PHYSICS 480 – QUANTUM MECHANICS I

Fall Semester 2014 MWF 12:30-1:20 WAT 114
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<u>Course Description:</u> Quantum mechanics, along with the theory of relativity, is one of the cornerstones of modern physics. This course comprises the first semester of senior level quantum mechanics at the University of Hawai'i. Traditionally, the pedagogy of quantum mechanics has been largely influenced by its historical development, gently converging on fundamental principles using concepts such as the wavefunction and the correspondence principle. The contemporary realization among educators is that such an approach is an ineffective way to study and apprehend the principles of quantum mechanics. The present course employs a modern approach that lays out the fundamental ideas at the outset, thus motivating the student to develop and practice a "quantum mechanical way of thinking" from the start. This approach provides much greater unity in both the understanding of quantum principles and their application to a wide range of physical problems, and lays a solid foundation for further study at more advanced levels.

<u>Primary textbook:</u> David H. McIntyre, *Quantum Mechanics, A Paradigms Approach,* Pearson Higher Ed., 2012

<u>Supplemental text:</u> James Binney & David Skinner, *The Physics of Quantum Mechanics,* Cappella Archive, 2013, available online at http://www-thphys.physics.ox.ac.uk/people/JamesBinney/QBhome.htm

<u>Course website:</u> https://laulima.hawaii.edu → PHYS-480-001 [MAN.72471.FA14] → Resources

<u>Grade distribution:</u>

Weekly assignments:	25%
Midterm examinations 1 and 2:	50%
Final examination:	25%

<u>Grade assignment:</u>

A+	90 >	B+	75–80	C+	60–65	C–	40–50
A	80–90	B	65–75	C	50–60	D/F	< 40

COURSE OUTLINE

~ Dates	Topics	Chapter
8/25–9/5	fundamentals of quantum mechanics; spin measurements; quantum state vectors and Dirac notation; basis states; quantum superposition; postulates of quantum mechanics.	QM 1
9/8–9/19	operators and linear algebra; measurement and uncertainty; commuting observables; uncertainty principle; spin operators.	QM 2
9/22–10/3	time evolution and the Hamiltonian; application to spin states; neutrino oscillations and light-matter interactions.	QM 3
October 3	*Midterm Examination #1*	
10/6–10/15	position representation and the ψ-function; position and momentum operators; the Schrodinger equation; application to bound systems and potential wells.	QM 5
10/17–10/29	unbound states; 'wavepackets' and superposition states; uncertainty principle; 'wavepacket' spreading and diffraction; tunneling; motion in three dimensions.	QM 6
November 3	*Midterm Examination #2*	
10/31–11/12	quantum harmonic oscillator; ψ-functions; Dirac notation and matrices; uncertainty principle; superposition states and time evolution; the coherent state.	QM 9
11/14–11/21	transformations and observables; symmetries and conservation laws; Heisenberg picture; repeated position/momentum measurements.	BS 4
11/24–12/8	angular momentum; eigenvalues and eigenstates; commutation relations; orbital (*L*), spin (*S*), and total (*J*) angular momentum; position representation.	BS 7 QM 7
12/10	topics in quantum measurement.	Suppl.[†]
Dec. 15–19	*Final Examination*	

Student Learning Objectives

In addition to the specific topics listed in the outline above, students are expected to have proficiency in the following general areas after completing this course:

1) a good working knowledge of the fundamental postulates of quantum mechanics.
2) the fundamental nature and significance of probability amplitudes and the analytic description of quantum states in terms of them; the concepts of Hilbert space and state vectors.
3) the significance of operators in quantum mechanics and their relation to physical observables.
4) the concept of compatible observables and the meaning and implications of the commutator.
5) the meaning of the Uncertainty Principle and its relation to Heisenberg's original gedankenexperiments.
6) the Schrodinger equation; energy eigenstates and their signficance for time evolution.
7) the quantum mechanical description of classical objects.
8) the mathematical description of observables with continuous spectra.
9) the quantum harmonic oscillator, including its energy spectrum, its time development, and the concept of the coherent state.
10) the significance of symmetry in quantum mechanics.
11) the quantum mechanical properties of angular momentum, and the fundamental similarities and differences between spin and orbital angular momentum.
12) an understanding of the concept in measurement in quantum mechanics.
13) a solid understanding and good working knowledge of advanced mathematical techniques.