January 18, 2011

Physics 3660:
Quantum Mechanics II
Spring 2011

Overview

Course Description: The familiar physical world appears to obey classical laws of physics. This is not the entire picture though; when one gets down to tiny length scales, systems of particles obey a completely different set of principles, many of which have completely unexpected consequences. This portion of our world is the realm of quantum mechanics, to which the 3560/3660 two-semester sequence is designed as an introduction. The emphasis in the first semester was developing the basic knowledge of the subject, often through instructive yet unrealistic examples. Here the emphasis will be integrating that knowledge with an eye towards actual real world systems.

Course Goals: There are several technical course objectives:

- To understand the quantum mechanical treatment of complicated systems
- To become proficient in the tools we use to approach these often unsolvable problems
- To use these tools to predict the behavior of real world systems

Applications will be the focus this semester. However, since we are not residents of the subatomic world, even the applications we consider in this class will be mostly unfamiliar to us. Therefore an additional component of the class will be to identify the impact of quantum mechanics applications in our everyday physical world. The dynamics at the tiniest length scales might be irrelevant to us, but as we will see these dynamics influence many familiar processes, and in fact play a big role in making the everyday world the familiar place we know and love.

In this class we will confront complicated problems, many of which are actually unsolvable. The real world is full of such problems so although our techniques will be technical and specific in nature, the spirit of our problem solving strategies will be useful in a variety of arenas. Can I take this challenging problem and break it into its easy and hard parts? What simplifying assumptions can I make to make the problem easier to solve? Are these assumptions applicable? How accurate is the solution I come up with? We will develop the skills used for answering the above questions in the context of quantum mechanics but the spirit of these problem solving strategies will be transferable to other aspects of your life.

Meeting Those Goals: We will need to understand and become proficient in the tools of the trade. You will demonstrate this ability through weekly homework assignments, two in-term exams and a final.

We will explore the impact of QM in the everyday world through collaborative projects, each collaboration focusing on a specific topic. Each group will be responsible for educating others on the importance of QM in the topic you have chosen and the relevance of the effect in the everyday world.

Details

When and where and who: This class is comprised of three weekly meetings – Monday, Wednesday and Friday mornings, 11:00-11:50am, in 218 Physics.

My name is Prof. Chris Neu, and I will be your instructor. There will be a grader for the class, those details are forthcoming.

Success in this course is possible for every single student through being diligent, working thoughtfully and seeking help when one needs it. However the material of this class will be challenging. If you find yourself struggling **come see me during office hours** or **contact me through some other means.** I want to help you succeed in this class; seek me out if you are in need of help.

My contact information:

Prof. Christopher Neu
119 High Energy Physics Building
chris.neu@virginia.edu
434-243-8490
google: cneu34
AIM: chrisneu1234

I hope to see you regularly in office hours. If you cannot do this however, for whatever reason, email is a good way to reach me. I will hold **office hours in 22A Physics** every Wednesday immediately after lecture for an hour. **Note** that my actual daily office is **in a different building** than the one in which lecture and office hours take place. Keep that in mind when looking for me. Additional office hours can be made by appointment - just contact me via email.

I am often available through Google Chat and AIM. Green status means I am available to be asked questions. I cannot guarantee a rapid response but there is a very good chance I will be able to give you some guidance. Office hours are really the best place to hash out deep questions.

Information on this course is accessible through the UVaCollab system from https://collab.itc.virginia.edu/portal - search for 'PHYS 3660' and you will find the course web site.

Other important notes:

Textbook: *Introduction to Quantum Mechanics*, 2nd Ed., by David Griffiths. Lectures will follow the material in the text closely, and homework assignments will be partially assigned from the in-text exercises. Other texts are available in the Physics Library if you would like additional resources.

Grading:	Homework	30%
	Projects - group component	15%
	Projects - individual component	5%
	In-term Exams (2)	30%
	Final Exam	20%

Homework: Weekly problem sets will be assigned through the course web site every Friday and will be due the following Friday in class. The homework will attempt to span the material that is covered that week in lecture, although I reserve the right to bounce around a bit.

You are allowed to work together with other members of this class. But the work you turn in **must be your own**. Copying verbatim or nearly verbatim others' responses to homework problems constitutes cheating, see below.

A request for an extension of any homework deadline must be received at least a week before it is due and must be accompanied by a credible reason.

Group Projects: So often in quantum mechanics one can be overwhelmed by the mathematical rigor required for mastery of the subject; at times one can forget that it is the physical world that we are learning about, and these challenging concepts have implications that on our daily lives.

We will combat this effect by participating in student-led group projects. The focus of these projects is to demonstrate the impact and relevance of quantum mechanical effects in the everyday world of human experience – or future advances quantum mechanical effects could unlock. Below are a handful of topics groups can choose from:

- Quantum mechanics and our sun
- Quantum mechanics and plant life
- Quantum mechanics and the human body
- Quantum mechanics and everyday chemistry
- Quantum mechanics and computing
- Quantum mechanics and communications
- Quantum mechanics and the electrical grid

Other topics are of course possible – creativity is encouraged – but are only acceptable upon approval from me. Additionally, there can be no duplicate topics.

Groups will be determined on the first day of class. There will be 4 groups of 3-4 people. Topics must be chosen by the group and approved by me by 1 February. I recommend acting quickly, some topics are better than others.

There are multiple components of each project, so I suggest group members should be assigned roles and components they are responsible for. However I further recommend all group members contribute to all components, to ensure a coherent product in the end.

Components of the projects are:

- Paper (25%)
- Presentation (25%)
- Poster (25%)

- Web site (25%)

For the paper, we will use this as an opportunity to practice crafting a publication for a scholarly journal, as you will hopefully do many times as a professional scientist. Hence there is no minimum page number requirement – but instead a maximum: 4 pages total, including all text, figures, tables, bibliography. Four pages – however double column, minimal line spacing, 11 point font. I will provide you with an example that I would like you to follow. Make good use of this allowed space since it is precious – think of it as your only chance to communicate your ideas. Papers will need to convey the main points of the topic you are covering and must be professional in every way. Lastly, papers must be submitted in one of these electronic formats: .pdf, .doc, .ps. If these formats are unfamiliar to you, come see me and we can discuss. No hard copies are necessary, in fact none will be accepted.

Similarly, the presentation component will be a chance to hone your skills at giving a talk of the style that are given at a major international conference. Most such talks are necessarily short – 12 minutes maximum, with 3 minutes for questions. We will adhere to the same rules here, and I will be strict, as the moderators are at conferences. The talk must be professional in every way and should be prepared in electronic format (for example, PowerPoint, .ppt). If this software is unfamiliar to you, come see me and we can discuss. I will provide you with some example talks, good and bad, so you can see how better talks are prepared.

Poster sessions are also fairly common at conferences in the basic sciences, and so here too you will get some experience creating a scholarly poster. I will send you an example file that you can use to get an idea of what a good poster looks like. I also recommend using PowerPoint software for the poster. Groups will be expected to get the poster printed and ready for display.

Modern science is a global endeavor, so research groups must have a presence on the web to help communicate their work to colleagues around the world. Hence the final component of these projects will be to chronicle your report on a dedicated web site. The web site must be completely professional in every way. It will be public, and so I will ask some scientists I collaborate with who reside off-Grounds to critique their content. Some web hosting is possible in the department although other options can be explored. More details on the hosting will follow.

This whole enterprise will culminate in late April in a "Quantum Mechanics Fair". Guests will be invited to come and hear your talks, read your papers, evaluate your web sites and examine your posters. The entire Physics Department will be invited, along with guests from across Grounds. The date and location for this event is not yet determined. It will however be safely in the semester, so there should be no problems with extended absences, travel, etc.

A final component is a project prospectus, which is basically a report in early March, midway to the April "Quantum Mechanics Fair", that states what progress your group has made since choosing your topic. In situations like these it is tempting to do zero work until a week or so before the project is due. Projects executed in this way are typically unprofessional and unacceptable. Hence we will have a halfway point "checkup" where you should report on your (hopefully frequent) group interactions, the roles each group member will be responsible for, what issues and challenges you have encountered and foresee. This prospectus, one submitted per group, is due on Friday 4 March 2011. Electronic submissions are expected, to me via email.

Assessment and grading of the projects will have two facets:

- Group component, common to all group members, determined by me. This portion is based on the overall completeness, clarity, and accuracy of your complete project. Credit will be subtracted for particularly unprofessional components. This is worth half of your project grade.
- Individual component, determined by the other members of your group. Each group member will provide an assessment of the contributions for each other group member. These assessments will be anonymous to you but non-anonymous to me. This is done to guard against individuals who do not work as hard as their colleagues – presumably such individuals will get poor marks from their fellow group members. The point is – you are now a part of a collaboration, you have responsibilities, and you must provide – or better yet, exceed – your expected contributions. This is worth half of your project grade.

This project is an important part of this class. Do not treat it lightly. I highly recommend meeting with your group regularly and working on it steadily from now until April. This is how research in the sciences is conducted – methodically over an extended period of time. You need to identify the necessary pieces, prioritize them and start pursuing them. This is how it will be in the professional world you will soon enter, in whatever discipline you ultimately choose. Now is the best time to get some practice.

Exams: There will be two in-term exams and one final exam in this class:

Exam I	Wednesday 2 March 2011
Exam II	Wednesday 13 April 2011
Final Exam	Thursday 5 May 2010 – 9:00am - noon

All exams will be held in our classroom, 218 Physics. Exam I and II will be during normal class meeting time. There may be out-of-class portions of any of Exams I or II or the Final, this will be at my discretion and announced in advance, so please be aware. Requests to reschedule any exam must be made at least 2 weeks in advance and will only be granted in extreme circumstances.

Honor code: Do not cheat on homework, presentations and exams.

Given the collaborative learning environment I try to foster, it is quite easy to cheat in this class. Similarly it is often pretty easy for me or a grader to tell when you are cheating. Don't do it. You might feel like it is a great benefit to you to copy someone else's solution, or to obtain the solutions from some available source, or some other sort of scheme I may or may not be aware of. By cheating you are only shortchanging yourself and your education. An honest, earned B- is far better than a stolen, dishonest B+. Arriving at success through dishonest means will not be tolerated.

Further, your reputation in the department, and the quality of the statements I make when I am asked to speak on your behalf in terms of recommendations for future opportunities, will surely reflect the quality of your work, including this aspect. So please keep this in mind when you are making the decision to be, or not to be, an honest scholar.