Quantum Mechanics I

PHY C56 - Winter 2017

Lecture	Tuesday	10:00 am - 12:00 pm	BV 361
Tutorial	Wednesday	10:00 am - 12:00 pm	BV 359

"The more I ponder the physical part of Schrödinger's theory, the more disgusting it appears to me."
– Heisenberg commenting on Schrödinger's *Wave Mechanics*

"If one has to stick to this damned quantum jumping, then I regret ever having been involved in this thing."
– Schrödinger commenting on Heinsenberg's *Matrix Mechanics*

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Office Hours

Tuesday	03:30 pm - 04:30 pm
Wednesday	01:30 pm - 03:30pm
Thursday	10:30 am - 12:30 pm

Course Description

The course will start with a review of key ideas from linear algebra. Using the mathematical tools learned up to this point we will continue by developing the formalism of quantum mechanics in the form of Hilbert spaces and the Dirac notation; observables and the statistical interpretation; and the uncertainty principle. We will then apply this formalism to solve the problem of the hydrogen atom, to extend the classical angular momentum into quantum mechanics, and to introduce the concept of spin. Time permitting, we will study two-particle systems; fermions and bosons; and atomic structure.

By the end of the course you will be able to:

- Identify and define the formal mathematical structure of Quantum Mechanics.
- Apply the fundamental laws and principles of Quantum Mechanics to describe and solve problems of observables with discrete and continuous spectra.
- Analyze the solutions to quantum mechanical problems within the statistical paradigm.
- Explain and illustrate how Quantum Mechanics describes the structure of the hydrogen atom, the spectra of measurements of angular momentum, and the notion of quantum mechanical spin.

Math Prerequisites: Algebra I (MATA23); Vector Calculus II (MATB42); Diff. Equations I (MATB44)
Physics Prerequisites: Intro. to Quantum Physics (PHYB56); Electricity and Magnetism (PHYB21)

Required Materials

- **Textbook:** ***Introduction to Quantum Mechanics*** by David J. Griffiths (Cambridge 2016)

Use the textbook and the class schedule at the end of this document to prepare **before** each lecture and to work on the questions and exercises that will be the basis of the problem sets and tutorial quizzes.

- **Calculator:** A scientific non-programmable calculator is required.

Grading Scheme

Component	Points	Due Date
Tutorial Work	15	Ongoing (Weekly Tutorials)
Test #1	15	Week 5 (Tentative)
Test #2	25	Week 9 (Tentative)
Final Examination	45	Exam Period (April 05 - 22)

Grade Components

Tutorial Work (15%)
During the tutorials we will discuss the most important points in the problem sets as well as difficult points you may have encountered in your readings. Please note that the problem sets will not be collected or graded and it is your responsibility to make sure you understand the discussions presented in these problems. The assessment of your work will be a combination of tutorial quizzes, group work, blackboard problems, electronic homework, and take-home questions.

Test #1 (15%)
This **90-minute** long test will be scheduled *tentatively* during **Week 5**. Content includes all lecture discussions, textbook readings, and problem sets up to and including the material discussed in **Week 4**.

Test #2 (25%)
This **2-hour** long test will be scheduled *tentatively* during **Week 9**. Content includes all lecture discussions, textbook readings, and problem sets up to and including the material discussed in **Week 8**.

Both tests will include conceptual questions in multiple-choice and short-answer format, and detailed problems. The only aids allowed are your non-programmable scientific calculator, and a hand-written, double-sided, and letter-sized aid sheet. Note that photocopies or computer printouts are not allowed.

Final Examination (45%)
The final examination will be scheduled during the exam period of **April 05 - 22**. Content for the final examination includes all the topics discussed in the assigned textbook readings, lecture presentations, problem sets, and tutorial quizzes. The final examination will be **3 hours** long and the format includes conceptual multiple-choice and short answer questions as well as detailed problems. The only aids allowed are your non-programmable scientific calculator, and **one** hand-written, double-sided, and letter-sized equation sheet. Please note that photocopies or computer printouts are not allowed.

Class Policies and Course Support

e-mail
Before you ask a question via e-mail, please check the forums in the **Discussion Board** of the course website. If your question has not been asked, please post it instead of sending it by e-mail so that others with a similar query can benefit from the answers. The forums in the discussion board are monitored regularly by the course instructor and your peers, making it the best way of communicating for various queries of a diverse nature.

However, if the electronic forums are not the best place for your query, make sure you send your e-mail from an official **utoronto.ca** address (e.g., your UTmail+ account), as all other addresses will be filtered out automatically. For a quicker response time include the code **PHYC56** in the subject line of your message. I reply to e-mails within a period of 24 hours and I rarely reply to e-mails during weekends.

Absences
In the case of a **valid** and **documented** problem that supports an absence to a tutorial, the grade will be calculated on the basis of all other work. In the case of a **valid** and **documented** problem that supports an absence to the first test, the second test will have its weight increased accordingly. In the case of a **valid** and **documented** problem that supports an absence to the second test, the final examination will have its weight increased accordingly. If the problem is health-related use the official form: http://www.utsc.utoronto.ca/∼registrar/resources/pdf_general/UTSCmedicalcertificate.pdf

Name and Student Number
Any work you hand in must clearly indicate your name and student number, this includes tutorial work, tests, and the final exam. Any work you submit that fails to meet this requirement will be penalized with a 10% deduction, provided we are able to identify the work as yours. If we are unable to identify the work as yours, a grade of zero will be awarded.

In-class Conduct

- Lectures and tutorials start at 10:10 am and end at 12:00 pm. Late arrival or early departure from class is inappropriate and disruptive so please be considerate.
- Regarding anything that you want to use in the classroom: if you are not using it to perform a task specifically related to what we are doing in class at that very moment, you must put it away. This includes but is not limited to cell phones, laptop computers, tablets, and other electronic devices.
- Do not bring or consume food in the classroom as this creates unwanted distractions that will negatively affect the learning environment.

Academic Integrity and Respect for the Academic Endeavor
Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto is a strong signal of each student's individual academic achievement. As a result, the University treats cases of cheating and plagiarism very seriously. The University of Toronto's *Code of Behaviour on Academic Matters:*

http://www.governingcouncil.utoronto.ca/policies/behaveac.htm

outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences. Potential offences include, but are not limited to:

- In papers and assignments: Using someone else's ideas or words without appropriate acknowledgment; submitting your own work in more than one course without the permission of the instructor; making up sources or facts; obtaining or providing unauthorized assistance on any assignment.
- On tests and exams: Using or possessing unauthorized aids; looking at someone else's answers during an exam or test; misrepresenting your identity.
- In academic work: Falsifying institutional documents or grades; falsifying or altering any documentation required by the University, including (but not limited to) doctor's notes.

All suspected cases of academic dishonesty will be investigated following procedures outlined in the *Code of Behaviour on Academic Matters*.

If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources such as:

http://sites.utoronto.ca/academicintegrity/resourcesforstudents.html

Access*Ability*

Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the Access*Ability* Services Office as soon as possible. I will work with you and Access*Ability* Services to ensure you can achieve your learning goals in this course. Enquiries are confidential. The UTSC Access*Ability* Services staff (located in SW302) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations (416) 287-7560 or ability@utsc.utoronto.ca

Class Schedule

This schedule is ***tentative*** and might change during the term in order to accommodate for variations in the lectures in response to performance and feedback from the students. Some topics might be removed and others added to adjust for variations in the background of the class. Announcements will be made whenever needed.

Please note that it is your responsibility to read the assigned sections and chapters **before** each lecture.

During the lectures we will concentrate on the most important and difficult aspects of the theories and concepts from your textbook readings. Therefore, failing to complete the textbook readings before each lecture will negatively affect your ability to understand and participate in the class discussions.

Dates	**Tuesday Lecture** 10am - 12pm	**Wednesday Tutorial** 10am - 12pm
Jan. 03	**Vectors and Matrices**	**Eigenvectors and Eigenvalues**
Jan. 04	Appendix: 1 - 3	Appendix: 4 - 6
Jan. 10	**Hilbert Space and Observables**	**Problem Set # 01**
Jan. 11	Chapter 3: 1 - 2	Tutorial #01
Jan. 17	**Eigenfunctions and Operators**	**Problem Set # 02**
Jan. 18	Chapter 3: 3 - 4	Tutorial #02
Jan. 24	**The Uncertainty Principle**	**Problem Set # 03**
Jan. 25	Chapter 3: 5	Tutorial #03
Jan. 31	**Dirac Notation / Quantum Oscillator**	**Problem Set # 04**
Feb. 01	Chapter 3: 6 / Chapter 2: 3	Tutorial #04
Feb. 07	**Spherical Schrödinger Equation**	**Problem Set # 05**
Feb. 08	Chapter 4: 1	Tutorial #05
Feb. 14	**The Hydrogen Atom**	**Problem Set # 06**
Feb. 15	Chapter 4: 2	Tutorial #06
Feb. 21	**Reading Week**	**Problem Set # 07**
Feb. 22	**Reading Week**	Tutorial #07 (Electronic Homework)
Feb. 28	**Angular Momentum**	**Problem Set # 08**
Mar. 01	Chapter 4: 3	Tutorial #08
Mar. 07	**Spin - Part I**	**Problem Set # 09**
Mar. 08	Chapter 4: 4	Tutorial #09
Mar. 14	**Spin - Part II**	**Problem Set # 10**
Mar. 15	Chapter 4: 4	Tutorial #10
Mar. 21	**Two-Particle Systems**	**Problem Set # 11**
Mar. 22	Chapter 5: 1	Tutorial #11
Mar. 28	**Atoms**	**Problem Set # 12**
Mar. 29	Chapter 5: 2	Tutorial #12