PSU - DEPARTMENT OF PHYSICS
PH 411/511 ECE 598 : INTRODUCTION TO QUANTUM MECHANICS

(I) ***GENERAL INFORMATION :***

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Office hours : Tue., Th. : 2:00 p.m. - 3:00 p.m., or by appointment

Course grade : Homework (4 problem sets in total) : 20% ; Midterm (open book) : 30%
Final (take home + in class open book exam) : 50%
Project (optional) : 15% + 85% of the above = total grade

Project : an independent study on one of the following topics : (i) the intellectual development of QM; or (ii) quantum nanostructures; or (iii) quantum computers.

Nature of the course : This will serve as a single course for seniors/fresh grads., as well as the first sequence of the formal graduate course in quantum mechanics (previously PH 617).

Structure of the whole sequence PH 511, 618, 619 :

: PH 511 will deal mostly with ***time-independent*** problems in the wave-mechanical approach, including both exactly-solvable ones and various approximation schemes.

: PH618 will deal mainly with ***time-dependent*** problems and ***scattering theory***.

: PH 619 will contain a variety of ***special topics*** in QM which may include the following : ***theory of angular momentum***; ***abstract and most general formulation of QM due first to Dirac***; ***theory of measurement***; ***conceptual issues dealing with the foundation of QM***; ***some of the latest developments in QM such as the discovery of the Berry phase***; ***introduction to path-integral formalism; and relativistic QM***.

Objectives of PH 411/511 ECE 598 : The objectives are threefold :

: to learn QM (mainly wave mechanics) through class lectures and homework problems of its formulation in an ***axiomatic*** approach, and its application to simple physical systems of interest.

: to trace the original developments of the founding physicists (Heisenberg, Schrodinger, and Dirac) during those "glorious years" (1925-27) by completing a project (optional), the details of which are provided in the appendix of the present Lecture Notes.

: to provide a descriptive introduction to the development of an emerging discipline - the so-called "***quantum engineering*** " - referring to the design and manipulation of the nano-world (nanostructures, quantum computers...etc.).

Texts and References : Since there exists at least ***two different approaches*** in the teaching of QM : (i) the ***abstract and more general*** approach using the concept of ***state vector*** formulated in Hilbert space throughout, and (ii) the more conventional ***wave-mechanical*** approach using the concept of wave function throughout; the following list of references is divided into these two categories. Since there are tens if not hundreds of QM texts available in the market or from the library, only some selected ones will be listed. Additional information on references will be provided to students when class begins.

The abstract approach :

*J. J. Sakurai : "*Modern Quantum Mechanics* ", (Addison-Wesley, 1994)

*G. Baym : " *Lectures on Quantum Mechanics* ", (W. A. Benjamin, 1969)

R. P. Feynman et al : " *The Feynman Lectures on Physics v. 3 : Quantum Mechanics* ", (Addison-Wesley, 1965)

* These references are at a more advanced level than the one in our present course.

The "conventional approach" :

S. Gasiorowicz : " *Quantum Physics* ", (Wiley, 1996)

D. Griffiths : " *Introduction to Quantum Mechanics* ", (Prentice-Hall, 1995)

R. H. Dicke and J. P. Wittke : " *Introduction to Quantum Mechanics* ", (Addision-Wesley, 1960)

P. M. Mathews and V. Venkatesan : " *A Textbook of Quantum Mechanics* " (Tata McGraw-Hill, 1976)

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This is adopted as our text. Many homework problems will be taken from this book. Refer to the brief descriptions of some very useful references which can be found on pp. 461-465 of Gasiorowicz's book.

Note: all the three books by Gasiorowicz, Griffiths, and Dicke and Wittke are reserved in the PSU library and can be checked out for reference for a time period of 2 days.

(II) ***COURSE OUTLINE FOR PH 411/511 ECE 598*** **:**

A. FORMULATION (1) : (## Chapters 1,2,3,4,6 and appendix A)

1. Brief review of old quantum theories (1901-23) and the need for a consistent theory (a "mechanics") which treats the many diverse phenomena in one context.
2. The idea of wave-particle duality (De Broglie, 1924).
3. Mathematics of wave packets.
4. Wave mechanics (Schrodinger, 1926) and its correspondence to classical mechanics.
5. Brief remark on matrix mechanics formulated by Heisenberg, Born and Jordan in 1925.

B. APPLICATION (1) : (## Chapters 4,5,9-12)

6. Exactly solvable stationary problems :
   a. One dimensional systems.
   b. Three dimensional systems.

C. FORMULATION (2) : (## Chapters 6,7,8 and appendix B)

7. More mathematical properties of the operators and wave functions.
8. N-particle systems.

D. APPLICATION (2) : (## Chap. 16 and Special Topic 3)

9. Methods of approximation for stationary problems :
   a. Perturbation (non-degenerate case).
   b. Degenerate perturbation theory (first order).
   c. Variation.
   d. Others such as WKB, ...etc.