PHY 256: Intro to Quantum Physics
Formal Syllabus: Fall 2022

Course Web Sites:

The official (quercus) site is https://q.utoronto.ca/courses/278096

I will rely more on Piazza (piazza.com/utoronto.ca/fall2022/phy256h1) for announcements, class discussions, and the like, as I find Quercus a top-heavy and inflexible system poorly adapted to our needs – **please sign up on the Piazza page immediately**. *I strongly encourage you to use it for posting questions and comments and discussing the course material throughout the term.*

I will maintain a list of reading assignments and links to important course material (videos, problem sets, et cetera) at https://www.physics.utoronto.ca/~aephraim/256/PHY256-ListOfMaterials.html ; keep track in particular of the reading assignments at https://www.physics.utoronto.ca/~aephraim/256/PHY256-Readings.html and pre-lecture videos at https://www.physics.utoronto.ca/~aephraim/256/PHY256-Videos.html

First class (& organisational meeting):

Monday September 12th, 1:10pm (MP 103)
[First tutorials on Weds Sep 14 & Fri Sep 16]
Note that there are already two pre-lecture videos posted (more details follow below).

CLASS RECORDINGS:

Class periods, including your participation, will be recorded on video and streamed for the benefit of the students in the "online section" and those who for health reasons need to be absent; the recordings will be made available online (to the U of T community only). Course videos and materials 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 or student materials or videos without the explicit permission of the instructor.
For questions about recording and use of videos in which you appear please contact your instructor.

Textbook(s)

Required Text: *Quantum Mechanics* by David McIntyre

(https://www.uoftbookstore.com/adoption-search-results?ccid=32998&itemid=56906)

[should also be available as an online resource]

Recommending supplementary texts:

Principles of Quantum Mechanics by R. Shankar

Lectures on Physics vol. III by R.P. Feynman

(free at https://www.feynmanlectures.caltech.edu/III_toc.html)

QED: the strange theory of light and matter, R.P. Feynman

(*Q is for Quantum* by T. Rudolph)

Teaching staff

Professor: Aephraim M. Steinberg
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Derek Churchill
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Felix Desrochers

Note: I strongly recommend using Piazza as the primary means for contacting us about course-related matters, to prevent messages from getting lost in otherwise overloaded inboxes.

Lectures, pre-lecture videos, and tutorials:

Pre-lectures: videos will be posted, to be watched before class (https://www.physics.utoronto.ca/~aephraim/256/PHY256-Videos.html)

Lectures: MW 1:10-2:00 MP 103
Discussion sections :

TUT0101 = W15-16 **ES B142*** (Christian)
TUT0102 = W15-16 PB255 (Aleksandra)
TUT0201 = W16-17 **ES B142*** (Christian)
TUT0202 = W16-17 MP118 (Derek)
TUT0301 = F13-14 MP137 (Emily)
TUT0302 = F13-14 MP118 (Derek)
TUT0401 = F15-16 MP134 (Emily)
TUT0402 = F15-16 AB114 (Aleksandra)

Office hours TBA (most probably rotating among a few different times to be accessible to as many students as possible, probably in MP 1101, 11th-floor lounge)

NB: **There are two posted pre-lectures for review** of mathematical material which will be important from the start of the course; they can be found immediately at https://www.physics.utoronto.ca/~aephraim/256/PHY256-Videos.html and **I recommend watching them by Monday, September 12th**.

*** – NOTE CHANGE OF ROOM**

MOST IMPORTANT MESSAGE
Quantum Mechanics is Fascinating!

I hope you will puzzle over it and take advantage of your instructors and fellow students to discuss it. We will use Piazza (and/or Quercus's native discussions feature) to ask questions and share ideas. I urge you to make use of these chats, in addition to every opportunity to discuss in person.

Please sign up on Piazza at piazza.com/utoronto.ca/fall2022/phy256h1 right away;
and monitor https://www.physics.utoronto.ca/~aephraim/256/PHY256-ListOfMaterials.html for Reading and Video assignments (there are already 2 videos available, for "reviews" of complex numbers, Euler's formula, and basic manipulations of matrices, eigenvalues, and eigenvectors).

OVERVIEW

Quantum physics is one of the major scientific and intellectual developments of the past century. Not only has it revolutionized people's understanding of the structure of matter, but it underpins a broad cross-section of modern technology, from the transistors in your computer to the lasers carrying data over the internet. More than that, however, it has led to a radical change in the underlying way we understand the world. This change is not limited to atoms, or even to the microscopic world in general. It applies whether we are discussing atoms and molecules, metals and semiconductors, electricity, magnetism, light, or the universe itself.

We will start with the fundamental concepts of quantum mechanics and will then develop the basic mathematical and conceptual tools to deal with important topics such as the uncertainty principle, interference, entanglement, tunneling, and the structure of the atom. You will be challenged to develop your intuition about the quantum world, with discussions based largely on two-level systems such as photon polarization, the Stern-Gerlach experiment, and two-slit interferometers. We will touch on potential applications such as quantum cryptography and quantum computers.

APPROXIMATE SYLLABUS

UNIT	"Technical" lectures	"Conceptual" complements
1	QUANTUM STATES & MEASUREMENT Photo polarisation & electron spin Photoelectric effect	Waves + the two-slit interferometer
2	THE CONCEPTUAL HEART OF QM From probabilities + amplitudes to bras, kets, operators, & observables Superposition & uncertainty -> entanglement	Complementarity + the quantum eraser
3	WAVES OF PROBABILITY AMPLITUDE Bohr atom Schrödinger Equations	Entanglement: the Einstein-Podolsky-Rosen "paradox" and Bell's Inequalities
4	1D PROBLEMS Bound + unboud states Harmonic oscillator	Quantum computation, quantum cryptography, quantum teleportation, and all that
5	TIME-DEPENDENCE Wave packets + propagation Oscillations	Tunneling times
6	HYDROGEN and the periodic table (separation of variables -> angular momentum)	Bose-Einstein condensation?

Grading

	Fraction of Grade
Problem Sets	20%
Mid Term	30%
Final Exam	50%

Policies on Assignments

All assignments, readings, and videos will be posted at https://www.physics.utoronto.ca/~aephraim/256/PHY256-ListOfMaterials.html (this link is also available under "Assignments").

Due Dates:

Assignments will be posted on Piazza and Quercus. Due dates and times will be explicitly listed.

Tentative schedule:

PS1 due W 28 Sep; PS2 due W 12 Oct; PS3 due M 14 Nov; PS4 due 25 Nov; PS5 due 8 Dec

The problem sets are to be submitted electronically.

Only selected homework problems will be marked; the purpose of the assignments is not primarily evaluation of your performance, but rather to give you the opportunity to work through the material, develop your understanding, and also prepare for the exams. Solution sets will be posted a few days after the problem sets are handed in, and obviously no assignments can be accepted after the solutions are out.

You are strongly encouraged to use both discussion sections and office hours to raise any and all questions about quantum physics -- this includes textbook readings, topics from lecture, past homework solutions, problem sets you are presently working on, or just any question that comes to your mind. As mentioned at the top, using Piazza or the Quercus discussion groups is another great way to bat ideas around and develop a deeper understanding

Late Policy and Extensions:

You should endeavour to complete your assignments on time in order to keep up with the material and avoid running out of time at the end of term.

No problem sets will be accepted after the solution sets are posted (generally a few days after the due date).

A problem set not handed in will be counted as a zero, unless an official exception is requested, e.g., for medical reasons. Circumstances such as extra-curricular activities, or other problem sets and tests will not be considered as a valid excuse.

Collaboration: Education is based on discussion and exchange of ideas. You are strongly advised to discuss the course material via Quercus/Piazza, and/or to form study groups. Discussing how best to approach problem sets can be very useful. However, the solutions you hand in must be your own work. **Do not copy any part of someone else's assignment**. **Do not copy material found from any source (e.g. books, articles, websites), aside from *properly cited* short quotations. Nor is it sufficient to take the derivation from an outside source and rewrite it in your own hand.** This is plagiarism and is a serious academic offense and we will take appropriate measures.

Re-grade Requests: If you disagree with a grade you have received, you may contest it. In order to do

so, you should write to the marker explaining in detail what you think the error in the grading was. You may only request a re-grade within 2 weeks of the date the graded assignment is returned.

Midterm and Final Exams

The midterm exam is tentatively scheduled for Wednesday, October 26th during the class period – more details will be issued about exam rooms closer to the date.
The final exam will be in the 3-hour time slot scheduled by Arts & Sciences.
No collaboration or communication with any one else is allowed during the exams!
You are not allowed to use any internet resources – in particular, do not copy or base your work on material found from any source! This is plagiarism and is a serious academic offense and we would be forced to take appropriate measures.

Academic Integrity

Academic integrity is fundamental to learning and scholarship at the University of Toronto. Participating honestly, respectfully, responsibly, and fairly in this academic community ensures that the U of T degree that you earn will be valued as a true indication of your individual academic achievement, and will continue to receive the respect and recognition it deserves. Familiarize yourself with the University of Toronto's Code of Behaviour on Academic Matters (http://www.governingcouncil.utoronto.ca/policies/behaveac.htm). It is the rule book for academic behaviour at the U of T, and you are expected to know the rules.

Tests and Exam: Midterm tests and the final exam must be done individually, involving no communication at all with your peers. It is strongly advised not to engage in any behaviour that might be construed by the invigilators for the tests/exam as an attempt to obtain information from another candidate or from another test/exam paper.

The University of Toronto treats cases of academic misconduct very seriously. All suspected cases of academic dishonesty will be investigated following the procedures outlined in the Code. The consequences for academic misconduct can be severe, including a failure in the course and a notation on your transcript. If you have any questions about what is or is not permitted in this course, please do not hesitate to contact me. If you are experiencing personal challenges that are having an impact on your academic work, please speak to me or seek the advice of your college registrar.

Accommodations

If you have a learning need requiring an accommodation the University of Toronto recommends that students immediately register at Accessibility Services at http://www.studentlife.utoronto.ca/as.

Location: 4th floor of 455 Spadina Avenue, Suite 400
Voice: 416-978-8060
Fax: 416-978-5729
Email: accessibility.services@utoronto.ca

The University of Toronto supports accommodations of students with special learning needs, which may be associated with learning disabilities, mobility impairments, functional/fine motor disabilities, acquired brain injuries, blindness and low vision, chronic health conditions, addictions, deafness and hearing loss, psychiatric disabilities, communication disorders and/or temporary disabilities, such as fractures and severe sprains, recovery from an operation, serious infections or pregnancy complications.

As the instructor of this course, you are also invited to communicate with me at any time about your learning needs. Confidentiality of learning needs is respectfully and strictly maintained.

Equity, Diversity and Excellence

At the University of Toronto, we strive to be an equitable and inclusive community, rich with diversity, protecting the human rights of all persons, and based upon understanding and mutual respect for the dignity and worth of every person. We seek to ensure to the greatest extent possible that all students enjoy the opportunity to participate as they see fit in the full range of activities that the University offers, and to achieve their full potential as members of the University community.

Our support for equity is grounded in an institution-wide commitment to achieving a working, teaching, and learning environment that is free of discrimination and harassment as defined in the Ontario Human Rights Code. In striving to become an equitable community, we will also work to eliminate, reduce or mitigate the adverse effects of any barriers to full participation in University life that we find, including physical, environmental, attitudinal, communication or technological.

Our teaching, scholarship and other activities take place in the context of a highly diverse society. Reflecting this diversity in our own community is uniquely valuable to the University as it contributes to the diversification of ideas and perspectives and thereby enriches our scholarship, teaching and other activities. We will proactively seek to increase diversity among our community members, and it is our aim to have a student body and teaching and administrative staffs that mirror the diversity of the pool of potential qualified applicants for those positions.

We believe that excellence flourishes in an environment that embraces the broadest range of people, that helps them to achieve their full potential, that facilitates the free expression of their diverse perspectives through respectful discourse, and in which high standards are maintained for students and staff alike. An

equitable and inclusive learning environment creates the conditions for our student body to maximize their creativity and their contributions, thereby supporting excellence in all dimensions of the institution. For more information please see http://about.hrandequity.utoronto.ca/.