PHYS 4380 Quantum mechanics I Syllabus

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Office hours For outside classroom discussion you can see me during office hours: T-R 02:30-03:30 pm, WF 11:00am-01:30pm or *by appointment*.

Text **A Modern Approach to Quantum Mechanics** (2nd Edition) by John S. Townsend, University Science Books (2012) (ISBN 978-1-891389-78-8) is the required textbook for this course.

Additional Materials In preparing my teaching material that I use in the classroom and available at https://www.mtsu.edu/faculty/derenso/docs/Theoretical-Physics-IV/Theo-Phys-Part-IV-Quan-Mech.pdf, I refer to more other quantum mechanics books and some free online resources. The following are some quantum mechanics books that I use as additional references. Some of these books are classic quantum mechanics textbooks that still have been used in some universities.

Comparable to this course

- Stephen Gasiorowicz, *Quantum Physics*.
- David J. Griffiths, *Introduction to Quantum Mechanics*.
- C. Cohen-Tannoudji, B. Diu, F. Laloe, *Quantum Mechanics*.
- Liboff, *Introductory Quantum Mechanics.*
- Merzbacher, *Quantum Mechanics.*
- Shankar, Ramamurti, *Principles of Quantum Mechanics*.
- J.-L. Basdevant and J. Dalibard, Quantum mechanics.
- B. Reed, *Quantum Mechanics*.
- Feynman, Richard P., Robert B. Leighton, and Matthew L. Sands. *The Feynman Lectures on Physics*.

More advanced than this course

- L. D. Landau and L. M. Lifshitz, Quantum Mechanics: Non-Relativistic Theory.
- Sakurai, Modern Quantum Mechanics.
- Sakurai, Advanced Quantum Mechanics.

Purpose To provide physics majors (or chemistry and mathematics majors with sufficient mathematics and physics background) with a strong and relevant introduction to quantum theory. The approach taken in this course is unusual in that the first half of the course will deal exclusively with discrete (usually two) level systems. It is within the framework of these relatively simple systems that the conceptual and procedural development of the theory will take place, thereby (hopefully!) addressing the nationally acknowledged problem of a lack of conceptual understanding of the quantum theory among students who have completed a course in quantum mechanics. The second half of the course goes on to include a more traditional approach to the subject.

Grading The course grade will be determined by your performance on the homework assignments and the exams.

Homework	**30%**	**Grade**	**A**	**B$^+$**	**B**	**B$^-$**	**C$^+$**	**C**	**C$^-$**	**D$^+$**	**D**	**D$^-$**	**F is**
Midterm exam	**35%**	**Min Score**	**90**	**87**	**83**	**80**	**77**	**73**	**70**	**67**	**63**	**60**	**< 60**
Final Exam	**35%**												

Participation & grading *The grading scale is fixed. However, there will be additional 0-3 points that will be added to your final score depending on your full attendance (that also include coming to class on time) and active participation in class. There will be an attendance sheet that you need to sign on at the beginning of each class.*

Homework There will be a weekly homework assignment. Homework assignments will be distributed in class or posted on the course website and it will be due on the following week. Each homework

assignment consists of at least five problems. ***You are required to work out and submit at least two problems. Submitting the solutions to all the problems assigned in each homework set will impact the extra 0-3 points that will be added to your final grade.*** The lowest homework score will be dropped. To be accepted, homework has to be readable and understandable. Here, I list some ingredients that make a homework useful to you and also easy to read and grade for me:

- Work out the details and fully explain your line of reasoning. This is the only way to fully test and show your understanding of the technicalities and of the concepts.
- Highlight your final results.
- Always check that the final result makes sense physically, i.e. whether it has the correct physical units and, if it is a numerical result, the correct order of magnitude.
- The solution of each problem ***must*** be presented according to the order assigned in the homework. You must also begin the solution to each problem on a new page. ***Never use the back pages!***
- You ***must*** turn the complete solutions of each homework assignment along with the cover page.

If the steps of the solution of a problem are not readable, credit will not be given although the final result seems to be right.

In addition to the regular problem sets, I may list additional optional problems or some links to other sources of problems, some with solutions –Doing problems is the best way to learn physics and to develop great analytical skills that you will need in tackling physical or none physical problems. That is why physicists (problem solvers) recruited to work in many none physics related sectors and be successful.

- **Due date**: HW problems are due at the beginning of class (at 01:00 pm), one week after the HW problem set is assigned. No mercy will be granted on the due date and time. Remember, I give partial credit, so the last 10 minutes of work will not make much difference.
- **Late policy**: Problem sets will be accepted up to three days late at the due date for 50% credit, and after that not at all. You may turn in part on-time and part late. Please make a note in the space provided on the problem set cover page if it is being split this way. You do not need to contact me to turn in a problem set late at 50% credit, or to turn in part on-time and part late.
- **Extensions**: You will have one full-credit one-week extension for this semester. No need to contact me just write it on your problem set. Otherwise, extensions will be granted for good reasons only- **physical or mental health issues, family emergency, etc**. You must contact me before the homework is due and you must provide some sort of proof (e.g., note from health center, counseling center). A heavy amount of other coursework is not sufficient reason for an extension (though you may use your free extension in such circumstances - so save it until you really need it!).
- **Solutions**: Solution sets to each HW assignment will be posted on the course website. Graded problem sets will be returned to you in class roughly one week after they are due. If you are absent, you must pick it from outside my office in one week period. After one week you will not be able to get it as I often recycle unwanted papers. You should keep a copy of your homework sets so you can review them with the solutions.
- **Collaboration**: Collaboration is permitted on homework assignment, but each student's solution must be the result of his or her own understanding of the material. You must use collaboration work carefully. If you rely on your colleagues too much, you will do poorly in the fixed-time, independent in class exam environment. I have observed that students with good exam scores tend to also have done well on homework, but that good homework scores do not predict good exam scores.

- **Mathematical software**: Use of mathematical software like Mathematica is allowed, but will not be available for exams. When it comes to using mathematical software, I would like to quote a professor of physics: "***It is absolutely essential that you develop a strong intuition for basic calculations involving linear algebra, differential equations, and the like. The only way to develop this intuition is by working lots of problems by hand; skipping this phase of your education is a really bad idea***."

Exams

There will be a midterm exam worth 35% and a final exam worth 35%. The tentative schedule for the midterm (in class & take-home) is ***Wednesday October 11, 2018.*** The final exam would be ***comprehensive and it also has in class & take-home portions. The take-home portion*** will be distributed in class on ***Tuesday December 04, 2018 and is due at beginning of in-class final exam portion which will be on Thursday December 12, 1:00 - 3:00 p.m.*** All in class exams will be closed-book.

Dropping

It is the policy of the Department of Physics & Astronomy that no drops will be approved after the deadline posted in the university's course Schedule Book. The deadline for dropping ***without a grade*** for this semester is ***September 09, 2018.*** Deadline for students to drop a course with a grade of "W" is ***October 31, 2018.***

Disabilities

If you have a disability that requires assistance or accommodation, or if you have questions related to any accommodations for testing, note takers, readers, etc, please speak with me as soon as possible. Students may also contact the Office of Disabled Students Services (898-2738) with questions about services.

Lottery Scholarship

To retain Tennessee Education Lottery Scholarship eligibility, you must earn a cumulative TELS GPA of 2.75 after 24 and 48 attempted hours and a cumulative TELS GPA of 3.0 thereafter. You may qualify with a 2.75 cumulative GPA after 72 attempted hours (and subsequent semesters), if you are enrolled full-time and maintain a semester GPA of at least 3.0. A grade of C, D, F, or I in this class may negatively impact TELS eligibility. Dropping a class after 14 days may also impact eligibility; if you withdraw from this class and it results in an enrollment status of less than full time, you may lose eligibility for your lottery scholarship. Lottery recipients are eligible to receive the scholarship for a maximum of five years from the date of initial enrollment, or until a bachelor degree is earned. For additional Lottery rules, please refer to your Lottery Statement of Understanding form (http://www.mtsu.edu/nancial-aid/forms/LOTFOD.pdf) or contact your MT One Stop Enrollment Counsel or (http://www.mtsu.edu/one-stop/counselor.php).

Academic Honesty

Academic misconduct will not be tolerated in the Department of Physics and Astronomy. Offenses include, but are not limited to: Plagiarism, Cheating, Fabrication, and Facilitation. Instances of academic misconduct will, at a minimum, result in a zero for the assignment in question, followed by submission of a formal complaint to the Office of Judicial Affairs. If signs of cheating are detected or observed, all parties involved (copiers and facilitators) will receive a grade of zero and be included in the report. There will be no exceptions, all instances will be reported. Details regarding MTSU and TBR policy, including definitions for the offenses listed above, are available at http://www.mtsu.edu/juda_/integrity.php.

IX Statements

1. Students who believe they have been harassed, discriminated against or been the victim of sexual assault, dating violence, domestic violence or stalking should contact a Title IX/Deputy Coordinator at 615-898-2185 or 615-898-2750 for assistance or review MTSU's Title IX website for resources. http://www.mtsu.edu/titleix/
2. MTSU faculty are concerned about the well-being and development of our students and are legally obligated to share reports of sexual assault, dating violence, domestic violence and stalking with the University's Title IX coordinator to help ensure student's safety and welfare. Please refer to MTSU's Title IX site for contact information and details. http://www.mtsu.edu/titleix/

Personal electronic devices

Cell phones, laptops, i-Pads, Kindles, and other electronic devices must be turned off and put away during class unless the instructor determines and communicates that these devices are allowed to be used in the class. If so allowed, you may be directed to turn off any device if it is not being used for class purposes. You are not permitted to take photos or record any part of a class/lab/other session unless explicitly granted permission by the instructor or the MTSU Disability Access Center. Sanctions for violation of this policy may include dismissal from the class, attendance penalties or loss of class participation points, failure in the class, or other penalties that the instructor determine to be appropriate.

Topics

1. Review of relevant topics
• Vectors and Dirac notation
• Orthogonal matrices, the rotational operator, and Dirac notation
• Eigenvalues and Eigenvectors
• The state vector, average, and standard deviation
• Magnetization, Magnetic moment, angular momentum, and spin
2. Stern-Gerlach Experiments
• The Original Stern-Gerlach (SG) Experiment
• Virtual experiment by SG device
• The spin quantum state vector and generalization to physical observable
3. Rotation of Basis States and Matrix Mechanics
• Matrix representation of the state vector
• Rotation Operators
• The identity and Projection operators
• Matrix Representation of Operators
• Changing representations...It is all about the completeness relation
• Expectation values
• Photon Polarization and the Spin of the photon
4. Angular Momentum
• Commutation relations for the rotation operators
• None commuting operators and the uncertainty principle
• Commuting operators and the eigenstates
• Angular momentum eigenvalue equation
5. Time evolution of a quantum system
• The evolution operator, the quantum Hamiltonian, and the Schrödinger equation
• Schrödinger, Heisenberg, and interaction pictures
• A quantum system of two interacting particles (spin-1/2 particle)-
6. Wave mechanics in one dimension
• Plane waves and wave packets
• The Schrödinger equation; the probability Interpretation of the wave function
• Expectation values and the momentum in a wave mechanics
• The Heisenberg equation and Newton's second law (classical limit)
• The time-independent Schrödinger equation and classic one-dimensional problems
7. The harmonic oscillator
• From classical to quantum Harmonic oscillator
• The Harmonic oscillator in terms of the "ladder operators"
• Back to Schrodinger equation
8. Orbital Angular Momentum
• Angular Momentum operators, angular momentum eigenvalue equation
• Representation of the eigenstates in spherical coordinates
9. The Schrödinger Equation in Three Dimensions and the Hydrogen Atom
• The Schrödinger Equation and the angular momentum
• The Hydrogenic atom