PHYC 4151 / 5151 Quantum Physics II – Provisional Syllabus

Department of Physics and Atmospheric Science

Fall 2025

Dalhousie University acknowledges that we are in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People and pays respect to the Indigenous knowledges held by the Mi'kmaq People, and to the wisdom of their Elders past and present. The Mi'kmaq People signed Peace and Friendship Treaties with the Crown, and section 35 of the Constitution Act, 1982 recognizes and affirms Aboriginal and Treaty rights. We are all Treaty people.

Dalhousie University also acknowledges the histories, contributions, and legacies of African Nova Scotians, who have been here for over 400 years.

Lecturer

Prof. Ted Monchesky, e-mail: Theodore.Monchesky@Dal.Ca, office: Dunn Rm 239

TA

Harold Smith Perez, e-mail: hsmithperez@dal.ca, Office: Dunn Rm 243

Lectures

Tuesday & Thursday, Dunn 101, 10:05 am – 11:25 am

Tutorials

Thursday, Dunn 208, 2:35 pm – 3:55 pm

Note that Tutorial and Lecture times may be swapped some weeks (see the lecture schedule below, and check for updates on BrightSpace during the term)

Course Delivery

In-person

Course Description

This course builds on the concepts and theory of quantum mechanics presented in "Quantum Physics I" (PHYC 3640) by introducing additional topics of fundamental importance, including: spin, identical particles, time-independent perturbation theory, variational approach, WKB approximation, time-dependent perturbation theory, and scattering theory.

Course Prerequisites

PHYC 3640.03 Quantum Physics I or equivalent

Learning Objectives

Familiarity with the physical concepts and theoretical approaches for: calculating the properties of particle spin, the treatment of multi-particle quantum systems, computing approximate eigenenergies and eigenfunctions from complicated Hamiltonians using perturbation theory, finding approximate ground state energies using the variational approach, calculating bound state energies and tunneling rates with the WKB approximation, using time-dependent perturbation theory to calculate atomic transition rates.

Course Materials

Required textbook:

- D.J. Griffiths and D.F. Schroeter *Introduction to Quantum Mechanics*, 3nd Ed., (Cambridge University Press, 2018).
  I expect that you will all have a copy from your previous course PHYC 3640. We will cover most of the remainder of the textbook with the exception of Chap 6 and Chap. 12. There are many good problems in the book. I will use the 3rd Ed. of the textbook for most of the course, with exception of the unit on the adiabatic approximation: the 2nd Ed. does a much better job of covering this topic.

Recommended reference textbooks:

I encourage you to make use of other textbooks, as each brings its own insights and perspectives that are valuable in gaining a deeper understanding of the material. Griffiths provides concise and insightful descriptions, but it is not as rigorous as other textbooks. There are many excellent textbooks. Here are some of the ones that I found useful in preparing for the course.

- R. Shankar, *Principles of Quantum Mechanics*, 2nd Ed., (Plenum Press 1999)
  This is one of my favourite quantum mechanics textbooks. Shankar is known for his clear explanations of the fundamental concepts. I considered using this as a textbook for the course. Although this is a very accessible reference, its level of detail is better suited for a graduate course. This is the book that I used when I was a graduate student.
- B. Zwiebach *Mastering Quantum Mechanics Essentials, Theory, and Applications* (MIT Press, 2022)
  This is an excellent textbook that is also very clear but it covers topics in greater depth than we will go, but I think that this will be an excellent reference for the course. The textbook is based on lectures notes from Zwiebach's three courses on quantum mechanics at MIT, which are freely available (see for example https://ocw.mit.edu/courses/8-06-quantum-physics-iii-spring-2018/).
- J. S. Townsend, *A Modern Approach to Quantum Mechanics*, 2nd Ed., (Science books, 2012)
  This is a textbook that has been used in the past for PHYC 4151. I am told that students liked the book, although I prefer Griffiths. However, unlike Griffiths, Townsend does make extensive use of bra-ket notation throughout the book, which is what we will be using. This textbook is inspired in part by the Feynman Lectures and Sakurai's book, which presents spin as a way of introducing Quantum Mechanics.
- C. Cohen-Tannoudji , B. Diu, F. Laloe, *Quantum Mechanics, Vol. 1 and 2*, (Wiley Interscience, 1977).
  This is encyclopedic textbook covers the same range of topics in 1516 pages as what Griffiths covers in 485 pages. This is what was assigned to me when I was a student, and it wasn't fun learning from. However, there is a lot of useful material in there and it is worth having a look at. It contains many interesting examples.
- J. J. Sakurai, *Modern Quantum Mechanics*, Revised Ed., (Addison Wesley, 1994).
  This is a classic textbook at the graduate level. There is now a 3rd edition with contributions from an additional author.

Course website:
Brightspace

Announcements
Announcements pertaining to lectures and laboratory will be made via e-mail.

Course Assessment

	Method 1	Method 2
1st Midterm	17%	best of two quizzes 22%
2nd Midterm	17%	
Tutorials	2%	2%
Assignments	30%	30%
Exam	34%	46%
	100%	100%

Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale, shown below.

A+ (90-100)	**B+** (77-79)	**C+** (65-69)	**D** (50-54)
A (85-89)	**B** (73-76)	**C** (60-64)	**F** (<50)
A- (80-84)	**B-** (70-72)	**C-** (55-59)	

Course Policies on Missed or Late Academic Requirements
Midterm: There is no make-up test for a missed midterm: method 2 will automatically be applied in this case to calculate your final grade.
Exam: If a student misses the final exam for good reason, they should contact the Lecturer as soon as possible and sub and submit a
Problem Sets: Late assignment will have 10% deducted per day after the due date, and no credit will be given for assignments handed in after the solutions have been provided. If you are unable to submit an assignment for good reason, you need to contact the Lecturer as soon as possible and submit a "Student Declaration of Absence form" upon return to class. For a valid excuse, an extension will be provided when possible; otherwise the assignment mark will be dropped.

Students enrolled in PHYC 5151 will be required to complete additional Problem Set questions.

Lectures, Tutorials and Reading Assignments

The following is a rough outline for the lectures and tutorials, subject to change depending of the needs of the class. You are expected to read the relevant chapters in the textbook before coming to class. Lecture notes will be posted on Brightspace.

Date	Lectures and Tutorials	Reading
Sep 23	L1: Review of linear algebra	Typed notes
Sep 25	L2: Review of linear algebra review	
Sep 25	Tutorial 0: Dirac Notation	
Sep 30	*Truth and Reconciliation Day*	
Oct 02	L3: Spin	
Oct 02	L4: Matrix representation of spin	4.4
Oct 07	Tutorial 1: Spin	
Oct 09	L5: Addition of angular momentum	4.4.3
Oct 09	L6: Adding orbital and spin angular momentum	4.4.3
Oct 14	Tutorial 2: Addition of angular momentum	
Oct 16	L7: Identical particles	5.1.1 - 5.1.2
Oct 16	L8: Identical particles with spin	5.1.3 - 5.1.4
Oct 21	Tutorial 3: Identical particles	
Oct 23	L9: Time independent perturbation theory	7.1
Oct 23	L10: Time independent perturbation theory (con't)	7.1
Oct 28	Tutorial 4: Non-degenerate perturbation theory	
Oct 30	L11: Degenerate perturbation theory	7.2
Oct 30	Tutorial 5: Degenerate perturbation theory	
Nov 04	L12: Zeeman and hyperfine interaction	7.4 - 7.5
Nov 06	Tutorial 6: Zeeman interaction	
Nov 06	L13: WKB approximation	9.1 - 9.2
	Reading week. Nov 10 - Nov 14	
Nov 18	Tutorial 7: WKB Approximation	
Nov 20	L14: Scattering	10.1
Nov 20	L15: Scattering (scattering phase shifts)	10.2 - 10.3
Nov 25	L16: Scattering (Born approximation)	10.4
Nov 27	Tutorial 8: Scattering	
Nov 27	L17: Time dependent perturbation theory	11.1
Dec 02	L18: Emission and absorption	11.2
Dec 04	L19: Spontaneous emission	11.3
Dec 04	Tutorial 9: TDPT	
Dec 09	L20: Fermi's Golden Rule	11.4

Tutorials

The tutorials involve problems that you work on in small groups. Your participation and effort during the tutorials will be graded on a scale from 0 to 2. You will be permitted to miss one week of tutorial without question. Any absence beyond this will require a "Student Declaration of Absence form".

Course Policies related to Academic Integrity

You are encouraged to work on problem sets together, but the assignment that you hand in **must** be in your own words, and the calculations **must** be your own. When you complete your assignments, make sure that you explain your thought process. Putting your thoughts into words is a very useful way of learning the material more deeply. The problem sets will be approximately every week.

You are encouraged to read sources other than the assigned textbook. It is valuable to get different perspectives on a topic. However, you are not permitted to consult solutions manuals for the textbook, or other written solutions to assignment problems.

Midterms

Tentative dates
1st Midterm: Wed Oct. 15, 6:00 pm – 7:30 pm
2nd Midterm: Wed Nov. 19 6:00 pm – 7:30 pm

University Policies and Statements

Recognition of Mi'kmaq Territory
Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel, and support. Visit or e-mail the Indigenous Student Centre at 1321 Edward St or elders@dal.ca. Additional information regarding the Indigenous Student Centre can be found at: https://www.dal.ca/campus_life/communities/indigenous.html

Internationalization
At Dalhousie, 'thinking and acting globally' enhances the quality and impact of education, supporting learning that is "interdisciplinary, cross-cultural, global in reach, and orientated toward solving problems that extend across national borders." Additional internationalization information can be found at: https://www.dal.ca/about-dal/internationalization.html

Academic Integrity
At Dalhousie University, we are guided in all our work by the values of academic integrity: honesty, trust, fairness, responsibility, and respect. As a student, you are required to demonstrate these values in all the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity. Additional academic integrity information can be found at: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility
The Student Accessibility Centre is Dalhousie's centre of expertise for matters related to student accessibility and accommodation. If there are aspects of the design, instruction, and/or experiences within this course (online or in-person) that result in barriers to your inclusion, please contact the Student Accessibility Centre (https://www.dal.ca/campus_life/academic-support/accessibility.html) for all courses offered by Dalhousie with the exception of Truro. For courses offered by the Faculty of Agriculture, please contact the Student Success Centre in Truro (https://www.dal.ca/about-dal/agricultural-campus/student-success-centre.html)

Conduct in the Classroom – Culture of Respect
Substantial and constructive dialogue on challenging issues is an important part of academic inquiry and exchange. It requires willingness to listen and tolerance of opposing points of view. Consideration of individual differences and alternative viewpoints is required of all class members, towards each other, towards instructors, and towards guest speakers. While expressions of differing perspectives are welcome and encouraged, the words and language used should remain within acceptable bounds of civility and respect.

Diversity and Inclusion – Culture of Respect
Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness (Strategic Priority 5.2). Additional diversity and inclusion information can be found at: http://www.dal.ca/cultureofrespect.html

Student Code of Conduct
Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner - perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution. The full Code of Student Conduct can be found at: https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

Fair Dealing Policy
The Dalhousie University Fair Dealing Policy provides guidance for the limited use of copyright protected material without the risk of infringement and without having to seek the permission of copyright owners. It is intended to provide a balance between the rights of creators and the rights of users at Dalhousie. Additional information regarding the Fair Dealing Policy can be found at: https://www.dal.ca/dept/university_secretariat/policies/academic/fair-dealing-policy-.html

Originality Checking Software
The course instructor may use Dalhousie's approved originality checking software and Google to check the originality of any work submitted for credit, in accordance with the Student Submission of Assignments and Use of Originality Checking Software Policy. Students are free, without penalty of grade, to choose an alternative method of attesting to the authenticity of their work and must inform the instructor no later than the last day to add/drop classes of their intent to choose an alternate method. Additional information regarding Originality Checking Software can be found at: https://www.dal.ca/dept/university_secretariat/policies/academic/student-submission-of-assignments-and-use-of-originality-checking-software-policy-.html

Student Use of Course Materials
Course materials are designed for use as part of this course at Dalhousie University and are the property of the instructor unless otherwise stated. Third party copyrighted materials (such as books, journal articles, music, videos, etc.) have either been licensed for use in this course or fall under an exception or limitation in Canadian Copyright law. Copying this course material for distribution (e.g. uploading to a commercial third-party website) may lead to a violation of Copyright law.

Student Resources and Support

University Policies and Programs
Important Dates in the Academic Year (including add/drop dates): http://www.dal.ca/academics/important_dates.html
Classroom Recording Protocol: https://www.dal.ca/dept/university_secretariat/policies/academic/classroom-recording-protocol.html
Dalhousie Grading Practices Policies: https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html
Grade Appeal Process: https://www.dal.ca/campus_life/academic-support/grades-and-student-records/appealing-a-grade.html
Sexualized Violence Policy: https://www.dal.ca/dept/university_secretariat/policies/health-and-safety/sexualized-violence-policy.html
Scent-Free Program: https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html

Learning and Support Resources
General Academic Support – Advising (Halifax): https://www.dal.ca/campus_life/academic-support/advising.html
General Academic Support – Advising (Truro): https://www.dal.ca/about-dal/agricultural-campus/ssc/academic-support/advising.html
Student Health & Wellness Centre: https://www.dal.ca/campus_life/health-and-wellness.html
On Track (helps you transition into university, and supports you through your first year at Dalhousie and beyond): https://www.dal.ca/campus_life/academic-support/On-track.html
Indigenous Student Centre: https://www.dal.ca/campus_life/communities/indigenous.html
Indigenous Connection: https://www.dal.ca/about-dal/indigenous-connection.html
Elders-in-Residence (The Elders in Residence program provides students with access to First Nations elders for guidance, counsel, and support. Visit the office in the Indigenous Student Centre or contact the program at elders@dal.ca or 902-494-6803: https://cdn.dal.ca/content/dam/dalhousie/pdf/academics/UG/indigenous-studies/Elder-Protocol-July2018.pdf
Black Student Advising Centre: https://www.dal.ca/campus_life/communities/black-student-advising.html
International Centre: https://www.dal.ca/campus_life/international-centre.html
South House Sexual and Gender Resource Centre: https://southhousehalifax.ca/about/
LGBTQ2SIA+ Collaborative: https://www.dal.ca/dept/vpei/edia/education/community-specific-spaces/LGBTQ2SIA-collaborative.html
Dalhousie Libraries: http://libraries.dal.ca/
Copyright Office: https://libraries.dal.ca/services/copyright-office.html
Dalhousie Student Advocacy Services: https://www.dsu.ca/dsas?rq=student%20advocacy
Dalhousie Ombudsperson: https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html
Human Rights and Equity Services: https://www.dal.ca/dept/hres.html
Writing Centre: https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html
Study Skills/Tutoring: http://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html
Faculty of Science Advising Support: https://www.dal.ca/faculty/science/current-students/undergrad-students/degree-planning.html