PHY-6624, Quantum Mechanics-II

Spring 2003, MW 16:00-17:15, MAP-306

Instructor - Dr. Aniket Bhattacharya

Textbook: J. J. Sakurai, *Modern Quantum Mechanics*

Supplementary Textbook: R. Shankar, *Principles of Quantum Mechanics*, 2nd ed.

Office: MAP 429
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or by appointment

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This is a graduate level advanced course on quantum mechanics. The materials that will be covered in this course are outlined below. If you have taken PHYS-5606 (Quantum Mechanics-I), or an excellent undergraduate course on Quantum Mechanics (modern approach using bra-ket notations), then most likely you will be doing fine. If you have difficulties in the first few lectures, then see me immediately; may be, I will be able to help you. The format of the course, tests, grading procedures etc. are very similar to PHY-5606 and is outlined below.

Homework: Homeworks will be an indispensable part of going on with and doing well in the course. Almost every week I will assign homework which will be graded. Nothing could be better than if you get together in small groups and initiate pertinent discussions. I also strongly encourage you to see me at my office for discussions, questions about HWs, *etc.*. Your comments (sooner is the better) will definitely help me to design better teaching strategies, or even course contents. You can also communicate through *e-mail*. But I urge that you do the homeworks yourselves.

Group Assignments: There will be several group assignments; the idea is to collectively carry out some long calculation, which otherwise may be very time consuming. This will also give you opportunities to exchange different ideas, concepts, *etc.*.

Tests: There will be two **midterms**[†] (in class and closed books/notes) and a **comprehensive** Final[‡].

Grade: Your final grade will be determined by your overall performance weighted in the following manner:

Homework - 40%, Midterm I - 15%, Midterm II - 15%, Final - 30%

I will adopt +/- grading policy; *i.e.*, your grade can be of any of the following:
A-, **A**, **B-**, **B**, **B+**,**C-**, **C**, **C+**.

[†]Midterms are in class tests; the day and the format of the tests will be discussed in the class

[‡]Final exam is scheduled from 16:00-18:50, on Wednesday, April 23, 2003.

References : I strongly advice that you go to the library and browse through the books on quantum mechanics. Here I mention some of the most used and cited texts.

Quantum Mechanics, Landau & Lifshitz
Lectures on Physics, Vol-III, R. P. Feynman
Principles of Quantum Mechanics, P. A. M. Dirac
Quantum Mechanics, E. Merzbacher
Quantum Mechanics, L. Schiff
Quantum Mechanics, N. Zettili

Course Outline:

- Addition of angular momenta: Example: Spin-$\frac{1}{2}$ problem, spin singlet and triplet states. General case: Representation of total spin, Direct Product and Irreducible representation & Clebsch-Gordan efficients.

- Infinitesimal rotation in Quantum Mechanics, Construction of finite rotation, representation of a rotation operator, rotation matrices, Matrix elements of Tensor Operators & Wigner-Eckart theorem

- Application of CG technology and Wigner-Eckart theorem: Isotopic Spin; Spin-orbit interaction and fine structure, Zeeman and Paschen-Back Effects.

- Schrödinger, Heisenberg, and Interaction picture. Precession of spin-$\frac{1}{2}$ particle in Heisenberg representation; Spin Dynamics: spin precession and resonances, maser and atomic clock

- Time dependent perturbation theory; adiabatic and harmonic perturbation, interaction of radiation with matter, Fermi golden rule

- Introduction to Scattering: Representation of free particle wave function in spherical-polar co-ordinates, Differential cross-section, The Born Approximation, Partial waves, Calculation of scattering cross-sections.

- N-particle systems; identical particles; Bosons and Fermions; Quantum chemistry: energy levels of atoms and molecules; The Helium atom

- Hartree and Hartree-Fock approximations

- Introduction to second quantization

- Introduction to Dirac equation and its applications

I will not strictly follow the text book, nor the sequence in which the topics are presented. Therefore I recommend that you **attend all of my lectures** in order to perform better in this course. But the topics that I will cover are all contained in the text book.

Depending upon our pace and general interests, I may include some special topics. Your suggestion is very much welcome ! As we go along with the course your constant feed back will definitely be very helpful. Please feel free to contact me.