Physics 143b – Quantum Mechanics II
Syllabus – Fall 2024

This course builds on the basic concepts of quantum mechanics covered in Physics 143a and introduces path integral method, identical particles and many-electron theory, WKB approximation, time-dependent perturbation theory, scattering theory, relativistic quantum mechanics, and quantum information theory together with some applications.

Instructor:
Matteo Mitrano (lectures) mmitrano@g.harvard.edu Lyman 341

Teaching Fellow:
TBD TBD@g.harvard.edu

Course meeting times:
Lectures: Monday, Wednesday, 12:00 PM - 1:15pm. Attendance is required and contributes to the final course grade.

Sections: Sections (1.5 hours) meet once each week. Attendance is required and part of your grade. The purpose of the sections is to work through examples relevant to the homework problems in smaller groups. Section meetings begin in the second week of class.

Office Hours: Prof. Mitrano will hold office hours each week (day/time TBD). If you need to meet with Prof. Mitrano outside of the course times, please send him an e-mail to arrange a time. Office hours for the TFs will be posted on the course website during the first week of class.

Course Grading:
Your course grade will be computed from the following:

- 1st Midterm: TBD 15%
- 2nd Midterm: TBD 15%
- Final exam: TBD 25%
- Homeworks 40%
- Lecture and section attendance 5%

Homework Assignments:
Homeworks: There will be weekly problem sets except during midterm examination weeks. The homeworks will be made available on Thursday at 12pm (noon) and will be **due on Canvas at 12pm (noon)** on the following Thursday. You are encouraged to work cooperatively on problem sets. Anything that you hand in must be worked through and written down by yourself.

Extensions and grading: As solutions are posted together with the new problem sets, we will not accept late homework in almost all circumstances. We will not be able to grant extensions due to conflicts with extracurriculars or other courses. Extension related to major emergencies (illness, family emergency, environmental issues) must be agreed by email with the instructor prior to the homework due date and may not be granted. To receive full credit on a problem, the solution must be correct and written up with clear step-by-step explanations (possibly typeset in LaTeX or equivalent). **We will drop your lowest homework score when computing your final grade.**

Academic Integrity Policy: For assignments in this course, you are encouraged to consult with your classmates as you work on problem sets. However, after discussions with peers (or course instructional staff such as tutors, TF/TAs, course assistants), make sure that you can work through the problem yourself and ensure that any answers you submit for evaluation are the result of your own efforts. In addition, you must cite any books, articles, websites, lectures, etc that have helped you with your work using appropriate citation practices. Similarly, you must list the names of students with whom you have collaborated on problem sets. Copied homeworks are clearly recognizable and will be flagged.

Use of software: We ask that you clearly indicate the use of Mathematica and ChatGPT (as well as other code) and describe in which way it was used.

Exams:
In-class Exercises: There will be random exercises in certain classes to reinforce key concepts and prompt discussion. These will be graded on participation only and will count towards your class attendance grade.

Midterm Exams: There will be two in-class midterm exams. Each exam will be designed to be completed in 75 minutes. More information regarding the exams will be available near the exam dates.

Final Exam: There will be a regular 3-hour final exam during a day/time scheduled by the Registrar's office.

Textbooks:
1. Introduction to Quantum Mechanics, 2nd or 3rd Edition, by David J. Griffiths.
2. A Modern Approach to Quantum Mechanics, 2nd Edition, by John S. Townsend.

Both books are on reserve in the Cabot library.

Course expectations:
Physics 143b encompasses a wide variety of quantum phenomena which constitute the foundation to understand some of the most exciting development of contemporary physics. We support an open, stimulating and supportive environment. We expect you to contribute in making the class a supportive, enjoyable, and respectful environment for all your colleagues. This includes behavior during class, section and problem-solving groups. If you witness inappropriate behavior – even when not directed towards you – please immediately tell Prof. Mitrano. Inappropriate conduct will be reported.

Prerequisites:
Physics 143a or permission by the Head Tutor.

Announcements:
All communication will be through Canvas announcements; therefore, you are encouraged to read your e-mail.

Accessibility:
Harvard University values inclusive excellence and providing equal educational opportunities for all students. Our goal is to remove barriers for disabled students related to inaccessible elements of instruction or design in this course. If reasonable accommodations are necessary to provide access, please contact the Disability Access Office (DAO). Accommodations do not alter fundamental requirements of the course and are not retroactive. Students should request accommodations as early as possible, since they may take time to implement. Students should notify DAO at any time during the semester if adjustments to their communicated accommodation plan are needed.

Topics:
1. Path integrals: Principle of stationary action; propagator; path integral; applications.
2. Identical particles: Identical particles; many-electron atoms; central field approximation; Hartree-Fock method; the periodic table; energy bands; quantum statistics.
3. WKB approximation: WKB method; connection formulas; tunneling; bound states; applications.
4. Time-dependent perturbation theory: Time-dependent perturbation theory; the interaction picture; Fermi's golden rule; sudden and adiabatic perturbations; applications.
5. Scattering theory: Scattering cross-section; the Born approximation; partial wave expansion; applications.
6. Relativistic quantum mechanics and quantum fields: The Klein-Gordon equation; quantization of electromagnetic field; photons and atoms; spontaneous emission; the Dirac equation; gauge symmetry; introduction to quantum electrodynamics.
7. Quantum computation: EPR paradox; Bell inequalities; quantum computation.