Physics 214: Introduction to Quantum Mechanics
Spring 2015
Exam 3 Study Guide

The purpose of this study guide is to help you to focus your exam preparation effort on certain key areas that are most likely to appear on the exam.

Focus areas and skills: The primary focus of the exam will be (1) qualitative plots of wavefunctions and (2) scattering (reflection and transmission) from potential energy barriers. The exam will also cover: commutators, groundstate energy estimation using the uncertainty principle, and the identification of the \( n, \ell, m \) state of hydrogen from the counting of angular and radial nodes.

Here is what you should be able to do:

Evaluate simple commutators by reducing them to the canonical commutation relations

\[
[x, \hat{p}_x] = i\hbar, \quad [y, \hat{p}_y] = i\hbar, \quad [z, \hat{p}_z] = i\hbar.
\]

What you will be asked to do will be simpler than \([\hat{L}_x, \hat{L}_y]\) on Problem Set 9, so if you understand that problem, you should be in good shape.

Write down the Hamiltonian operator \( \hat{H} \) in terms of \( \hat{p} \) and \( x \) for the 1D systems that we have encountered, or given the potential \( V(x) \) of a new system.

Estimate the ground state energy using the uncertainty principle (as in the \( V(x) = \frac{1}{2}ax^4 \) example in Lecture 30 notes, or \( V(x) = a|x| \) in the homework problem on Problem Set 10.)

Draw qualitative sketches of wavefunctions, given the potential (as on Problem Set 8). Identify qualitative errors in an incorrectly sketched wavefunction, given the potential.

Identify the state \( n, \ell, m \) of hydrogen given a picture of the electron cloud (i.e., what we practiced in the “name that wavefunction” game on the last day of class).

For scattering from a potential \( V(x) \), carry out an analysis of matching conditions, and determine the reflection and transmission coefficients (within reason, given time limitations).

Know the solutions to the time-independent Schrödinger equation in a region of constant potential \( V_0 \): for \( E > V_0 \) (sum of complex exponentials), \( E < V_0 \) (sum of real exponentials), and \( E = V_0 \) (equation \( d^2\psi/dx^2 = 0 \), with solutions \( \psi(x) = Ax + B \). Note the last case! You will need this for one of the problems on Exam 3.