The problems for this set have all been taken from Robinett and include problems from chapters 16, 17 and 18 of that text. Eight problems seems like a lot for an abbreviated period with exam in the middle, and this time only four of these problems are Robinett’s Q problems, rather than his P problems, but then this leaves but four P problems. This is the last problem set that will come from Robinett, as lectures after this period will be based either of the project type, ie quantum information (on Mondays), or material from Schleich (Wednesdays and Fridays).

In quantum mechanics, state vectors represent directions in a Hilbert space. In practically all of the book of Robinett we have been trying to find energy eigenstates with are also function of position. The $\psi_0$ of the harmonic oscillator is a Gaussian function of position. But we could as well have $|0\rangle$ be the vector $(1 \ 0 \ \ldots)^\dagger$, and the state $|n\rangle = (0 \ \ldots \ 0 \ 1 \ 0 \ \ldots)^\dagger$ and have the Hamiltonian be a matrix comprised of raising $\hat{a}^\dagger$ and lowering $\hat{a}$ operators (matrices), where $\hat{a}|n\rangle = \sqrt{n}|n-1\rangle$, $\hat{a}^\dagger|n\rangle = \sqrt{n+1}|n+1\rangle$ such that $\hat{a}^\dagger\hat{a}|n\rangle = n|n\rangle = n|n\rangle$ and the Hamiltonian $\hat{H}|n\rangle = \hbar\omega(n + 1/2)|n\rangle = (n + 1/2)\hbar\omega|n\rangle$. In fact, this is the way that problems in lasers, semiconductors and engineering in general are solved, that is, without resorting to positional representations if at all possible. With this, try the following:

1. Answer Q16.5 on page 353 of Robinett.

As I mentioned in class, the idea of degeneracy is a rather important one. We do live in a three dimensional world, and if the temperature were high enough, everything would be maximally symmetric (and of course we wouldn’t exist as our frozen in states would be disallowed). Even the frozen is states of the everyday world have a multitude of symmetries built in, and this affects the way that we count available states. The number of available states is a fundamental one in designing electronic, optoelectronic, optical and just about any other kind of device we can imagine that does anything useful. Let us first consider some degeneracies of square two dimensional containers:

2. Work out P16.7 on page 355 of Robinett.

Simple harmonic oscillators have degeneracies too. Here you will be working on a problem about optical fibers with elliptical cross sections and, therefore, polarization preserving characteristics, although Robinett doesn’t let you know this. That is, in trying to:


Schleich is big on pictorial representations of quantum states, and generally these representation need to be as near to classical as possible in order to be easily recognizable. Here is a question related to quantization of classical orbits:

4. Answer Q17.1 on page 396 of Robinett.
Here is a problem about spherical harmonics that you can answer without having to know anything about angular momentum to speak of:

5. Work out a solution to P17.8 on pages 397-398 of Robinett.

Sometimes it is good to work out orders of magnitude:

6. Answer Q18.1 on page 433 of Robinett.

Sometimes it is good to think about crazy ideas as sometimes they aren’t so crazy. Here is a question which can relate to the states of quantum well electronic/optoelectronic device and maybe a bunch of other useful things as well:

7. Answer Q18.3 on page 433 of Robinett.

We won’t be doing too much more with position representations of wavefunctions in this course. This problem seems a fitting last one to look at for future reference. The hydrogen atom and even the shapes of its orbitals (as they are the basis for the orbitals of every element molecule and other such things) are something useful:

8. Do P18.1 on page 433 of Robinett.