General

1. The exam will cover all material from problem set 5 to problem set 9.

2. You may bring a 3×5 index card full of formulas.

3. There is a formula sheet on the web site. But you may NOT use this on the exam.

4. The practice exam is from last year. It was way too long and perhaps too hard.

5. The practice exam is a good way to study. BUT THE PRACTICE EXAM IS NOT COMPREHENSIVE. i.e. there is more stuff that we covered which could appear on the exam that is not on the practice exam. In particular, I think that the material in `PS9` is not adequately covered on the practice test. (I had a different emphasis last time) Not all of the material on the practice exam is guaranteed to appear.

6. THE HOMEWORK IS COMPREHENSIVE. If you can do it all you will be prepared. All solutions are online. My intent is that nothing on the exam should be unfamiliar.

Subject and Problems

1. Understand solid angles and how they are used when describing scattering. The Rutherford experiment is a prototype. PT4, HW5: 4.8, 3, 4

2. Use and derive the Bohr model and generalization. Especially important for estimates: PT 1, PT2, HW6: all – for example 2,3,4

3. Debroglie waves, wave packets, and the uncertainty principle. HW7: 1 , HW7 3.19, 3.28, 3.30

4. Skills with wave functions:

   (a) Determine probabilities to find an electron in a region of space given the wave function HW7: 5.7

   (b) Determine the most likely position of finding an electron. HW7: 5.2

   (c) Normalize the wave function HW7: 5.10

   (d) Compute the average position, variance in position, average momentum and the variance in momentum. Determine the average kinetic energy and potential energy many examples from HW7 and HW8

   (e) Show that this or that function obeys the time dependent or time independent Shrödinger equation and determine the energy in the time independent case. `HW7:5.10, HW8:2, PT3, EX5.9`

5. Qualitative features of the wave function:

   (a) Understand that the ground state is a balance between the kinetic and potential energies and that this provides an order of magnitude for the size HW8: 2, HW9 5.22, PT:2

   (b) Understand that in the classically allowed region the local wavelength is determined by the available kinetic energy, $k^2 \propto (E - V)$. HW9: 5.25, 5.27, 5.30, PT: 5

   (c) Understand that in the classically forbidden region one decreases exponentially as one goes deeper into the forbidden region, and increases exponentially as one goes out of the forbidden region. The rate is governed by $\Psi \propto e^{\pm\kappa(x-x_o)}$ where x_o is the classical turning radius, $\kappa^2 \propto (V - E)$ HW9: 5.25, 5.27, 5.30, PT: 5.

   (d) Understand that it is requiring that the wave function $\psi \to 0$ at $x \to \pm\infty$ that leads to discrete energies. see Lecture L19_slides

   (e) Describe qualitatively the $n - th$ excited state of a given potential. HW9: 5.22

6. Specific solutions to the Shrödinger Equation:

   (a) Know and the particle in the box wave functions and energies. e.g. PT3, HW9

   (b) Know the energies associated with the harmonic oscillator and be able to use the table of harmonic oscillator wave functions given in class. If this table of wave functions is needed it will be provided. HW8: 2, HW9: 6.32

7. Calculate the effect of a perturbing potential on the energies. HW9: 3

Specific Mathematical Skills we have developed:

1. Know a few Taylor series and how to use. For this test $\sin(x), \cos(x), \exp(x), (1+x)^\alpha$ should do it. This will appear in some (probably minor) way.

2. Know that products of sin's and cos's can be written as sums of sin's and cos's. This is clear if you use complex exponentials instead of sin's and cos's. We used this in several ways: analyzing beats, to do integrals involving the particle in the box. HW7: 1,

3. Understand complex numbers: Quiz that never happened, HW7: 2