FAU

FLORIDA ATLANTIC UNIVERSITY

COURSE CHANGE REQUEST
Graduate Programs

Department Physics

College Charles E. Schmidt College of Science

UGPC Approval ____________
UFS Approval ____________
SCNS Submittal ____________
Confirmed ____________
Banner Posted ____________
Catalog ____________

***Current* Course Prefix and Number** PHY 6645	***Current* Course Title** Quantum Mechanics 1

*Syllabus must be attached for **ANY** changes to current course details. See Guidelines. Please consult and list departments that may be affected by the changes; attach documentation.*
(none)

Change title to:

Change prefix
From: **To:**

Change course number
From: **To:**

Change credits*
From: **To:**

Change grading
From: **To:**

*Review Provost Memorandum

Change description to:

Change prerequisites/minimum grades to:
(none)

Change corequisites to:

Change registration controls to:

Please list existing and new pre/corequisites, specify AND or OR and include minimum passing grade.

Effective Term/Year for Changes: Fall 2019

Terminate course? Effective Term/Year for Termination:

Faculty Contact/Email/Phone Chris Beetle <cbeetle@fau.edu> 7-4612

Approved by		***Date***
Department Chair	[signature]	3/12/19
College Curriculum Chair	[signature]	3/12/19
College Dean	[signature] Bob Stackman 2019.03.12 09:26:48 -05'00'	
UGPC Chair		
UGC Chair		
Graduate College Dean		
UFS President		
Provost		

Email this form and syllabus to UGPC@fau.edu one week before the UGPC meeting.

GRADUATE COLLEGE
MAR 12 2019
Received

Spring 2019 **Quantum Mechanics I**

Physics (PHY) 6645
3 credit hours
11:00 – 12:50 TΘ
Science & Engineering 319A

Course Web Site https://canvas.fau.edu/courses/59857

Instructor

Prof. Chris Beetle
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cbeetle@fau.edu

Office hours: by appointment.

Required Text

- J.J. Sakurai and J. Napolitano. *Modern Quantum Mechanics*, 2nd Edition. (Cambridge, 2017.) ISBN 978-1-108-42241-3.

This is the first in a sequence of two courses on introductory quantum mechanics for graduate students. The goal of the course is to establish a sound foundation in quantum theory generally, and non-relativistic quantum mechanics specifically, as a basis for future work in subsequent courses and in research.

The material covered in this course forms the basis for one component of the Physics Department's annual Candidacy Exam for admission to its Ph.D. program. Students receiving a final grade of A (or A-) in this course will be exempted from that component of the Candidacy Exam.

Prerequisite Background

While this course is largely self-contained, students will likely benefit from a sound understanding of several topics usually covered in undergraduate courses on quantum mechanics and modern physics:

- non-relativistic wave mechanics in one or more dimensions,
- eigenvalue problems for matrices and differential operators, and
- Fourier analysis and special functions, including spherical harmonics.

Any student who is concerned about his or her preparation for this course should meet with me as early in the semester as possible to discuss the matter.

Course Description and Objectives

This course will aim to cover the following topics:

- principles of quantum kinematics and dynamics,
- the quantum theory of angular momentum,
- continuous and discrete symmetries in quantum mechanics,
- perturbation theory and other approximation methods,
- non-relativistic scattering theory, and
- (time permitting) multi-particle quantum systems.

The course will follow a traditional lecture format, with an emphasis on solving specific problems. Computer demonstrations will be used if and when possible. A detailed course schedule is attached, which includes due dates for homework assignments and exams.

The objectives of the course are threefold. It will help students prepare for the Physics Ph.D. Candidacy Exam. It will provide the essential foundation needed for more advanced courses in the Physics Ph.D. curriculum. Finally, and most importantly, it will cover the basic background needed for contemporary physics research.

Evaluation

Grades in this course will be calculated using a weighted curve based on several factors:

- 15% – class participation.

  At least one student volunteer will serve as a recording secretary during each lecture. That student will scan his or her notes from the lecture and upload them to the course's Canvas site. The goal of this approach is to free the rest of the students to engage more actively and ask questions. Asking and answering questions during class will also contribute to this component of the overall course grade.

- 35% – homework assignments

  There will be approximately ten homework assignments due at various times during the semester. A preliminary schedule of due dates is attached. Each student's solutions will be graded based on completeness, clarity, and correctness. Please note that illegible or poorly organized work will be returned ungraded.

  Students are allowed, and indeed encouraged, to discuss and collaborate on solving the homework problems. But no copying, either from other students or from other sources, is allowed on the solution sets submitted for grading.

- 50% – three (equally weighted) in-class exams.

  Two midterm exams will be held during special, 2.5-hour sessions outside of the normal class schedule. We will fix the exact times of these sessions during the first week of class. I have chosen the in-class exam format because it most closely resembles the format of the Ph.D. Candidacy exam.

  The third exam will be held at the end of the term, during the period scheduled by the University, on **Tuesday, April 30 from 10:30 AM to 1:00 PM.**

  Collaboration on exams is not allowed.

Course Policies

Late Assignments

All assigned coursework must be ready at the *beginning* of the lecture on the date it is due. If a student has a family emergency or illness, he or she may request an individual extension *by email at least twenty-four hours before* the assignment is due. I reserve the right to approve or deny such requests at my discretion. Exceptions can also be made for students' participation in University-approved activities and religious observances. Please advise me of any such conflicts.

Extra Credit

No extra credit will be offered.

Collaboration on Assigned Coursework

Students are encouraged to collaborate on homework assignments. Copying is not allowed. Collaboration on the exams is also not allowed.

Incomplete Grades

Grades of Incomplete (I) are reserved for students who are passing the course, but unable to complete all assigned course work on time due to exceptional circumstances such as those outlined above for late assignments. Unless such circumstances can be documented, work not completed at the end of the semester will be assessed as a zero in the final grades.

Important Dates

- Around Tuesday, February 5 — Midterm Exam I.
- Tuesday, March 5 — No class due to Spring Break.
- Thursday, March 7 — No class due to Spring Break.
- Around Tuesday, March 19 — Midterm Exam II.
- Tuesday, April 23 — Optional review session at the normal class time.
- Tuesday, April 30 — Final Exam from 10:30 AM to 1:00 PM.

Attendance Policy Statement

Students are expected to attend all of their scheduled University classes and to satisfy all academic objectives as outlined by the instructor. The effect of absences upon grades is determined by the instructor, and the University reserves the right to deal at any time with individual cases of non-attendance.

Students are responsible for arranging to make up work missed because of legitimate class absence, such as illness, family emergencies, military obligation, court-imposed legal obligations or participation in University-approved activities. Examples of University-approved reasons for absences include participating on an athletic or scholastic team, musical and theatrical performances and debate activities. It is the student's responsibility to give the instructor notice prior to any anticipated absences and within a reasonable amount of time after an unanticipated absence, ordinarily by the next scheduled class meeting. Instructors must allow each student who is absent for a University-approved reason the opportunity to make up work missed without any reduction in the student's final course grade as a direct result of such absence.

Disability Policy Statement

In compliance with the Americans with Disabilities Act Amendments Act (ADAAA), students who require reasonable accommodations due to a disability to properly execute coursework must register with Student Accessibility Services (SAS) and follow all SAS procedures. SAS has offices across three of FAU's campuses – Boca Raton, Davie and Jupiter – however disability services are available for students on all campuses. For more information, please visit the SAS website at www.fau.edu/sas/.

Counseling and Psychological Services (CAPS) Center

Life as a university student can be challenging physically, mentally and emotionally. Students who find stress negatively affecting their ability to achieve academic or personal goals may wish to consider utilizing FAU's Counseling and Psychological Services (CAPS) Center. CAPS provides FAU students a range of services – individual counseling, support meetings, and psychiatric services, to name a few – offered to help improve and maintain emotional well-being. For more information, go to http://www.fau.edu/counseling/.

Code of Academic Integrity Policy Statement

Students at Florida Atlantic University are expected to maintain the highest ethical standards. Academic dishonesty is considered a serious breach of these ethical standards, because it interferes with the university mission to provide a high quality education in which no student enjoys an unfair advantage over any other. Academic dishonesty is also destructive of the university community, which is grounded in a system of mutual trust and places high value on personal integrity and individual responsibility. Harsh penalties are associated with academic dishonesty. For more information, see University Regulation 4.001.

Date	Lecture Topic	Reading
	Quantum Mechanics I (PHY 6645)	
Tue Jan 8	**Quantum Mechanics of Two-State Systems** ▶ The Stern–Gerlach experiment ▶ Quantum states ▶ Quantum measurement ▶ Quantum observables • Outlook	Chapter 1
Thu Jan 10	**Mathematical Structure of Quantum Theory** ▶ States: Hilbert space ▶ Measurements: Projections and bases ▶ Observables: Operators and eigenstates ▶ Transformations: Unitary operators ▶ Application to spin-½ systems	
Tue Jan 15	**Examples from Wave Mechanics** *Problem Set I Due* • Particle in a box • Free particle • Scattering from a δ-function well • Infinite-dimensional Hilbert spaces	
Thu Jan 17	**Schrödinger Representation** • Position representation • Momentum as the generator of translation • Momentum representation • Canonical commutation relations • Gaussian wave packets	
Tue Jan 22	**Quantum Dynamics** *Problem Set II Due* • Unitarity and the Schrödinger equation • Schrödinger and Heisenberg pictures • Ehrenfest theorems • Transition amplitudes	Chapter 2
Thu Jan 24	**Simple Harmonic Oscillator** • Energy spectrum • Raising and lowering operators • Time evolution • Coherent states	
Tue Jan 29	**Applications of Wave Mechanics** *Problem Set III Due* • The wave function • Probability density and flux • Solvable models in wave mechanics • WKB approximation • Propagators and path integrals	

Date	Lecture Topic	Reading
Thu Jan 31	▼ **Coupling to External Potentials** • Electromagnetism and gauge transformations • Coupling to a magnetic field • The Aharonov–Bohm effect • Monopoles and gauge covariance	
Tue Feb 5	▼ **Review Session** *Problem Set IV Due* *Midterm Exam I (Evening, Chapters 1 & 2)*	
Thu Feb 7	▼ **Rotations and Angular Momentum** • Infinitesimal rotations and angular momentum • Weyl spinors • SO(3) and SU(2) • Euler angles	**Chapter 3**
Tue Feb 12	▼ **Ensemble states** • Mixed states • Density matrices • Time evolution of mixed states • Quantum statistical mechanics	
Thu Feb 14	▼ **Representations of the Rotation Group** • Ladder operators • Angular momentum eigenstates • Matrix representations • Wigner functions	
Tue Feb 19	▼ **Central Potentials** *Problem Set V Due* • Spherical harmonics • The radial wave equation • The spherical well • The isotropic oscillator • The Coulomb potential	
Thu Feb 21	▼ **Angular Momentum Addition** • Tensor product representations • Clebsch–Gordan coefficients • Recursion relations • Examples • Schwinger's oscillator model	
Tue Feb 26	▼ **Tensor Operators** • Vector and tensor operators • Addition of three angular momenta • The Wigner–Eckart theorem • Reduced matrix elements	

Date	Lecture Topic	Reading
Thu Feb 28	▼ **Symmetries in Quantum Mechanics** *Problem Set VI Due* • Symmetries, conservation, and degeneracy • SO(4) symmetry of the Coulomb problem • Parity reversal • Parity eigenstates	**Chapter 4**
Tue Mar 5	• **(No Class due to Spring Break)**	
Thu Mar 7	• **(No Class due to Spring Break)**	
Tue Mar 12	▼ **Discrete Symmetries** • Selection rules • Parity non-conservation • Discrete translation symmetries • Bloch's theorem	
Thu Mar 14	▼ **Time-Reversal Symmetry** • Anti-unitary transformations • Time reversal in wave mechanics • Time reversal for spin systems • Interactions with electromagnetic fields	
Tue Mar 19	▼ **Review Session** *Problem Set VII Due* *Midterm Exam II (Evening; Chapters 3 & 4)*	
Thu Mar 21	▼ **Time-Independent Perturbation Theory** • The perturbation expansion • Perturbed eigenvalues and eigenstates • Non-degenerate examples • Degenerate case	**Chapter 5**
Tue Mar 26	▼ **Hydrogen-Like Atoms** • Relativistic corrections • Spin-orbit coupling and fine structure • Zeeman effect in a magnetic field • van der Waals interaction	
Thu Mar 28	▼ **Other Approximation Methods** • Variational method • Interaction picture for time-dependent potentials • Nuclear magnetic resonance • Sudden and adiabatic approximations • Berry's phase	

Date	Lecture Topic	Reading
Tue Apr 2	▼ **Time-Dependent Perturbation Theory** *Problem Set VIII Due* • The Dyson series • Transition probabilities and rates • Absorption and stimulated emission • Dipole approximation • Energy shift and decay width	
Thu Apr 4	▼ **Scattering Theory** • Transition rates and cross-sections • The Lippman–Schwinger equation • The optical theorem • The Born approximation	**Chapter 6**
Tue Apr 9	▼ **Scattering Expansions** *Problem Set IX Due* • Partial wave expansion • Unitarity and phase shifts • Hard spherical scattering • Eikonal approximation	
Thu Apr 11	▼ **Scattering Approximations** • Low-energy scattering and bound states • Resonance scattering • Symmetry considerations • Inelastic scattering from atoms	
Tue Apr 16	▼ **Identical Particles** *Problem Set X Due* • Multi-particle systems • Permutation symmetries • Bosons and Fermions • Exchange energy • The Helium atom	**Chapter 7**
Thu Apr 18	▼ **Many-Particle Systems** • Second quantization • Degenerate electron gas • Quantizing the electromagnetic field • The Casimir effect	
Tue Apr 23	▼ **Optional Review Session (Reading Day)** *Problem Set XI Due*	
Tue Apr 30	▼ **Final Exam Period (1:15 – 3:45)** *During Class (Chapters 5, 6 & 7)*	