# Quantum Theory (PHYS 450): Week 10

Spring 2008 v1.0

In Chapter 10 Townsend does a series of 3D problems. We'll be solving Schrödinger's equation with different central potentials. The basic idea is the same as was done back in chapter 6: Find the Schrödinger equation for the specific potential then find the solutions by applying appropriate boundary conditions. It is boundary conditions which yield the quantization of the energy levels. In the current chapter, the mathematical sophistication is increased simply because we work in 3D. Concentrate on the details of (at least) one of these problems. Once you see the solution in one case, you can better see the way the problems work in the other cases.

Enjoy!

**Reading:**

Townsend Chapter 10
Davies and Betts Chapter 8

**Problems:**

Problems are due at the beginning of seminar. Please make a copy of your solutions before you arrive.

(1) 9.8
(2) 9.12
(3) 9.15
(4) 9.16(a)
(5) 9.18
(6) 9.19 For part (d) you may find your solution to 3.15 helpful
(7) 9.22
(8) 10.2
(9) 10.4 a classic GRE problem
(10) 10.5
(11) 10.6 The method is identical to that which Walter used last week.

**Seminar Presentations:**

Come to seminar with your presentation notes complete. **Ask questions about any gaps in your presentation before seminar.**

- Mike: "Uncertainty principle? Hold onto you wallet!" Review section 9.4 for us. Compute $\langle \mathbf{p} \rangle$ in a simple bound 1D system like the harmonic oscillator. Does this vanish? Why? Review the use of the uncertainty principle in Griffiths' problem 1.2 in *Introduction to elementary particles*. Comment on the nature of these arguments. When can we legitimately use the uncertainty principle? Finally, comment on the use of $a$ in the rigid rotator, equation 9.109.
- Dan T: Tell us about quantum cryptography and quantum teleportation. For a reference start with *The Quantum Challenge* **2nd edition** by Greenstein and Zajonc. (from last week)
- Ruth: Present the solution to the radial equation for the hydrogenic atom to the point of finding the energy levels, (10.35). When you present this, highlight only those conditions that are necessary to determine the energy levels , e.g. the asymptotic behavior. Jordan's presentation goes into the details of finding the radial solutions.
- Jordan: Present the series solution to the radial equation for hydrogenic atoms starting with (10.15). Concentrate on the series solution (pgs 279-280) and finding the radial functions (pgs 283-284) from the recursion relation. Include a solution to problem 10.5. Show how we can find $R_{30}$. Feel free to draw from Townsend and Davies and Betts. Write up your presentation

notes to distribute in seminar. Any algebra not done in the texts should go in these notes so that we all have a record of the complete solution.

- Walter: Present the solution for the energy levels of the infinite spherical well. Write up your presentation notes to distribute in seminar. Any algebra not done in the texts should go in these notes so that we all have a record of the complete solution.
- Nguyen: Present the solution to the 3D harmonic oscillator using spherical coordinates starting with (10.75). Highlight the series solution and the derivation of the energy levels. Include a solution to problem 10.11. Write up your presentation notes to distribute in seminar. Any algebra not done in the texts should go in these notes so that we all have a record of the complete solution.
- Emily: Present the finite spherical well and use it to model the deuteron. Work out the complete solution (pgs 289-290) filling in the necessary steps. Include a discussion of the "Swarthmore method" shown on page 291. Write up your presentation notes to distribute in seminar. Any algebra not done in the texts should go in these notes so that we all have a record of the complete solution.
- Wex: Delve intro the details of degeneracy in the hydrogen atom and the 3D harmonic oscillator
- Dan C.: Give us a qualitative overview of hydrogenic wavefunctions. Download a copy o"Atom in a Box" (http://daugerresearch.com/orbitals/index.shtml). Explain the phase using the color feature. Show us some superpositions with and without time evolution. Show us some transitions.