



PHYS 3960/1 Senior Physics (Advanced) Quantum Mechanics Semester 2, 2006

This document describes details of the Advanced Quantum Mechanics module and should be read in conjunction with the Senior Physics Handbook.

GENERAL GOALS OF THIS MODULE ARE THAT YOU:

- See that quantum mechanics is much wider than the application of Schrödinger equation.
- Become familiar and are able to use operator methods.
- Be able to relate operator methods to matrix methods and unitary transformation in Hilbert space.
- Use both of these methods in a number of applications that involve angular momentum such as spectroscopy and quantum computing.
- Become familiar with some approximation methods in applications where solutions in closed form are not tractable.
- Relate this theory to its applications in atomic, molecular and nuclear physics.

REFERENCE BOOK

The textbook for the Advanced stream is *Introductory Quantum Mechanics* (Fourth Edition) by Richard L. Liboff, and all students will be expected to have access to a copy. Other useful books are: David J. Griffiths *Introduction to Quantum Mechanics second edition* Pearson/Prentice Hall 2005, R.W. Robinett *Quantum Mechanics*, Oxford University Press, 1997, which has a call number of 530.12/510, a more mathematical book is Bransden and Joachain *Introduction to Quantum Mechanics*, Longman Publishers, 1989.

WEB RESOURCES

The lecturer's notes will be available under the University's WebCT environment, which can be accessed from www.physics.usyd.edu.au/ugrad/jpc.html or the USYDnet site intranet.usyd.edu.au. Access requires a Unikey (Extro account) Username and Password that is issued with your confirmation of enrolment. The University provides computer facilities in the Access Centres www.usyd.edu.au/su/is/labs/.

ASSIGNMENTS and ASSESSMENT

There will be **two** assignments for the Quantum Mechanics module, counting a total of 25 % towards your total assessment for the module. The other 75% comes from the examination at the end of the semester.

ASSUMED KNOWLEDGE

For this module (Advanced Senior Quantum Mechanics) it is assumed that you have passed, at the intermediate level, courses that include: Quantum Mechanics, Differential and Integral Calculus, and Linear Algebra.

MODULE OUTLINE

Below are the topics that will be covered by this course. **PLEASE NOTE the numbers given in brackets are the sections in the textbook (Liboff) that cover the same material. Please read those sections.**

THE WAVE FUNCTION (2.7, 2.9, 5.1)

Normalization, The statistical interpretation, Wave packets and the uncertainty principle

PROBABILITY, EXPECTATION VALUES, AND OPERATORS (3.3, 4.5, 4.6)

Normalization, Expectation values, Uncertainty, standard deviation and root mean square), Hermitian operators.

EIGENFUNCTIONS, EIGENVALUES, AND COMMUTATORS (3.5, 5.2)

Stationary states, Commutators.

THE SCHRÖDINGER EQUATION IN THREE DIMENSIONS (9.1 - 9.3, 10.6)

Schrödinger's equation for the hydrogen atom, Solution to the three dimensional Schrödinger equation, Angular momentum

MATRIX FORMULATION OF QUANTUM MECHANICS (4.3-4.6, 11.1 – 11.10, 9.4, 9.5, 12.1, 12.2, 12.4, 10.7)

Orthonormality, Dirac's bracket notation, Matrix methods, Unitary transformation, The angular momentum matrices, Spin, Addition of angular momentum, Fine structure, Selection rules, Hyperfine interaction.

BELL'S INEQUALITY AND QUANTUM COMPUTING (11.13, 16.1 – 16.4)

The EPR paradox, Bell's theorem, The Aspect experiment, What is a measurement, Qubits, Quantum gates, The quantum computer.

APPROXIMATION METHODS (13.1 – 13.4)

First and second order perturbation theory, Zeeman Effect, Stark effect, The variational method, Application of variational method to the helium atom.

MULTIPLE PARTICLE SYSTEMS (12.3, 12.5, 12.6, 12.8)

Indistinguishable particles, Fermions and Bosons, test for distinguishability, Pauli Exclusion Principle, Slater determinant, Bose-Einstein condensation, Multielectron atoms.