

# PHYS 4P51: Quantum Mechanics

Brock University, Fall 2025

Prof. Barak Shoshany

## Course overview

PHYS 4P51 is a quantum mechanics course at the 4th-year undergraduate level. It will be your last course in quantum mechanics before graduate school, and thus it should prepare you for graduate-level study and research.

My goal is that by the end of this course, you will gain a deep and intuitive understanding of the foundations of quantum theory, from the modern point of view of 21st-century theoretical physics - as it is currently understood by researchers in cutting-edge fields such as quantum foundations, quantum information, quantum computation, quantum field theory, and quantum gravity. Such an understanding will be absolutely crucial if you want to be a theorist, and will also be extremely useful if you want to be an experimentalist.

Before you begin this course, you should forget everything you learned about quantum mechanics before! We will re-learn quantum theory from scratch, developing it in an axiomatic and mathematically rigorous way from first principles. We will see that there is nothing particularly complex or mysterious about quantum mechanics (with the crucial exception of its philosophical interpretations), and obtain insight that will allow us to understand how it makes the universe works at the most fundamental level.

There is no textbook for this course. **My lecture notes** will contain everything you need to know. During the lectures I may sometimes teach bonus material (e.g. in reply to a student's question), but the exams will only cover the material that is in the notes. If you miss a lecture, you can make up the material by reading the notes without missing anything relevant to the exams.

There are no required fees for this course.

## Course syllabus

The course website also doubles as the course syllabus. If you need the syllabus in PDF format, simply **[click here](#)** to print it and choose "Save to PDF".

## About the professor

The professor for this course is **Dr. Barak Shoshany** (he/him). I did my BSc in mathematics and physics at **Tel Aviv University** in Israel and my MSc and PhD at **Perimeter Institute for Theoretical Physics** in Waterloo, Ontario. I then taught at the **University of Toronto** for a short time. I joined





Possible advanced topics that I hope to cover, which are not currently in the lecture notes, include: applications of group theory and representation theory, a rigorous treatment of continuous states and operators, density matrices, measurements in quantum information, quantum cryptography, interpretations of quantum mechanics in depth, and more. We won't have time to learn all of these topics, so I will choose which ones to cover based on the students' interests. If there is any specific topic you would like to learn, whether or not it is in this list, please let me know!

## Homework problem sets

There will be a homework problem set every week, which will include problems related to the material learned that week. Each problem set will be posted on Teams some time after the last lecture of the week. The homework problem sets do not need to be submitted, will not be marked, and will not contribute to your final grade directly; but solving them will be crucial for your success in the exams.

The problem sets can be solved either alone or together with other classmates, and discussion of the problem sets with other students, whether on Teams or in private, is strongly encouraged. I will provide solutions to each problem set two weeks after its release.

Each problem set will involve a subset of the exercises and problems in my **lecture notes** for the subsections we learned that week. If you want more practice, you should solve **all** the exercises and problems in the lecture notes. Detailed solutions to problems that are not in the homework sets will not be provided, but you can always ask me about them if you are not sure your solution is correct.

Large Language Models (LLMs) such as ChatGPT, Claude, and Gemini have reached a point where they can easily solve any homework problem in this course correctly, as long as a sufficiently advanced model is used. Therefore, you may feel tempted to simply give the problem sets to an LLM and copy the answers. However, since the homework problem sets are not graded, this will be a completely pointless exercise that will not help you learn anything and only waste your time. During the exams you will, obviously, not be allowed to use LLMs, so if you do not practice solving problems on your own, you will surely fail the exams!

## Exams and grading

There will be 3 exams during the term, roughly one per month. Each exam will test the students' understanding of the material learned up to the exam date. The exams will be scheduled for a time that works for all of the students; we will schedule them together during the lectures.

The exams will be given in person, at a room which will be booked once the exams are scheduled. I will be present in the exam room for the duration of the exam in case clarification is needed for any of the exam questions.

The exams will contain questions similar to the exercises and problems in the **lecture notes**. This means there will be both calculation and proof questions. The level will be the same as the questions in the notes - not harder, but also not easier. Some questions may be taken directly from, or be variations of, questions from the lecture notes, while other questions may be completely new.

In your answers, you may make use of any results derived or stated explicitly in my lecture notes, and **only** them. If you wish to use any non-trivial result that is not in the lecture notes, you must prove it directly from the material in the lecture notes. If you make any assumptions beyond what's in the lecture notes, your question will be marked as incomplete.

Since **notes are allowed**, you do not need to memorize anything! The exam is not meant to test your memory. It will test your level of understanding of the physics and math concepts you learn in the course, and your ability to apply them correctly and efficiently to concrete problems.

Once the timer starts, you will have exactly 2 hours to solve the exam (unless you have **extra time accommodations**). If you are late to the exam, you will not get any extra time, so please make sure to be at the exam room at least 15 minutes before the beginning of the exam.

Each exam will be worth a third of the final grade. After the average is calculated, it will be rounded to the nearest integer, with .5 rounded up. A final grade of 50% or more is required to pass the course.

## **Allowed material and academic integrity**

The only allowed material during the exams is my lecture notes, which you should print out ahead of time and bring with you to the exam. Do not wait for the last minute to print the notes! You are allowed to highlight parts of the notes if you wish, but you cannot write in them or add any additional material.

Computers, phones, tablets, smart watches, smart glasses, and other digital devices cannot be used, but you can use a calculator. Any students found using a digital device of any kind during the exam will be charged with academic misconduct.

### **Official statement from the Faculty of Mathematics and Science at Brock University regarding academic misconduct:**

Academic misconduct is a serious offense. The principle of academic integrity, particularly of doing one's own work, documenting properly (including use of quotation marks, appropriate paraphrasing and referencing/citation), collaborating appropriately, and avoiding misrepresentation, is a core principle in university study. Students should consult Section VII, "Academic Misconduct", in the "Academic Regulations and University Policies" entry in the **Undergraduate Calendar** to view a fuller description of prohibited actions, and the procedures and penalties. Information on what constitutes academic integrity is available at **Brock University Academic Integrity Website** .

The following are standard penalties imposed in academic misconduct cases in the Faculty of Mathematics and Science. Please be aware that the Associate Dean, Undergraduate Programs, may assign different penalties than those listed here, depending on the details of individual cases. Requests for special academic consideration, such as exceptions to academic regulations, will not be considered while academic integrity cases are ongoing.

Maximum penalties for misconduct in course work, including mid-term tests:

- First offense: Zero grade on assignment, additional penalty of 100% of the weight of the assignment to be subtracted from the final grade, mandatory completion of the AZLS Academic Integrity workshop.
- Second offense: Zero grade on assignment, 4-month suspension.
- Third offense: Zero grade in course, 1-year suspension, permanent removal from major program.
- Fourth offense: Permanent suspension / debarment.

Penalties for misconduct in final exams:

- First offense: Zero grade in course.
- Second offense: Zero grade in course, 4-month suspension.
- Third: Zero grade in course, 1-year suspension, permanent removal from major program.
- Fourth offense: Permanent suspension / debarment.

## **How to succeed in the exams**

To succeed in the exams, please make sure to:

- Attend all the lectures and **actively participate** in them. If something is unclear, ask for a clarification. If a topic inspires you to ask a followup question, ask it. If I ask the class (or you personally) a question, do your best to answer it. In my experience, the students who participate the most in class are also the students who get the highest grades in the exams!
- Thoroughly read and understand **my lecture notes** in order to revise and get a better understanding of what I said in the lectures. This is especially important if you missed a lecture. Also, please note that anything in the lecture notes can appear in the exam, even if I did not cover it directly in the lectures, unless explicitly stated otherwise.
- Make an honest effort to solve the weekly problem sets in their entirety. **Don't just read my solutions (or ask an AI for the solutions) without solving the problems yourself.** If you do that, you will never learn how to solve problems on your own, and you will not succeed in the exams! If you are stuck on a particular question, you should discuss it with your classmates.
- Read my solutions to the weekly problem sets very carefully. I try to make sure the solutions are as clear and detailed as possible. Your solutions to the exam questions should ideally look like my solutions to the weekly problem sets in terms of clarity, detail, and mathematical rigor.
- Solve as many as possible of the exercises and problems from **my lecture notes** corresponding to the sections we learned each week - preferably **all of them!** The exams are designed such that any student who successfully solved all the problems and exercises in the notes should be able to get 100%.
- Large Language Models (LLMs) such as ChatGPT, Claude, and Gemini can be an extremely useful tool in this course. They can answer your questions about the material, give you feedback on your homework solutions, and help prepare you for the exams. **However, if you always rely on LLMs to solve the problems and exercises for you, you will never learn how to solve them on your own!** Therefore, while you are encouraged to use LLMs as a

tool for learning, you must make sure to solve all the actual problems and exercises yourself. I already know that the LLMs can get 100% on all my exams; the purpose of the course is to get you to that level too.

- Make use of your greatest resource in this course: the professor. If you don't interact with me in any way, then you might as well just read a textbook or watch lectures on YouTube. I am available to you during the lectures, on Teams, and by email. You are always welcome to drop by my office. Don't be shy to ask for help if you need it - that's what I'm here for!

## Missed exams and extra time accommodations

### Missed exams

If you miss an exam due to legitimate medical, personal, or other issues, you must **email me** within 7 days of the exam. The following forms are acceptable:

- For medical issues only, the **Brock University Medical Verification Form** should be used. The form must be filled out in its entirety and signed by both you and a health professional.
- For medical or non-medical issues, the **Brock University Student Absence Self-Declaration Form** can be used, but only once per term, only for term tests (Exam 1 and Exam 2), and only for absences of up to 72 hours.
- For non-medical issues only, if the Self-Declaration Form cannot be used, your email should simply explain why you missed the exam and include any necessary proof. I will then determine whether your reason for missing the exam is legitimate.

If I am satisfied with the forms and/or proof you provided, I will schedule a day and time for you to take the exam in my office. Of course, you will be forbidden from asking other students about the contents of the exam; if you do, you will be charged with academic misconduct.

If you do not email me within 7 days, or your reason for missing the exam is not acceptable, your grade in the exam will be zero.

### Extra time accommodations

If you have any extra time accommodations from Student Accessibility Services, please **email me** your Approved Accommodations Summary letter **before** the exam date. Please make sure you appear on the OASIS portal, and that you have a valid Approved Accommodations Summary letter, before emailing me. If you don't know what these things mean, please ask your case manager.

If you have extra time accommodations, you will take the exam in the same room with everyone else, but you will have more time to solve it. Do not attempt to take the exam at the SAS exam center - they will not have the exam in the first place, and being able to ask me questions directly during the exam is extremely important for your success.

## Accommodations

Brock University is committed to fostering an inclusive and supportive environment for all students and will adhere to the Human Rights principles that ensure respect for dignity, individualized accommodation, inclusion, and full participation. The University provides a wide range of resources to assist students, as follows:

- If you need any accommodations related to exams, such as extra time, because of a disability or an ongoing health or mental health condition, please contact Student Accessibility Services (SAS) at [askSAS@brocku.ca](mailto:askSAS@brocku.ca) or (905) 688-5550 ext. 3240 as soon as possible to arrange your accommodations.
- If you require academic accommodation on religious grounds, you should make a formal written request to the professor during the first two weeks of the term, or as soon as possible after a need for accommodation is known to exist. Religious accommodations are not granted automatically, and will be considered on a case-by-case basis.
- If you are experiencing mental health concerns, contact the Student Wellness and Accessibility Centre. **Good2Talk** is a service specifically for post-secondary students, available 24/7, 365 days a year, and provides anonymous assistance: visit [the website](#) or call **1 866 925-5454** . For information on wellness, coping, and resiliency, click [here](#) .
- If you have been affected by sexual violence, the Human Rights & Equity Office offers support, information, reasonable accommodations, and resources through the Sexual Violence Support & Education Coordinator. For information on sexual violence, visit [Brock's Sexual Assault and Harassment Policy](#) or contact the Sexual Violence Support & Response Coordinator at [humanrights@brocku.ca](mailto:humanrights@brocku.ca) or (905) 688-5550 ext. 4387.
- If you have experienced discrimination or harassment on any of the above grounds, including racial, gender or other forms of discrimination, contact the Human Rights and Equity Office at [humanrights@brocku.ca](mailto:humanrights@brocku.ca) .

## Intellectual property notice

Any and all course materials created by the instructor in this course, including but not limited to notes, slides, homework problems, homework solutions, exams, exam solutions, and photo, audio, and/or video recordings, are the intellectual property of the instructor.

Any student who, without the instructor's express consent, **publicly posts or sells** the instructor's work, or takes a **photo, audio, and/or video recording** of the instructor's lectures, will be charged with misconduct under the university's Academic Integrity Policy and/or Code of Conduct, and may also face adverse legal consequences for infringement of intellectual property rights.