The first one is along the z-direction, $\mathbf{B}_1 = (0, 0, B_z)$. The second one is along the x-direction, $\mathbf{B}_2 = (B_x, 0, 0)$.

   (a) Assuming $B_x \ll B_z$ use the perturbation theory to find the energies and eigenstates up to the lowest non-vanishing order.

   (b) Solve the problem exactly and see if the perturbative solution in the previous part reproduces the exact solution when $B_x \ll B_z$.

2. Consider the *second excited* state of a quantum harmonic oscillator in 2D. The Hamiltonian of this system is given by

$$H = \frac{(p_x^2 + p_y^2)}{2m} + \frac{m\omega^2(x^2 + y^2)}{2}.$$

   Suppose this system is subjected to a weak perturbation in the form $H' = \alpha xy$, where $\alpha \ll m\omega^2$. Find the first-order corrections to the energy levels and the new eigenfunctions in terms of the unperturbed states.

3. Problem 6.40a (part b is not required) in Griffiths.