Quantum Theory (PHYS 450) Course Syllabus

Spring 2008 v1.0

1. Introduction to Phys 450:

Welcome to Quantum Theory and the world of the utterly strange!

Quantum mechanics is unique as far as I know in the fields of physics in that *what it means* is seriously debated in the physics and philosophy communities, and this debate has led to new avenues of experimental work. Many (most?) books at this level regard delving into these issues as something to hold at arms' length. (When I took this course for instance a bunch of us organized "gorilla seminars" so we could read the papers on the EPR paradox and discuss them!) David Griffiths, of the famous E&M text, presents the conceptual "what it means" material in an Epilogue. My view is that no time is better than now to understand these issues. Townsend has somewhat the same point of view and so we we encounter these puzzles in their natural habitat. In any case, rest assuaged that if you want to focus on *how it works* you can do that as well; much of the semester is about using your considerable resources to explore some very interesting physics. I hope you enjoy this material as much as I did (and do)!

2. Seminars

Quantum Theory will be taught in seminar format. This format is new to you all so let me explain a bit about it. The typical seminar consists of a series of 15 ± 10 minute student presentations punctuated by discussion. We'll take a 15 minute break in the middle of the class and enjoy some treats.

Your presentations will roughly follow the textbook. I'll assign presentations in the "Guides." Some of the presentations will not involve challenging material but, in addition to being absolutely clear on the material, think carefully on how is best to present the material. I encourage you to view your presentations as opportunities to explore the subject - bring in other resources, mention articles, tell us something new. If you don't like Townsend's presentation, then tell us about some other author's presentation of the material. (There will be a small library of books in the Common Room.) Some presentations will be challenging, perhaps by explicitly referring you to journal articles, but most will not be beyond textbook material. You will get a flavor for what I have in mind from my own presentations.

As with usual problem sets it is best to look over the material early to determine whether you will need to spend extra time preparing, asking questions, and researching the topic. It is even more critical in a seminar as the success of the seminar depends on all of us. Your presentations should be well-prepared and thoughtful. Poorly prepared presentations are not acceptable.

Make your presentations clear. You may use any method of presentation that is the most effective. I have found that it is possible, although not easy, to match the effectiveness of the blackboard. These will be "informal presentations" in that you should feel free to ask a question at any time - or even launch a discussion.

During the week previous to the seminar you will have a problem set to work on. These problems should help you explore and master the material. Bring **two** copies with you, one to turn in and one to refer to in seminar. With this preparation the discussions in seminar will be interesting, thoughtful, and may very well go beyond the basic material. Let's all work to make the discussion focused, fun, and supportive.

I realize that this is a challenging classroom environment! But (IMHO) it is, hands down, the best for learning physics. One of my major goals for the semester is for you to become proficient in teaching

yourself. You will take a little time getting used to it. That is fine. I've listed some useful points below to help you along. I will also send you feedback via email during the semester.

2.1. **Ideal, suggestions, and slogans:** My Platonic Ideal of The Seminar: The professor provides a detailed syllabus of a subject which, if followed carefully, will build a solid foundation of the subject. The students, working together with the professor, learn and present the material in class in a way which is clear to everyone. Discussion is active, intellectually challenging, non-threatening, and pushes the envelope of everyones understanding. In preparation every member has no problem asking others about a solution, an integral, or definition. In seminar any remaining questions are discussed in depth resulting in new insights which, naturally, arrive with a blinding flash of light.

The success of the seminar depends on every individual. We all contribute to seminar but I'd like to emphasize the complete reversal of roles. You take an active role in teaching yourselves. It is your class!

Here are a few suggestions:

(1) Nothing will help you better than to start preparing for seminar early. As good as they are, these chapters are not short stories; it would be unpleasant to read the entire chapter in one sitting. Further, read with a scratch pad and writing utensil; work through the presentation of the text. Allow plenty of time. Slogan: "Start early. Work slowly and carefully."
(2) Physics is not learned only by reading. To learn the subject one must try out the stuff by talking and writing about it and working through problems. For many of us this process has two purposes. One is to gain mathematical fluency. The other is to find the physics in the mathematics. Slogan: "Do all the problems carefully and completely."
(3) One of the aspects of the seminar experience that took me the longest to learn was the utility of asking a question. If you encounter difficulty, carefully formulate a question (often the question answers itself in this process!), then ask someone. If this person is madly preparing a midterm or a bernaise sauce or does not know the answer, try someone else. In particular do not hesitate to ask me (Science G052, x4919, smajor). If all else fails, go on to other problems and return to the question later. The slogan is: "Minimize frustration!"
(4) When writing solutions keep in mind that there is also a large difference in sketching a solution on your napkin at dinner and writing up the solution so that someone can read it (that may include you!) As with much writing, keep your audience in mind. Keep your classmates in mind but also try thinking of yourself in 3 months.
(5) Much of what is true for solutions also applies to presentations. Clearly state the issue or problem, outline the tools needed, and proceed providing information when needed. Feel free to skip algebraic steps once you have cleared it with the class. Show us (including me) something we don't already know, e.g. a new numerical solution or a experimental manifestation of a problem. Slogan: "To do well: Be clear. To impress, exhibit novelty."
(6) The best policy is to prepare fully for seminar before we meet and write up summaries and/or complete solutions after the actual seminar. It is not easy to keep up. But your notes will be loads of help for graduate school classes, qualifying exams... Think of this as writing up a book from which you can relearn the subject.
(7) It is never too early (or too late) to start being clear about what you understand and what you do not. There is a vast, amorphous plain between familiarity and understanding. Question your own understanding by trying it out on new situations. If your knowledge is not what is required, find the difference and learn from it.
(8) If you haven't already started, start keeping a sheet of paper with useful formulae so you can quickly answer questions such as, what is the spherical coordinate area element? (Did I hear this somewhere before?)

2.2. **Timing and scheduling:** Because our seminar time is precious please plan on arriving, with your solutions copied, 10 minutes before the official start of seminar at 1 PM. We may (frequently) run a bit late, but no later than 4:10 PM. If are unable to attend, please send me an email as soon as you know. Late notification hurts us all as I would not have time to reshuffle the presentations.

3. Texts:

John Townsend, *A Modern Approach to Quantum Mechanics*
Davies and Betts, *Quantum Mechanics* 2nd edition (optional)

4. Course info:

All materials will be available online. You can find them through the Courses tab on my homepage http://academics.hamilton.edu/physics/smajor/index.html. The latest versions will be labeled by a version number in the top right of the first page.

5. Problem sets

We will have weekly problem sets. Please photocopy your solutions so you can hand me a copy before seminar. Part of the role of seminars will be for you to fill in any gaps in your solutions. I strongly recommend that you write up final copies of your solutions after you have correct, complete solutions, normally after seminar. I will not be writing up nor distributing solutions.

6. Grades:

There are 4 parts to the grade:

(1) Problem sets: (25 %) Weekly problem sets will be due at the beginning of seminar once a week. Scoring works as follows: 85 % for a reasonable effort on solutions submitted at the beginning of seminar. Better solutions will receive a better score up to 100 %. Although I encourage you to work together you must write up your own solutions.
(2) Seminar participation and effectiveness (30%): Your presentations will be assessed for clarity and novelty.
(3) Mid-terms: (20 %) Two take-home midterms. The first will be early in the semester, about week 5.
(4) Final (25 %): This closed-book final will be self-scheduled during finals week. More on this later.

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