Syllabus for Quantum Mechanics I (PHYS 4310)

GENERAL INFORMATION

Course Instructor: Bill Rice, Email: wrice2@uwyo.edu, Office: PS116
Lecture time: MWF, 12:00–12:50 in EN 3070
Office hours: T 16:30–18:00, Room PS116; Other session TBD
Main textbook: *Introduction to Quantum Mechanics* (2^{nd} edition) by D. J. Griffiths

GRADING AND CLASS STRUCTURE

We will use the undergraduate textbook *Introduction to Quantum Mechanics* (2^{nd} edition) by D. J. Griffiths with added supplements from a variety of other sources. As a lecture-based course, there will be an emphasis on homework, quizzes, tests, and class participation. That being said, references to canonical experiments and current research topics will also be added to expand the depth and breadth of this course. The course grading breakdown is:

Homework: 40% (lowest HW score will be dropped)
Quizzes: 10% (lowest quiz score will be dropped)
Class participation: 5%
1^{st} Midterm: 15%
2^{nd} Midterm: 15%
Final: 15%

Grades will follow a course grading scheme:

A $\geq$ 90% ☺
B = 80% - 89%
C = 70% - 79%
D = 60% - 69%
F $<$ 60% ☹

Homework: Weekly assignments are due on Wednesday at 17:00 at PS116 (but handing in completed work during class on Wed. is also perfectly acceptable). Working in groups to complete HW is strongly encouraged. However, you must do your own work! Or, put slightly differently, developing the route to solving the problem together is great, but producing carbon copies of the solution calculations is not ok. For every day HW is late, 20% will be taken off the value of the graded assignment. HWs may include computer calculations. You can take any format you like, *e.g.*, Matlab, Mathematica, Origin, IDL, or Wolfram. As far as I know the Wolfram simulation package is available for free online and the student PCs at university computing islands have links to Matlab, etc. You can help each other out with the computing technicalities.
Quizzes: Weekly quizzes (one to three questions) given on random days at the beginning of class. If you cannot be in class, please let me know as soon as possible. Quizzes will often cover the assigned reading from Griffiths (so be sure to do the reading!) and/or important other aspects of course that I wish to stress. No calculators or notes will be allowed (or even necessary) to complete the quizzes.
Class participation: I believe it is critical that each one of you participates in asking questions to me, engaging in discussion, and answering questions that I (or others) pose. As such, a small component of your course grade will be based on your interactions within the course.
Tests: There will be three in-class tests given throughout the semester, one of which will be a final exam. I have reduced the amount each is worth to account for the reality that professional physicists/chemists/engineers always have references near by to "refresh" their memory. That being said, I believe that in-class tests are a good (though not perfect) way of evaluating whether or not you comprehend the material and know how to use the techniques and ideas taught in class.

COURSE EXPECTATIONS:

Quantum mechanics is the one of the "major" courses in any physicist's education. As such, this course is both scientifically *and* mathematically demanding, and it will require lots of effort, focus, and determination to do well in it. In order to help you, I will be offering an optional (but very strongly recommended) weekly class (during one of my office hour sessions) to cover the mathematical concepts we will use in this class. This 'extra' course will cover many of the more challenging mathematical concepts that you will need to solve the problems we will encounter throughout the semester.

I need to stress that it is incumbent upon you to (1) read and prepare (work basic problems, seek other references, discuss with others, etc.) **before** you come to class and (2) let me know, either through questions, email, in class comments, and/or at office hours, if and at what point you are struggling with the material. **It is critical upfront that you know that I will not cover everything in lecture**. Learning this material is your responsibility; my role is to help direct, foster, and encourage that process. Instead, I will point out the most important topics to focus on during your reading of the material and add depth, perspective, and understanding to the text. This class will be demanding and tough. As such, working in groups on HWs, learning the material, and studying for the tests is highly encouraged.

Last, and perhaps most importantly, I expect you to learn and think as a physicist. This course is not for those who like to hunt and peck around for the 'right' formula to use. Instead, the goal in this class is to learn how to find the right approach to solving abstracted problems dealing with phenomena that are on the order of the de Broglie wavelength. From there, we can explore this wonderful world of quantum physics step by step.

It is critical to be readily familiar with these mathematical concepts:

- Multivariate calculus
- Linear algebra (particularly, matrix operations, eigenvalues/eigenvectors, changing bases, and diagonalization)
- Complex numbers (contour integration is welcomed, but not needed)
- First- and second-order ordinary differential equations
- Simple solutions to partial differential equations, including solving by separation of variables
- Fourier transforms and series

If you are rusty on any of these concepts (or have just plain forgotten them!) then come to the previously-mentioned weekly math review sessions. In addition, there are several excellent mathematical physics books that I suggest you either pick up or find in the library:

- *Basic Training in Mathematics: A Fitness Program for Science Students* by R. Shankar (fast moving and at a pretty basic level, but it covers many topics and some of the explanations are rather good).
- *Mathematical Methods in the Physical Sciences* by M. Boas (a classic text in the field...excellent in many regards).
- *Mathematical Methods of Physics* by Matthews and Walker (advanced text that covers many topics, but is lacking on explanation, flow, and detail).
- *Mathematics for Physicists* by Deanery and Krzywicki (covers certain topics well, like complex variables, Riemann surfaces, and calculus of residues, but not great with differential equations).
- *A First Course in Partial Differential Equations* by H. F. Weinberger (more focused on the math, but has decent examples from physics).

DETAILED COURSE OUTLINE:

In broad brush strokes, we will focus on how to actual 'do' quantum mechanics: that is, we will learn the types of problems commonly available in QM, as well as the basic techniques used to solve them. Specifically, we will learn: how to solve the Schrödinger equation for different potentials (infinite and finite square well, simple harmonic oscillator, delta function, etc.), mathematical formalism for QM (bra-ket notation, Hermitian matrices, operators), solution of the Schrödinger equation in 3D (hydrogen atom), angular momentum, and spin. If we have time, we will also cover perturbation theory and selected special topics (Zeeman effect, Aharonov-Bohm effect, Berry's phase, Bell's Theorem, Quantum Zeno Paradox, quantum teleportation, Schrödinger cat states, etc.). A **tentative** course schedule is as follows:

Week 1 (Aug. 31 through Sept. 04): Historical background (class) and Chapter 1 (Griffiths); HW1 assigned.
Week 2 (Sept. 07 through Sept. 11): Holiday on 09/07; Finish Chapter 1 and Chapter 2.1; HW 1 due on 09/09.
Week 3 (Sept. 14 through Sept. 18): Chapters 2.2 and 2.3; HW 2 due on 09/16.
Week 4 (Sept. 21 through Sept. 25): Chapters 2.3 and 2.4; HW 3 due on 09/23.
Week 5 (Sept. 28 through Oct. 02): Chapters 2.4 and 2.5; HW 4 due on 09/30.
Week 6 (Oct. 05 through Oct. 09): Chapters 2.6 through 3.2; HW 5 due on 10/07.
Week 7 (Oct. 12 through Oct. 16): Chapters 3.2 and 3.3; **Mid-term 1** over Chapters 1 and 2 on 10/14.
Week 8 (Oct. 19 through Oct. 23): Chapters 3.4 and 3.5; HW 6 due on 10/21.
Week 9 (Oct. 26 through Oct. 30): Chapters 3.6 and 4.1; HW 7 due on 10/28.
Week 10 (Nov. 02 through Nov. 06): Chapters 4.1 and 4.2; HW 8 due on 11/04.
Week 11 (Nov. 09 through Nov. 13): Chapters 4.3 and 4.4; HW 9 due on 11/11.
Week 12 (Nov. 16 through Nov. 20): Chapters 5.1 and 5.2. **Mid-term 2** over Chapters 3 and 4 on 11/20.
Week 13 (Nov. 23 through Nov. 27): Chapter 8.1; Thanksgiving holiday on 11/25 and 11/27.
Week 14 (Nov. 30 through Dec. 04): Chapters 8.2 and 8.3; HW 10 due on 12/02.
Week 15 (Dec. 07 through Dec. 11): Special topics; HW 11 due on 12/09.

ACADEMIC HONESTY

Simply put, don't cheat. In the long run, you are only hurting your chances at succeeding at college and in the major. The actual university rules: *Academic dishonesty is defined in University Regulation 802, Revision 2 as "an act attempted or performed which misrepresents ones involvement in an academic task in any way, or permits another student to misrepresent the latters involvement in an academic task by assisting the misrepresentation."*

There is a well-defined procedure in place to judge such cases and serious penalties may be assessed. A short commonsense interpretation of the regulation could sound something like this: if it's not your work, then don't pretend that it is.

NB: Under this University Regulation (for better or worse), even an honest mistake is a violation. Not understanding one's involvement in academic dishonesty is not an excuse.

SPECIAL ACCOMMODATIONS

If you have a physical, learning, or psychological disability and require accommodations, please let me know as soon as possible. I will try to accommodate your condition as best as circumstances allow. You will need to register with University Disability Support Services (UDSS) in SEO, room 330 Knight Hall, 766-6189, TTY: 766-3073. If you choose to notify me late about such circumstances, you forfeit your right for special accommodation for that instance.