Physics 340 — Test 2 — Spring 1996

Takehome test — open book, computer, and notes, but you may not consult other people (except the instructor) about the test.

1. Calculate the commutator $[L, H]$, where $H = (p_x^2 + p_y^2 + x^2 + \lambda^2 y^2)/2$ and $L = xp_y - yp_x$, and where λ is a constant, p_x and p_y are the x and y momentum operators, and x and y are the corresponding position operators. Show your work. What does this result tell you about the operator L?

2. Compute the first 4 eigenvalues and eigenvectors for a particle of mass $M = 1$ in the potential $U(x) = x^{10}$. Take $\hbar = 1$. Compare your results with the energy levels of an infinite square well of width 2. (Hint: Modify *ho_demo.r* to do the calculation.)

3. Use first order perturbation theory to compute the changes to the energies of the 2-D harmonic oscillator, $H = (p_x^2 + p_y^2 + x^2 + y^2)/2$, due to the perturbation potential $U = -0.2\exp[-(x^2 + y^2)]$. Carry this out for all states with unperturbed energies $E = 1, 2, 3$ and present your results as an energy level diagram in which the total energies (unperturbed plus the perturbation) are plotted in the vertical vs. values of m in the horizontal. (Hint: Modify *xydipole.r* to do this calculation.)

4. This is a problem in numerical exploration. The demonstration *solid.r* computes the energies of a periodic potential designed to emulate a number of atoms lined up in a row. Compute the bound state energies (i. e., $E < 0$) for a particle in this potential for 2 to 8 atoms, with potential strength 8. Carefully, completely, and neatly describe what is going on and try to explain it if you can.