Example Questions for Exam #2
PHY361

• The exam will cover sections 4.1 – 4.8, 5.1 – 5.11, and 6.1 – 6.6. The questions from chapter 6 will focus on separation of variables in 2 and 3 dimensions, and on angular momentum. The exam will focus on principles discussed in class

Chapter 4:
• What is a cross section? Be able to calculate the total cross section from the number of hits and misses. What else do you need?
• Describe qualitatively the relation between atomic force, impact parameter vs scattering angle, and differential cross section.
• What is the highest frequency of the H spectrum?
• Draw a graph of the kinetic energy, electrical potential energy, and total energy as a function of ‘r’ of an electron in a circular orbit around the nucleus.
• How much energy does it take to ionize an electron in the n=2 orbital of a hydrogen atom? (eV)
• Describe the difference between spectra of an arc-lamp (in class) and an incandescent lamp.
• What two things are quantized in the Bohr model of atomic spectra?
• What is the correspondence principle? Give an example.
• What is the connection between de Broglie matter waves and the Bohr model?
• How was heavy hydrogen discovered?

Chapter 5:
• The relations between E, ω, p, and k: a) for a photon; b) for an electron matter wave. (Yes, again!)
• What is the physical interpretation of a wave function?
• List the requirements for well-defined wave functions.
• What are the probability amplitude, probability density, and probability, in terms of the wave function? What does it mean to normalize a wave function?
• What quantities are needed to specify: a) the classical state of a particle? b) the quantum state? How is the position of a particle represented in wave mechanics? How is the momentum represented?
• Why is the wave equation different for electric fields and matter waves?
• What is an operator, what does it do?) Give 2 examples of and the corresponding eigenfunctions / eigenvalues. Calculate the expectation value of an operator.
• What does it mean that the Schrödinger equation is linear in ψ? What is the result of linearity?
• For a given energy value, and potential function, show where the classical turning points are. Label the kinetic energy for three separate points on the potential.
• Explain the differences between the TDSE and TISE. How do you derive one from the other? How do the solutions different and what do they mean? What information do you need to solve each equation? Which equation is the quantum analog of F=ma? What is the time dependence associated with a solution ψ(x) of the TISE? What is an intuitive interpretation of the TISE?
• What is the connection between de Broglie matter waves and the Schrödinger equation?
• What is quantum mechanical tunneling? Give three examples tunneling effects or applications.
• Why is the ground state for any bound potential not equal to zero (ie. zero-point energy)?
• Be able to solve Schrödinger equation for infinite square well.
- Be able to sketch, for example, the approximate form of the wave function or the 4th energy state in an infinite square well, a harmonic oscillator, or some random U(x) given on a graph. I suggest playing with the TISE applet to get a good feel for what solutions look like (good reading journal material).
- Know the qualitative behavior of the energy-level spacing for different potentials.
- Describe the qualitative behavior of the wave function in regions where a) V(x)<E, b) V(x)>E.
- What is the difference between bound and unbound states? What does this have to do with boundary conditions and quantization of energy?

Chapter 6:

- Use separation of variables to solve for the energy values of a particle in a 2-d infinite square well (rectangular boundary L x L). Draw node lines for the first 9 wave functions.
- Draw the node lines for the first few lowest states of the infinite square well on a circular boundary.
- Use separation of variables to derive the TISE from the TDSE.
- What are degenerate states? Give an example.
- Solve the eigenfunctions of L_z. Why is angular momentum quantized?