## Problem Set 6

In this problem set, you'll get practice solving quantum mechanics problems using perturbation theory, one of the most important tools in this course.

### Problem 1

Do the Webwork problems for Tuesday, February 25th.

### Problem 2, hand in Thursday, February 27th (but attempt ASAP!)

a) For a particle of mass $m$ in a 1D harmonic oscillator potential $m\omega^2 x^2/2$ in the first excited state $|1\rangle$, what is the first order correction to the energy if we add a perturbation $\frac{1}{100}\omega p^2 x^2/\hbar$?

b) What is the first order correction to the state itself?

### Problem 3, hand in Thursday, February 27th (but attempt ASAP!)

a) What is the leading non-zero correction to the ground state energy of a harmonic oscillator if we add a perturbation $H_1 = \lambda p^3$?

### Problem 4: Reading question (hand in Tuesday, February 25th, participation credit)

Read the section in Griffiths on degenerate perturbation theory (7.2 in 3rd edition, 6.2 in older editions) for Tuesday. Answer the following: A quantum system has energy eigenstates $|\psi_1\rangle$, $|\psi_2\rangle$, and $|\psi_3\rangle$ with energies 0, $A$, and $A$ respectively. In this basis, we can write the Hamiltonian as

$$H_0 = A \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} . \tag{1}$$

The system is perturbed by adding a term

$$\lambda H_1 = \lambda A \begin{pmatrix} 3 & 1 & 7 \\ 1 & 0 & 1 \\ 7 & 1 & 0 \end{pmatrix} . \tag{2}$$

For the two states at energy $A$, what are the energies to first order in $\lambda$ for the shifted system?

**Problem 5: More Reading** (it is called reading week...)

For Tuesday, review the energy eigenvalues and eigenstates for the hydrogen atom (there is a Webwork question about this). Also, read up to page 4 in the "Notes on Rotations" and/or look at Griffiths 4.3.1, 4.4, and 4.4.1.