Quantum Physics III / Physics-434  
Fall 2012

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Lectures: M/W/F: 8:30 – 9:20  
RCH 306

Tutorial: W: 15:00 – 15:50  
MC 2038

Office Hours: M: 14:00 – 15:30  
F: 14:00 – 15:30

Marks: Assignments: 25%-25%  
Midterm: 30%-25%  
Final: 45%-50%

Course Type:  
- Technical & mathematically focused  
- Lectures are mostly blackboard lectures, except parts of some lectures that rely on a larger amount of graphing/figures.

Textbook:  
Quantum Mechanics, Second Edition  
B. H. Bransden & C.J. Joachain,  
ISBN: 0-582-35691-1  
Publisher: Pearson/Prentice Hall

Note: I will follow this textbook very closely

Other textbook/material:

References: Almost any of the quantum textbooks (hundreds) are all very similarly organized. Examples include:  
- Shankar, “Principles of Quantum Mechanics”,  
- Griffiths, “Introduction to Quantum Mechanics”,  
- Liboff, “Introductory Quantum Mechanics”,  
- Zettili, “Quantum Mechanics, Concepts and Applications”,  
- Merzbacher, “Quantum Mechanics”,  
- Messiah, “Quantum Mechanics”,
Course Content:

Part I) Interactions & perturbations in quantum mechanical systems

A) Formalism of perturbation methods

Ø A.1: Review of perturbation method for time-independent problems (B&J; Chapter 8)
- non-degenerate perturbation theory
- high-order perturbation theory
- degenerate perturbation theory
- examples from interacting systems (exchange-coupled spin-1/2, van der Waals interactions)

Ø A.2: Approximation methods for time-dependent problems (B&J; Chapter 9)
- time-dependent perturbation theory
- interaction picture and high-order time-dependent perturbation theory
- notions of selection rules
- sudden approximation
- adiabatic approximation (example: Berry phase)

B) Applications of perturbation theory – the context of a quantum system in interaction with E&M fields and E&M radiations (B&J; Chapters 11 & 12 and handouts)

Ø B.1: Static E&M fields – Part 1 (B&J; Chapter 12 and handouts)
- Lagrangian and Hamiltonian of charged particle in an E&M field
- elements of E&M theory (Maxwell’s equations)
- charged particles in an electromagnetic field (examples: Aharonov-Bohm effect, superconductors, Landau levels, magnetic monopoles,

Ø B.2: Dynamical E&M fields – Part 2 (B&J; Chapter 11 and handouts)
- application of time-dependent perturbation theory to quantum systems coupled to E&M radiation
- dipole selection rules, forbidden transitions,
- introduction to quantum electrodynamics, notions of second quantization, photon,
- application of high-order time-dependent perturbation theory of E&M field (examples: multiple photon, Raman effect)
- elements of quantum electrodynamics (QED)

C) Elements of scattering Theory (B&J; Chapter 13)
- scattering experiments and cross-section
- potential scatteringapplication of high-order time-dependent perturbation theory of E&M field (examples: multiple photon, Raman effect)
- method of partial waves and examples
- integral equation of scattering
- Born approximation

Part II) Learning more fundamentals & formalism

D) Symmetries in quantum mechanics (B&J; Chapter 5.10 and handouts)

E) Quantum mechanics from path integrals (B&J; Chapter 5.9 and handouts)

F) Identical Particles (B&J; Chapter 10 and handouts)

G) Elements of relativistic quantum mechanics (B&J; Chapter 15)
Some comments on course & lectures policies:

- **Difficulty of course:**
  - *This is a high workload course with several assignments (7-8 of them) that will often consist of some long and/or somewhat difficult problems.*
  - *Expect to work on assignments of the order of 5 hours a week.*
  - *That said, if you do the assigned work, diligently, on your own, you should expect to find the midterm exam and final exam rather straightforward.*

- Please endeavour to arrive in class on time (i.e. **before** 8:30).
- Students are encouraged to ask questions in class.
- If you have a **general** question of interest to all students, please, s’il vous plait, 請, per favore, bitte, por favor – ask DURING class so that everybody can benefit from the answer.
- Teaching, at least for me, requires a large amount of concentration. For this reason, I would like to ask students to please refrain from chatting during lectures:
  - Very brief questions of clarification quietly asked to a classmate that merely requires a one word answer (e.g. “is that an ’s’ or a ’5’ in that equation?) are fine, welcome and encouraged.
  - THAT SAID: More involved questions/discussions should be directed to me so that, again, all students can benefit from the answer.
  - Some years, there are groups of students that systematically embark on loud talking in class (including topics such as previous weekend activities!). Unfortunately, I am unable to allow this to go on in class and students constantly found talking in class will be asked to leave for the rest of the class. If repeated more than twice, students will be asked to refrain from attending the lectures for the whole semester.
- Assignments should be handed on time. Late assignments will be penalized by a **15%** mark reduction penalty for each late day.
- Do not take for granted that if you do so-so on midterm, that “recovery” with homeworks and in particular final will be straightforward.
- **Missing classes:** if you are the type of student who systematically skip classes, expect difficulties in this course.
- **Everything** I say/mention/explain in class and in tutorials is subject to questioning in homework, midterm or final except if stated otherwise.
  - *Hence:* learn to take notes in class above and beyond what I write on the blackboard.
- For flow sake in the course: some lectures will be swapped for tutorials, and vice versa – while applying a “sum rule” of 12 tutorials at least.
- Note that Friday October 19 class will be a tutorial since I have to be absent.
- Note that Wednesday morning October 31 class will likely be a tutorial and taught by the TA.

I hope you will find the course material interesting, challenging, enriching of your undergraduate Physics education and worthy of your time and energy. I look forward to teaching you and interacting with you over the course of the term.