MACQUARIE UNIVERSITY

Department of Physics
Division of ICS

Syllabus for Quantum Physics PHYS301 2005

TEXTS

There is no prescribed text for this unit. Some of the texts worth consulting are listed below.

R. P. Feynman, R. B. Leighton, and M. Sands	*The Feynman Lectures on Physics*, Vol III
A. Das and A. C. Melissinos	*Quantum Mechanics, a Modern Introduction.*
J. S. Townsend	*A Modern Approach to Quantum Mechanics.*
C. Cohen-Tannoudji, B. Diu, and F. Laloë	*Quantum Mechanics* Two Volumes
E. Merzbacher	*Quantum Mechanics*
A. Messiah	*Quantum Mechanics* Two Volumes
J. J. Sakurai	*Modern Quantum Mechanics.*
R. L. Liboff	*Introductory Quantum Mechanics.*
P. A. M. Dirac	*The Principles of Quantum Mechanics.*

The first three books are the ones most recommended. There are many other books on quantum mechanics to be found in the library.

Web-based Material From time to time, material such as assignments, assignment solutions, additional lecture material and so on will be made available on the web at http://www.physics.mq.edu.au/˜jcresser and follow the links there.

ASSIGNMENTS

There will be three assignments handed out on the 3rd,17th and 31st May and are to be returned, in each case, a week later.

SYLLABUS

The unit extends the study of quantum mechanics first introduced in PHYS201 with the emphasis on a more general formulation of the theory. The material presented is based, principally, on the material presented in Feynman, Leighton, Sands and the text by Das and Melissinos, but other sources such as supplied lecture notes are used.

Below is a breakdown of the material that we will try to cover in $\sim$ 20 lectures (!). Quantum mechanics is a vast subject, the most successful physical theory ever devised, and we can only hope to touch on what it is, where it comes from, and what it can do.

1. Introduction: What is quantum mechanics?
2. Wave mechanics vs quantum mechanics: the need for a more general formulation of quantum mechanics.
3. The two slit interference experiment and wave mechanics revisited.
4. The Stern-Gerlach experiment. Particle spin as a purely quantum mechanical phenomenon. Random outcome of repeated experiment performed on identically prepared systems.

5. Quantum States: The Dirac Notation

   (a) The abstract notion of a state. The two slit interference experiment rerevisited: superposition of wave function amplitudes in a new notation.
   (b) The Stern-Gerlach experiment revisited: interference and superposition of spin states, rather than waves.
   (c) Vectorial interpretation: base states, orthonormality, normalization, closure, and completeness, all built around the Stern-Gerlach experiment.

6. Operations on states

   (a) The mathematical concept of an operator and its physical significance in quantum mechanics.
   (b) Matrix representation of ket vectors, bra vectors, and operators.
   (c) Hermitean and unitary operators.
   (d) Eigenstates and eigenvalues of an operator.

7. Measurements and Observables

   (a) The physical significance of Hermitean operators in quantum mechanics, the completeness postulate, orthonormality, eigenstates as basis states.
   (b) Continuous and discrete basis states. The position representation and the wave function.

8. Time evolution in quantum mechanics

   (a) A postulate for the time dependence of probability amplitudes. Stationary states, particle trapped in a double well potential.
   (b) The Hamiltonian and equation of motion of quantum mechanical states, the time evolution operator, the Hamiltonian matrix, time evolution of a two state system.

If time permits, some of the following topics may also be covered.

9. Products of operators, commutators and compatible observables.

10. Differential operator expression for momentum

$$\hat{p} = -i\hbar\frac{\partial}{\partial x},$$

    the Schrödinger wave equation..

$$-\frac{\hbar^2}{2m}\frac{\partial^2\Psi(x,t)}{\partial x^2} + U(x)\Psi(x,t) = i\hbar\frac{\partial\Psi(x,t)}{\partial t}.$$

11. The simple harmonic operator in one dimension. An illustration of how to solve the one-dimensional Schrödinger equation.

J D Cresser
12^{th} April 2005