Physics 660 – Quantum Mechanics I – Fall 2023

Instructor: Prof. S. Martin email: `spmartin@niu.edu` office: 214 LaTourette

Class Meetings: M,W,F 10:00 – 10:50 in LaTourette 227.

Contingency: If it becomes necessary for one or more lectures to go online, they will be on Zoom, at a Meeting ID provided by email to registered students, and recorded and available on youtube within a few hours. If you haven't already done so, please make sure now that you have a Zoom client installed and tested on your favorite device. In-person lectures will not be recorded. You may also be interested to know that the 2020 lectures for this class are all available on youtube (search for "PHYS660 NIU Fall 2020").

Office Hours: Immediately after class, or on Zoom by appointment (short notice is fine). Do not hesitate to send email at any time requesting an Office Hours meeting. If I am available, it can happen immediately, or we can schedule it.

Course web page: `http://www.niu.edu/spmartin/phys660`
There is no Blackboard web page for this course. Everything relevant will be either sent to you by email, or linked to on the web page above, in pdf form.

Textbook: Typeset notes in pdf form, which will be sent to you (free!) by email on the first day of class. These notes will have a clickable table of contents, index, and equation numbers. Please do not distribute them to anyone. No other textbook is required.

Homework policies: Each homework set should be turned in by email as a single pdf file. NIU's copy machines provides a convenient way to scan your homeworks and have them automatically emailed to you. (The file size and quality will usually be much better than if you take a picture on your phone.) Please be neat and legible, and leave enough space for grading notes and corrections. No paper submission of homeworks will be accepted. Show your work! Neatness, organization, and clarity count! Homework should be turned in by midnight on the due date. Late penalty: 10% off for each day late up to 4 days; 100% off for > 4 days. You are encouraged to consult with each other, and with me, on the homework. **However, each of you must turn in only your own work. Do not turn in anything that you have copied, or anything that you do not understand. Do not use ChatGPT, Chegg, or any similar services, or send any materials from this course to such services, or get homework solutions from anyone outside or inside of NIU who may have previously taken this course or its equivalents at other institutions. The notes, homework sets, and exams for this class should not be distributed to, or discussed with, anyone other than your peers in this class and your instructor.**

Exam policies: Exams will be closed book, but you may bring one page of notes in your own original handwriting, and you will be given a formula sheet for coordinate systems and vector derivatives when necessary. No electronic devices are allowed.

Midterm 1 Exam: Monday, October 9, 2023, 10:00-10:59 AM.
Midterm 2 Exam: Friday, November 10, 2023, 10:00-10:59 AM.
Final Exam: Monday, December 11, 2023, 10:00-11:59 AM.

Extra Credit: For each substantive mistake in the class textbook that you find and report before I do, you will receive 2 extra percentage points on your final grade, up to a maximum of 6 points. (Grammar and punctuation corrections will be much appreciated, but usually won't count for an extra point unless you report more than one.) The first student to report the mistake gets the point. If more than one of you finds the mistake in collaboration, you can choose to split the point. Corrections to the notes will be collected and posted on the course web page in real time.

Grading: Your numerical score in this class is weighted according to 30% homework, 20% for each midterm exam, 30% final exam. Grades will be assigned according to your numerical score as a percentage, with the low cutoff for each grade as follows:

A 89%,	A− 85%,	B+ 82%,
B 77%,	B− 73%,	C+ 66%,
C 55%,	D 45%.	

I reserve the right to amend the above grading scale to be more lenient, but it is guaranteed not be made more strict. To obtain a D or better, you **must also** score at least 50% on the homework portion alone, regardless of your overall score; this requirement will not be changed. No C− or D+ or D− grade will be assigned.

General Suggestions: It is very strongly suggested that you do attend class and take notes. Do not suffer in silence; if you are stuck, please arrange for office hours by Zoom. Keep up with the reading and the homework. The best way to prepare for exams is to study homework problems and the concepts that they involve. Stay healthy!

Accessibility Statement: If you need an accommodation for this class, please contact the Disability Resource Center as soon as possible. The DRC coordinates accommodations for students with disabilities. It is located on the 4th floor of the Health Services Building, and can be reached at 815-753-1303 or `drc@niu.edu`. Also, please contact me privately as soon as possible so we can discuss your accommodations. Please note that you will not be required to disclose your disability, only your accommodations. The sooner you let me know your needs, the sooner I can assist you in achieving your learning goals in this course.

Topics to be covered in PHYS 660:

- Experimental necessity of quantum mechanics; non-classical features of our world
  - Classical instability of charged matter
  - Black-body radiation and Planck's constant
  - Photo-electric effect and particle-like features of light
  - Electron diffraction and wave-like features of matter
- Mathematical tools
  - Complex linear vector spaces
  - Inner products, Hilbert spaces, and orthonormal bases
  - Dual vector spaces
  - Operators
  - Matrix representation in an orthobasis
  - The Eigenvalue problem
  - Observables
  - Wavefunctions

  - Tensor product Hilbert spaces

- Core principles of quantum mechanics
  - The six basic postulates: states, observables, allowed results of measurements, probabilities of results of measurements, collapse of the state due to measurement, and Schrödinger's equation
  - Valid and invalid questions
  - Solving the time evolution of states

- Coordinate transformation operators and symmetries
  - Translations
  - Parity
  - Rotations

- Particle moving in one dimension
  - Gaussian wavefunctions
  - Time evolution of free particle states in one dimension
  - Properties of stationary states in one-dimensional potentials
  - Particle in a one-dimensional box
  - Bound states for the one-dimensional square well

- Harmonic oscillator
  - Position and momentum representations: the differential equations approach
  - Energy representation: the algebraic approach
  - Coherent states of the harmonic oscillator
  - Anisotropic three-dimensional oscillator

- Angular momentum and its representations
  - The eigenvalue problem for angular momentum
  - $j = 1/2$ representation and spin
  - $j = 1$ representation
  - Matrix representation for arbitrary j
  - Matrix representation for unitary rotation matrices
  - Orbital angular momentum representation in spherical coordinates

- Examples with spherical symmetry
  - Stationary states with spherical symmetry
  - Free particle in spherical coordinates
  - Particle confined to a sphere
  - Particle in a spherical potential well
  - Isotropic three-dimensional harmonic oscillator
  - Coulomb potential and hydrogen-like atoms

- Addition of angular momentum
  - Statement of the problem
  - Addition of $j_1 = 1/2$ and $j_2 = 1/2$
  - Addition of orbital angular momentum and spin 1/2
  - The general case and Clebsch-Gordon coefficients