Quantum Theory (PHYS 450): Week 7

Spring 2008 v1.1

This week we work through several 1D wave mechanics problems. As you will discover last week's 6.10 is the easiest 1D problem - and the model for the solution to other 1D problems.

Townsend focuses on the harmonic oscillator in chapter 7. This is key material, not just for the reason that it is a useful model, but for the reason that it is at the core of field quantization. Note the use of raising and lowering operators.

If you haven't already done so, be sure to finish your midterm by the end of the day on Monday.

Enjoy!

Reading:

Townsend Chapter 6
Townsend Chapter 7, sections 7.1 -7.8

Problems:

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

(1) 6.3
(2) 6.5 There is a typo in part (c). Sketch the *probabilities*, rather than the amplitudes.
(3) 6.7
(4) 6.12
(5) 6.16 The δ-function potential
(6) A particle of mass m is confined to a 1D ring of length L. Solve the quantum problem, i.e. find momenta, energy and a complete set of states.
(7) 6.19
(8) 7.1
(9) 7.2
(10) 7.6

Seminar Presentations:

Come to seminar with your presentation notes complete. If you have any doubt about your presentations, please ask questions before seminar.

- Emily: What is a solution to the trial? (continued from last week) Please also prepare to answer questions on 6.16 and the problems in chapter 7.
- Dan T.: What is this translation operator anyway? Explain how it is related to momentum. (continued from last week). Be prepared to present a solution to 6.3.
- Seth: A short proof of (generalized) Bell's inequalities. A little on Tsierson's inequality and *quantum* hidden variables from arXiv:quant-phys/0605008.
- Everyone: (Quick?) discussion of problems 5.4, 5.5, and 6.10 - Hey, where have you seen those functions before? What do we call them? How many different contexts and names can you come up with?
- Walter: Review the Phys 320 version of the Fourier transform and show that the ways of writing "1" in equations 6.57 a and b *are* Fourier transforms. Recommended resource: Boas
- Dan C.:Tell us about Gaussian wave packets and the spreading of the wave packet. Present a solution of 6.4 (Appendix D is handy) emphasizing the behavior of position, momentum, and the uncertainty relation
- Ruth: Read and work through Davies and Betts section 2.4 on the finite square well. Present a complete solution for the energy levels (something that is omitted in Townsend). Feel free

to come up with your own graphical or other method for finding the solutions. Discuss the various limits for "small wells" etc.

- Jordan: Read and work through Davies and Betts section 2.5 on the bouncing ball. This experiment has been done with neutrons! See http://arxiv.org/abs/hep-ph/0301145 especially pages 9-12.
- Mike: Summarize solutions to 6.8 and 6.9 (some numerics required).
- Wex.: Discuss the Heisenberg uncertainty principle and section 6.7 including the double slit experiement. Look up the Nature article in footnote 11 and present a summary of the paper.
- Nguyen: Use the discussion of tunneling and arbitrary potentials (pages 182-184) as a jumping off point to discuss the WKB method. Most of the slightly more advanced texts discuss the method.