

Introduction to Quantum Physics

PHY B56 - Fall 2022

LEC 01 Tuesday 9:00 am - 11:00 am BV 260
TUT 01 Wednesday 9:00 am - 11:00 am HW 402
TUT 02 Wednesday 3:00 pm - 5:00 pm BV 363

Instructor: Johann Bayer **Email:** jbayer@utsc.utoronto.ca
Office: SW 503A
Phone Number: 416-287-7327 **Course Website:** q.utoronto.ca

Office Hours - Preliminary Schedule

Tuesday	2:30 pm - 4:30 pm	In-person
Thursday	10:30 am - 11:30 am	Virtual
Thursday	2:30 pm - 3:30 pm	Virtual

For important details please check the Office Hours information available on the course website.

Course Description, Learning Outcomes, and Requisites

We will start the course with a brief introduction to the experimental basis of Quantum Mechanics and the properties of the wave function. Schrödinger's equation will then be studied with some applications in one dimension. Further topics will include square potential wells, the quantum harmonic oscillator, uncertainty principles, delta potential, scattering, and tunneling.

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

- Identify and define the basic vocabulary used in Quantum Physics.
- Recognize the experimental evidence that led to the revision of Classical Physics.
- Illustrate conceptually and with experimental examples, the main differences between the quantum and classical paradigms.
- Apply the basic ideas of Quantum Mechanics to the study and analysis of one-dimensional models.
- Develop and implement problem-solving strategies useful in the analysis of examples and questions related to the description, behaviour, and evolution of systems under the one-dimensional Schrödinger equation.
- Identify the main ideas and core physical principles in Quantum Mechanics, and demonstrate their knowledge through deliberate time management and reflective judgement of the questions and problems in tutorial work, tests, and the final exam.
- Self-assess the level of confidence in the acquired knowledge of the core concepts and ideas in the field of Quantum Mechanics, through the decision-making process associated with the allocation of resources during tests and the final exam.
- Review and update the mathematical toolbox of quantitative and analytical skills relevant and useful in the scientific endeavour in general and to the study of Physics in particular.

Corequisite: Techniques of the Calculus of Several Variables I (MATB41)

Pre-Requisites: Introduction to Physics IIA (PHYA21); Calculus II (MATA36/MATA37)

Required Materials

- **Calculator:** A scientific, non-programmable, and non-graphing calculator is required.
- **Textbook:** *Introduction to Quantum Mechanics* by David J. Griffiths (Cambridge, 3rd Ed.)

The schedule provided at the end of this document indicates the chapters and sections you must read **before** each lecture discussion. The textbook also provides the conceptual questions and detailed problems that will be the subject of the weekly problem sets, reading quizzes, and tutorial work.

- **Textbook:** *Quantum Mechanics* by Robert Scherrer (Pearson, 1st Ed.)

Handouts on the **Origins of Quantum Mechanics** and **Complex Numbers** will be provided.

- **Technical Requirements for Remote and Online Learning:**

Please review the minimum and recommended technical requirements for learning in the remote and on-line environment. You must have access to a fast and reliable Internet connection to participate in virtual office hours and for any course components that might end up being converted to synchronous online delivery from the expected in-person schedule. This might include, but is not limited to, tutorial sessions, tests, and the final exam, depending on the latest UTSC Regulations.

Use of a computer (laptop or desktop) instead of a mobile device (smartphone or tablet) will be critical during any electronic forms of assessment. It is strongly recommended that you connect via wire (Ethernet) to your modem or router instead of using wireless access (WiFi), to ensure stability and reduce interference. Additionally, you will be required to produce scans of handwritten work in PDF format for tutorial work on weeks where the assigned tasks must be completed after the end of the session and, in the event of a transition to online delivery, for tests and the final exam. This can be accomplished using a dedicated scanner, a document scanner app using the camera in your smartphone, or a direct-to-digital annotating solution. More details and suggestions are available in the course website.

Grading Scheme

Component	%	Due Date
Reading Quizzes	5	Ongoing (Pre-Lecture)
Tutorial Work	20	Ongoing (Weekly Tutorials)
Test #1	15	Week 6 (Tentative)
Test #2	20	Week 10 (Tentative)
Final Examination	40	Exam Period (December 08 - 20)

Grade Components

Reading Quizzes (5%)

Each week on the course website you will be asked a set of questions from the assigned readings for the upcoming week. You will have until **9:55 pm on Monday** to submit your answers. Each quiz is worth **5 points**, and your final grade is the total sum of all quizzes up to a maximum of **50 points**. Use the **Class Schedule** found at the end of this document to prepare for the lecture videos and reading quizzes.

Tutorial Work (20%)

Prior to each tutorial session you will have the opportunity to review the problem set containing relevant examples and problems for that week. During the tutorials we will discuss the most important points from the problem set as well as any difficulties you may have encountered in your weekly readings.

Depending on the goals and discussions for a given session, the tasks that will be assessed as the tutorial work for credit could be assigned for completion during the session or they could be assigned for completion after the end of the session. Work submitted for credit will be graded out of **10 points**, and the final grade is the average of the **best 10** results. The format and modality of the tutorial work for a given week will not be announced in advance and will only be revealed during the respective tutorial session. For further details, review the information available in the course website under Problem Sets & Tutorial Work.

Test #1 (15%)

This **2-hour**¹ test will be scheduled during **Week 06**. Content includes all lecture discussions, textbook readings, and problem sets up to and including the material assigned and discussed in Week 05.

Test #2 (20%)

This **2-hour**¹ test will be scheduled during **Week 10**. Content includes all lecture discussions, textbook readings, and problem sets up to and including the material assigned and discussed in Week 09.

Final Examination (40%)

The **3-hour**² final examination will be scheduled during the exam period of **December 08 - 20**. Content for the final examination includes all the topics discussed in the assigned textbook readings, lecture discussions, problem sets, and tutorial work.

Format and Allowed Aids - Tests and Final Examination

Both tests and the final examination will include conceptual questions in multiple-choice and short-answer format, as well as detailed problems.³ The only aids allowed are your non-programmable and non-graphing scientific calculator, and a hand-written, double-sided, and letter-sized aid sheet that may not include explicit problem solutions. Photocopies or computer printouts are not allowed.

Class Policies and Course Support

Copyright Notice

All course materials, including assignments and various assessment instruments, belong to your instructor, the University, and/or other sources depending on the specific facts of each situation, and are protected by copyright. Do not download, copy, or share any course materials without the explicit permission of the instructor.

Name and Student Number

Any work you hand in physical form as paper hard-copy must clearly indicate your name and student number, this includes tutorial work, tests, and the final exam. Failing to meet this requirement will result in 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.

¹In the event that UTSC guidelines require online delivery of a test, its length will be increased to 2.5 hours.

²In the event that UTSC guidelines require online delivery of the final exam, its length will be increased to 4.0 hours.

³In the event that UTSC guidelines require online delivery of a test or the final exam, you must submit work for the detailed problems in that test or final exam following the same protocols used for the submission of tutorial work problems.

Absences

In order to ensure fairness in the assessment of all students, there will be no default makeup options for any term work. In the case of a **valid** and **documented** problem that supports a missed assignment the grade will be calculated on the basis of all other submitted 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.

Exceptional circumstances requiring a makeup test would be reviewed on a case-by-case basis. Any resulting makeup tests will be scheduled as oral examinations to be conducted in-person.

All valid and documented absences must be declared through **both** the Absence Declaration in ACORN **and** the DPES Self-declaration Absence Form, and the onus is fully on the student to contact promptly the course instructor. Depending on the circumstances you might be required to provide additional supporting documentation to your instructor, such as a completed Verification of Illness or Injury form.

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*:

<https://governingcouncil.utoronto.ca/media/15068/view>

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; using someone else's clicker or multiple clickers for participation grades.
- 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 (see <https://www.utscc.utoronto.ca/vpdean/academic-integrity>).

AccessAbility

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 AccessAbility Services Office as soon as possible. I will work with you and AccessAbility Services to ensure you can achieve your learning goals in this course. Enquiries are confidential. The UTSC AccessAbility Services staff (located in AA142) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations. Contact by phone (416) 287-7560 or email at ability@utscc.utoronto.ca

Email Communications

If you want to ask a question via email, please first check the various threads in the PeppeR section of the course website. Quite likely, you are not the only person with that same question, and if that question has already been asked, you will find the answer there. If the question has not been asked, go ahead and post it yourself instead of sending it by email. This way you will also help other students facing the same issue. These discussions 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 these electronic forums are not the best place for your specific concern, make sure you send your email 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 **PHYB56** in the subject line of your message. I reply to emails within a period of 24 hours and I rarely reply to emails during weekends.

Policies for In-Person Lectures and Tutorials

- All students are required to follow the latest UTSC Regulations concerning COVID-19.
- Lectures start at 9:10am and end at 11:00am. Tutorials run from 9:10am to 11:00am and 3:10pm to 5:00pm. Late arrival or early departure is inappropriate and highly disruptive so please be respectful of the learning environment.
- 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.
- Consumption of food or drinks in the classroom during lectures or tutorials is not permitted as this creates unwanted distractions that negatively affect the learning environment.

PeppeR on Quercus

The course website supports electronic forums useful for questions and discussions on course content, conceptual and detailed problems, textbook readings, as well as any issues relating to administrative aspects of the course such as deadlines and scheduling.

It is recommended that you check the threads on a regular basis to keep on top of current issues. You can subscribe to the various threads in order to receive email notifications when new posts are available.

Class Schedule

This schedule is *tentative* and might change during the term in order to accommodate for variations in the lectures in response to student performance and understanding of the various topics.

Please note that it is your responsibility to read the assigned sections **before** each lecture discussion and in preparation for the completion of the respective reading quiz.

The lectures will **not** be a direct repetition of the basic material found in the textbook. Instead, we will concentrate on important and difficult aspects of the theory and concepts from your textbook readings.

A minimum understanding of the basic concepts from the assigned readings will be the assumed starting point for each lecture discussion. As a result, failing to complete the textbook readings before each lecture will significantly affect your ability to understand the class discussions.

Week # Date	Tuesday Lecture	Wednesday Tutorials
Week 01 Sep. 06-07	Light and Matter Waves Scherrer Ch.1: 1, 3, 4	No Tutorial Session
Week 02 Sep. 13-14	Bohr's Atom and Blackbody Radiation Scherrer Ch.1: 5, 2, 6	Problem Set #01
Week 03 Sep. 20-21	Schrödinger's Equation Griffiths Ch.1: 1 - 4	Problem Set #02
Week 04 Sep. 27-28	Wave Functions and Uncertainty Griffiths Ch.1: 5 - 6	Problem Set #03
Week 05 Oct. 04-05	Stationary States Griffiths Ch.2: 1	Problem Set #04
Week RW Oct. 11-12	Reading Week	Problem Set #05
Week 06 Oct. 18-19	The Particle in a Box Griffiths Ch.2: 2	Problem Set #06
Week 07 Oct. 25-26	The Free Particle and Wave Packets Griffiths Ch.2: 4	Problem Set #07
Week 08 Nov. 01-02	Delta Potential and Scattering Griffiths Ch.2: 5	Problem Set #08
Week 09 Nov. 08-09	The Finite Square Well Griffiths Ch.2: 6	Problem Set #09
Week 10 Nov. 15-16	Quantum Harmonic Oscillator I Griffiths Ch.2: 3	Problem Set #10
Week 11 Nov. 22-23	Quantum Harmonic Oscillator II Griffiths Ch.2: 3	Problem Set #11
Week 12 Nov. 29-30	The WKB Approximation Griffiths Ch.9: 1 - 2	Problem Set #12