Physics 580 | **Quantum Mechanics I** | Prof. P. M. Goldbart
Handout 1 | `webusers.physics.illinois.edu/∼goldbart/` | 3135 (& 2115) ESB
24 August 2010 | Introductory Notes | University of Illinois

Quantum Mechanics I is the first of a sequence of two graduate-level courses designed to teach you both the principles and some applications of quantum mechanics. The subject is very well developed and there is a lot of material to cover. Therefore I shall have to assume that you have had some exposure to quantum ideas, perhaps through a course or two at the undergraduate level. In particular, I shall assume that you have had some experience with wave mechanics, and with solving the Schrödinger equation for systems such as the hydrogen atom and the harmonic oscillator. If you do not have such a background it is possible that you will find the course rather challenging. Please come and talk to me if you're in this category, especially if you feel you need to take this course now.

It's my firm belief that the circle of ideas developed in *Quantum Mechanics I* and *II* are amongst the highest of the high-water marks in human thought. My first encounter with this material was truly exhilarating. I hope you find yourself feeling the same way about quantum theory.

For some of you this will be your first year in graduate school and (especially if you are teaching for the first time) you may initially find the experience quite bewildering. Indeed, the fact that you *will* get used to it may be difficult for you to believe. Nevertheless, let me stress at the outset that if at any time you find yourself having serious difficulties, please don't hesitate to come and see me or call me, either during office hours or at any other time. You can also reach me by e-mail at `goldbart@illinois.edu`.

There is a course web site, reachable from `webusers.physics.illinois.edu/∼goldbart/`. From it you can obtain my lecture notes, homework handouts, *etc.* You can also reach a useful page, *Course News*, on which I shall post various notices pertaining to the course (*e.g.*, times and locations of office hours and make-up lectures, any typographical errors in homeworks). It's worth getting into the habit of checking this page from time to time.

I plan to teach this course in the following way. During the lectures (2:30–3:50 p.m. on Tuesdays and Thursdays in 144 Loomis Laboratory) I shall develop the theoretical concepts of quantum mechanics and try to illuminate them using examples drawn from a variety of physical situations. Please don't hesitate to ask questions or raise points in class. It may be that you are clarifying a point for others too, and you may be helping me judge whether I'm being understood. My lecture notes will be available via the internet: occasionally these notes will be upgraded or augmented; sometimes they will contain peripheral topics and technical details that we do not have time to cover in class.

There will be a weekly set of assigned problems, usually due the week after they are issued. I don't think quantum mechanics can be mastered without *getting your hands dirty* and, accordingly, the problem sets will count significantly towards your final grade. Tackling the homework with friends is often instructive, but please be conscious of the fact that written exams will be closed-book, as will be any necessary oral exams.

Grading is a difficult issue, especially in graduate school. We shall probably have a midterm examination some time in October, and we shall have a final examination in December (both probably in 144 Loomis). Together with your homework, these examinations will generate your final grade.

I shall hold an office hour once per week at a mutually convenient time in a location to be determined. I warmly encourage you to come to these sessions; it's a part of my teaching commitment and I expect to devote these periods to this class. In my experience, these informal discussions can be extraordinarily rewarding.

There are two teaching assistants for the course. Information about how to contact them will be posted on the *Course News* web page.

Handout 2 consists of a probable syllabus for the course. The syllabus is flexible and may well be adjusted as we proceed. I shall not present the material in the order of its historical development. Rather, my aim is to give a reasonably complete course in modern non-relativistic quantum mechanics, thinking of it simply as a new mechanics which contains classical mechanics in an appropriate limit. (Limited aspects of relativistic quantum mechanics and quantum field theory will be addressed in *Quantum Mechanics II*.) We shall rely heavily on a small number of postulates that embody the theory, and shall emphasize those areas that you are likely to use as you progress through graduate school and beyond. It is quite likely that the physics you learn here will be central to much of your future research.

We now come to the thorny subject of text books. Many excellent ones might have been required, and I particularly welcome your comments on this subject. However, my own notes are fairly complete and will be available on the web (for free) and from the Illini Union Bookstore (if you wish to purchase them). So, I have elected not to make any books required; instead, I simply recommend that you have available to you at least one of the following: Baym's *Lectures on Quantum Mechanics*, Sakurai's *Modern Quantum Mechanics*, or Shakar's *Principles of Quantum Mechanics*. *Handout 3* contains a list of books that you may find useful. Some of them, including the recommended books just mentioned, are on reserve at Grainger Engineering Library. Amongst them, I especially draw your attention to *Quantum Mechanics* by Gottfried and Yan, and *Quantum Mechanics* by Merzbacher.

It's a good idea to spend some time browsing through a selection of the books on reserve (and any others that you find interesting). Time spent finding a book that you are comfortable with is a worthwhile investment. You may also find it extremely profitable to spend some time reading the books by Dirac and by Landau and Lifshitz. These books are not easy to digest but, once you feel comfortable with a topic, the insight they furnish can help you gain a more sophisticated understanding.

Parenthetically, I remark that as you proceed through graduate school I strongly encourage you to spend some time browsing in the library (at books and journals), on the internet, and in bookstores. In particular, try to get into the habit of reading the remarkable series of books by Landau and Lifshitz entitled *A Course in Theoretical Physics*. Initially, you may find this series discouragingly terse, but you will gradually get used to (and, I hope, learn to appreciate) their minimal style. Additionally, don't be afraid to return to *The Feynman Lectures on Physics*, from time to time, for Feynman's individual and stimulating view of physics. I also highly recommend Feynman's little book *QED*, which I think should be required reading for everyone planning to study quantum mechanics, as well as 't Hooft's *In Search of the Ultimate Building Blocks*. And don't hesitate to ask people to recommend interesting books and articles.

Finally, we are fortunate to have a large number of high-calibre seminar and colloquium series here on campus, and you should try to attend at least some of them regularly. Especially while you are in the process of making the crucial decision of what research field to enter, it is very important to hear something about a broad range of fields. You can find out about most relevant seminars and colloquia from the Physics Department website (`www.physics.illinois.edu`) via *Upcoming Events* or (on the day) from the Physics Department's *Today's Events* notice board. Additionally, I shall announce interesting-looking events in class. You may wish to make a note of the following regular events:

Condensed Matter Theory seminar	Monday	190 ESB	12:00 noon
Theoretical Biophysics seminar	Monday	3269 or 2269 BRI	3:00 p.m.
High Energy Physics seminar	Monday	144 LLP	4:00 p.m.
High Energy lunch seminar	Tuesday	464 LLP	12:00 noon
Astronomy colloquium	Tuesday	134 Astron.	4:00 p.m.
Quantum Information and AMO	Wednesday	280 MRL	12:00 noon
Astrophysics/Relativity	Wednesday	464 LLP	12:00 noon
Nuclear Physics seminar	Wednesday	464 LLP	4:00 p.m.
BCDE seminar	Thursday	464 LLP	12:00 noon
Nonlinear Dynamics and ...	Thursday	280 MRL	12:00 noon
Physics colloquium	Thursday	141 LLP	4:00 p.m.
Condensed Matter seminar	Friday	190 ESB	1:00 p.m.
Physics of Living Cells seminar	Friday	144 LLP	2:00 p.m.

You may be pleasantly surprised by how much you can follow, especially after you have attended several talks and have got used to the style of presentation. However, don't be afraid to sit near the back and leave if you have more important things to do.