Instructor: Kenneth Lane, PRB 579, ext. 3-4512; lane@bu.edu

Class: Tuesday and Thursday, 9:30–11:00 AM in PRB 150.

Discussion: Wednesday, 10:00–11:00 AM in PRB 150.

Office hours: Monday, 2:00–4:30 PM and Tuesday, 1:00–2:00 PM. You can usually see me at other times by sending an e-mail or calling to make an appointment. Please take advantage of this! Announcements will be made by e-mail. Check your e-mail frequently!

Homework Quiz Grader: Kip Barros, SCI 333; kbarros@bu.edu. If you have a question on how to solve a homework problem, ask me or Kip. For questions regarding grading of a homework quiz (see below), please ask Kip first. If you are still not satisfied, see me.

Attendance and Participation: Your attendance in class and discussion section and participation in class discussions are strongly recommended. Attendance and participation in class discussions will account for up to 10% of your course grade.

Principal Text:

Supplemental Texts: (on reserve in the the Science Library):
Secondary: Quantum Mechanics, by Ernest Abers
Tertiary: Lectures on Quantum Mechanics, by G. Baym;
Modern Quantum Mechanics, by J. J. Sakurai
Feynman Lectures on Physics, Vol. III, by R. P. Feynman, R. B. Leighton and M. Sands;
Quantum Mechanics, by R. Shankar

Final Grade: Your final grade will be based on homework quizzes (30%), a midterm exam (25%), a final exam (35%), and class participation (10%). Homework will be assigned, with the assignments delivered to you by e-mail as a pdf file. You are encouraged to work together on homework. There will be a ~ 20 minute quiz based directly on the homework during about 7 to 10 of the Wednesday discussion sections. Your homework grade will be determined by how you do on these quizzes. The date of the midterm exam will be announced at least two weeks in advance. The final exam is currently scheduled to be on Saturday, December 16, at 9:00–11:00 AM. This time period is likely to be extended; an announcement will be made later in the semester. Collaboration on exams is NEVER allowed. There will be NO make-up exams.
It is your responsibility to know and understand the provisions of the CAS Academic Conduct Code. Printed copies are available in room CAS 105. I will refer cases of suspected academic misconduct to the Dean’s Office. Proven cases of cheating on a midterm or final exam will result in a zero grade for that exam.

The last day to drop classes (without a "W" grade) is 5 weeks from the start of the semester — Friday, October 6. The last day to withdraw (with a "W" grade) is 8 weeks from the start of the semester — Friday, October 27. See http://www.bu.edu/reg/dates.htm.

**Format of the lectures:** The topics of the lectures are listed below. They follow Gottfried’s and Yan’s textbook and my notes (which are mainly on group theory and symmetries). I strongly recommend that you read the relevant material, at least superficially, **BEFORE** I lecture on it. That way, you will have a much better understanding of my lectures, and you will be able to ask timely questions. Following my lecture, you can go back and re-read the text and work problems to solidify your understanding. **THIS IS BY FAR THE BEST ADVICE I CAN GIVE YOU FOR SUCCEEDING IN THIS COURSE!**

**COURSE & LECTURE OUTLINE**

I. **Introduction to Quantum Mechanics** (G-Y, Chapters 1,2)
   1. Introduction to the course; background questionnaire; knowledge test (ungraded).
   2. Uncertainty principle; superposition.
   3. Hilbert space; Dirac notation; complete set of states. Hermitian and unitary operators; unitary transformations.
   4. States and probabilities; probability amplitudes; complete set(s) of commuting observables; density matrix.
   5. Canonical quantization; uncertainty relations. Dynamical equation of motion; the Schrödinger, Heisenberg and interaction pictures.

II. **Low-Dimensional Systems** (G-Y, Chapters 2 and 4)
   6. Two-state systems. The $NH_3$ molecule; level-crossing and repulsion; transitions. (G-Y, Chap. 4)
   7. The harmonic oscillator; Dirac’s operator formalism. (G-Y, Chap. 4)
   8. Propagators and Green’s functions. (G-Y, Chap. 2)
   9. Scattering in one dimension; reflection and transmission coefficients; δ-function and square-well potentials. (G-Y, Chap. 4)
   10. Analytic properties of $R$ and $T$; exponential decay law. (G-Y, Chap. 4)

**Midterm Exam** – either here or after item 15.
III. Symmetries, Part 1 (KL notes and G-Y, Chapters 2,3,7)

11. Symmetries and conservation laws. (G-Y, Chaps. 2.5 and 3)
12. Introduction to group theory: Definitions; Lie groups; generators and transformations; representation theory. (KL notes; G-Y, Chap. 7)
13. Symmetries in quantum mechanics: Quantum symmetry groups; \[ \{Q, H\} = 0; \] fundamental theorem of symmetries in quantum mechanics; degenerate states as (irreducible or reducible) group representations. (KL notes, G-Y, Chaps. 2,3,7)
14. Angular momentum: spectrum and eigenstates; rotations. (KL notes; G-Y, Chap. 3)
15. Orbital angular momentum. (KL notes; G-Y, Chap. 3)
16. The rotation group — \( SO(3) \) and \( SU(2) \): Irreducible representations of \( SU(2) \) generators and transformations (“rotations”); Representations of generators and rotations for \( j = \frac{1}{2} \) and \( j = 1 \); the functions \( d^j_{mm'}(\theta) = \langle jm|e^{-ij\theta}|jm'\rangle \). (KL notes; G-Y, Chap. 7)
17. Examples: The 2-D harmonic oscillator; motion in a magnetic field and Landau levels. (KL notes and G-Y, Sect. 4.3)

IV. Symmetries, Part 2 (KL notes and G-Y, Chaps. 2,3,7)

18. Addition of angular momenta; Clebsch-Gordan coefficients and series (Kronecker product). (KL notes; G-Y, Chaps. 3,7)
19. (Optional) \( SU(N) \) for \( N \geq 3 \). (KL notes)
20. Irreducible tensor operators; Wigner-Eckart theorem for \( SU(2) \). (KL notes; G-Y, Chap. 7)
21. Space reflection and parity. (KL notes; G-Y, Chap. 2)
22. Identical particles. (KL notes, G-Y, Chap. 7)
23. An example of everything — the kaon system: \( K^0 - \bar{K}^0 \) and CP-symmetry; \( K_S \) and \( K_L \); isotopic spin and \( K \)-decays to pions; the \( |\Delta I| = \frac{1}{2} \) rule for nonleptonic \( K^0 \) and \( K^+ \)-decays. (KL notes)

V. Hydrogenic Atoms (G-Y, Chapters 3 and 5)

24. Two-body problem and the Coulombic bound state problem (KL notes and G-Y, Sect. 3.6).
25. Algebraic solution of the Coulombic bound state problem (KL notes and G-Y, Sect. 5.2).