Your homework grade includes an explicit 10% that reflects your ability to communicate the work well, including an interpretative statement about your result/mathematics.

1. **Based on McIntyre 10.8** (Magnetic perturbation to spin 1)
   We're going to add an additional piece to this problem in the text and then break it into 2 parts (the second part is Q3 of this homework). For this first part, the actual values of g and B aren't relevant (you'll use them in the graph in Q3 of this homework).
   The nitrogen nucleus has spin 1 and a gyromagnetic ratio $g_N = 0.404$. A nitrogen nucleus is placed in a constant magnetic field in the z-direction $\vec{B} = B_0\hat{z}$. An additional, perturbative magnetic field $\vec{B}' = B_2\hat{x}$ is applied to the system.
   (a) Find the new energy eigenvalues to first-order (i.e. to order ω_2/ω_0) now that the perturbation has been applied.
   (b) Find the new energy eigenstates to first-order (i.e. to order ω_2/ω_0) now that the perturbation has been applied.

2. **McIntyre 10.18** **with additional graphs** (delta function perturbation to infinite well)

Consider an infinite square well potential with walls at $x = 0$ and $x = L$; that is, $V(x) = 0$ for $0 < x < L$; $V(x) = \infty$ otherwise. Impose a perturbation on this potential of the form $H' = LV_0\delta\left(x-\frac{L}{2}\right)$ where $\delta(x)$ is the Dirac delta function.

a) Calculate the first-order correction to the energy of the nth state of the infinite well.
a1) Draw an energy spectrum for the unperturbed system and then one for the perturbed system so that the illustration makes clear how the perturbation affects the eigenvalues.
b) Give some physical insight into why your answer is different for even and odd values of n.
c) The ground state wave function is modified under the influence of the perturbation. Calculate the largest contribution to the first-order correction. (In other words, which state is mixed in the most?)
c1) Sketch the ground-state wave function $\varphi_{n=1}^{(0)}(x)$ and the perturbed ground state wave function $\varphi_{n=1}(x)$ so that it includes the largest correction, so that the illustration makes clear how the perturbation affects the ground-state wave function. (An additional exercise for helping your understanding would be to include other terms to see how much they change your answer.)

Now consider the case where we impose a rectangular bump perturbation on the infinite square well potential as shown in Fig. 10.12 (see text book), with ε a small number (ε is a length here, not an energy, just as a reminder).

d) Calculate the first-order correction to the energy of the ground state of the infinite well.

e) In the limit where ε goes to zero, compare your answer to (d) with the answer in (a). Discuss.

3. **The rest of McIntyre 10.8** (Magnetic perturbation to spin 1)
   In Q1, you found the corrections to the energies and state vectors to order ω_2/ω_0. Now find (and graph) the corrections to the energies (not state vector) to order $\left(\omega_2/\omega_0\right)^2$.

4. **McIntyre 10.17** (ramp perturbation to infinite well)
   This problem is relevant to the midterm, because it has is about first order corrections to energy eigenstates. I'm not asking you to turn it in before the midterm because is contains integrals that I wouldn't ask you to do in an in-class exam, but you should know how to get the point of doing the integrals.

All of the problems in this chapter can and should be completed to study for the midterm and final exam. <u>For the midterm, we will be concerned only with first-order, non-degenerate cases</u>.