MENG 31500: Advanced Quantum Engineering II
Winter Quarter 2026
Course Syllabus

Instructor:	Professor Aashish Clerk, ERC 289 (Eckhardt Research Center) aaclerk@uchicago.edu
Time and Place:	TR 11:00am – 12:20pm (KPTC 105)
Discussion section:	F 1:30pm – 2:50pm, (KPTC 105) (*will also use for makeup lectures*)
TA:	Andy Chu, ctchu@uchicago.edu (*will also arrange office hours*)
Office Hours:	Thursdays 4:30 – 5:30pm (*also at other times by appointment*)
Prerequisite:	PHYS 34100 (Graduate Quantum Mechanics I) MENG 31400 (Advanced Quantum Engineering) *(+ at least one semester of undergraduate quantum mechanics)*
Course home page:	Via Canvas; accessible at courses.uchicago.edu. *(Note that important course announcements and materials will be posted on Canvas, access is essential.*)

Course Goals and Objectives: Quantum mechanics underlies many areas of modern engineering, including materials science, photonics, electronics, metrology, and information processing. This course will give students a grounding in foundational aspects of quantum theory that play a crucial role in understanding and developing quantum technologies. It will continue the introduction to key concepts in quantum physics that was started in PHYS 34100 (graduate quantum mechanics I) and MENG 31400. At the end of this course, you should have a good understanding of standard approximation methods in quantum mechanics, the addition of angular momentum, and the basics of describing many-particle quantum systems.

Approximate list of topics:

1. Entanglement and the addition of angular momentum
    - Tensor product spaces and entangled states
    - Clebsch-Gordon coefficients
    - Wigner-Eckart theorem
2. Quantum information preliminaries
    - Bell's theorem, Hardy paradox
    - Super-dense coding

3. Time-independent perturbation theory
    - Degenerate and non-degenerate cases
    - Applications in atomic physics, quantum optics and quantum information
4. Time-dependent perturbation theory
    - Interaction picture
    - "Fermi's Golden Rule"
    - Applications in atomic physics, quantum optics and quantum information
5. Many-particle systems
    - Identical particles: fermions and bosons
    - Second quantization

Useful References: I will scan and post my handwritten lecture notes. The following textbooks (also used as primary references for PHYS 34100) will also be useful:

Modern Quantum Mechanics, 3rd Edition
J. J. Sakurai and J. Napolitano
Cambridge University Press, 2020

Principles of Quantum Mechanics (2nd edition)
R. Shankar
Plenium Press, 1994

Grading: The grade for this course will be based on problem sets (20%), a midterm exam (35%) and a final exam (45%).

Problem Sets: There will be approximately one problem set per week in the class, generally posted on Canvas on Mondays, and due the following Monday by midnight. A digital version of your work must be submitted through Canvas as **a single PDF** file before midnight on the relevant due date. The assignment you turn in must be your own work done in your own words. ***Late assignments will not be graded***.

Exams: There will be two exams in this course:

- A midterm exam will be held on **Wednesday Feb. 4 from 5pm – 7pm.**
- A final exam will be held during the regular final exam period (and will be centrally scheduled by the university).

Statement on accessibility
University of Chicago is committed to ensuring equitable access to our academic programs and services. Students with disabilities who have been approved for the use of academic accommodations by Student Disability Services (SDS) and need a reasonable accommodation(s) to participate fully in this course should follow the procedures established by SDS for using accommodations. Timely notifications are required in order to ensure that your accommodations can be implemented. Please meet with the course instructors to discuss your access needs in this course after you have completed the SDS procedures for requesting accommodations.