PHYS 4390 Quantum mechanics II Syllabus

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Office hours For outside classroom discussion you can see me during office hours: MF 11:00am-12:40pm, TR 02:30-03:30pm 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).

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*.
- W. Grieiner, *Relativistic quantum mechanics*

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.

Topics Topics will include both non-degenerate and degenerate perturbation theory with applications to atomic physics, an introduction to Quantum Field Theory, scattering, relativistic quantum mechanics, and if time permits we will be introduced to quantum informatics (quantum entaglement, quantum teleportation, and quantum computation).

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%**												
Final Exam	**35%**	**Min Score**	**90**	**87**	**83**	**80**	**77**	**73**	**70**	**67**	**63**	**60**	**< 60**

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 earn you a special consideration at the end of the samester.*** 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 on the due date.

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 a traditional in class fixed-time, independent 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 remember in any in-class fixed-time exams in the future (e.g. PhD qualifying exams in

graduate school) such mathematical tools will not be available. When it comes to using mathematical software, I would also 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%. Both exams will be take-home exams. The tentative schedule for the midterm exam is on ***Tuesday February 14, 2019 and the*** final exam on ***Tuesday April 23, 2019.***

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 ***January 27, 2019.*** Deadline for students to drop a course with a grade of "W" is ***March 24, 2019.***

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.

L	D	Date	Topics	
			In my note	**In textbook**
			Chapter 10: Orbital angular momentum and hydrogenic atoms	**Chap 9:8&9**
1	T	15 JAN	Classical and quantum orbital angular momentum	
2	H	17 JAN	Representation of the eigenstates in spherical coordinates	
3	T	22 JAN	The Schrödinger Equation and the angular momentum	
4	H	24 JAN	The Hydrogenic atom	
			Chapter 11: Time-Independent Perturbation Theory	**Chap 11:1-7**
5	T	29 JAN	Nondegenerate perturbation theory	
6	H	31 JAN	Degenerate perturbation theory	
7	T	05 FEB	Applications: The Stark effect, -the real Hydrogen-like atom, and the Zeeman effect	
			Chapter 12: Many-particle systems	**Chap 12:1-3**
8	H	07 FEB	Many particle system Schröudinger equation; the two-particle system	
9	T	12 FEB	Identical particles, the exchange operator, the Pauli principle	
10	H	14 FEB	The Helium atom-a two-fermion system: Perturbative approach and the Variational approach.	
			Chapter 13: Quantum field theory	**Chap 9: 1-9**
11	T	19 FEB	Time dependent perturbation theory, Electromagnetic waves in vacuum	
12	H	21 FEB	Canonical Quantization of the transverse field	
13	T	26 FEB	States of the electromagnetic field	
			Chapter 14: Quantum description of charge-field interaction	**Chap 9:1-9**
14	H	28 FEB	Classical to quantum approach; The dipole Approximation	
Spring break				
14	T	12 MAR	Atom-field interaction Hamiltonian	
15	H	14 MAR	A single two-level atom and single mode field interaction	
			Chapter 15: Scattering	**Chap 13:1-3**
16	T	19 MAR	Expression of the Cross section	
17	H	21 MAR	The Born Approximation	
18	T	26 MAR	An example of the Born approximation: The Yukawa Potential	
			Chapter 16: Introduction to relativistic quantum mechanics	**Chap 1 & 2:** W. Grieiner, *Rel.qua.mech*
19	H	28 MAR	The basics in theory of relativity	
20	T	02 APR	Relativistic wave equation for spin-0 particles-*the Klein-Gordon equation*	
21	H	04 APR	Relativistic wave equation for spin-1/2 particles-*the Dirac-equation*	
			Chapter 17: Intro to quantum information and quantum computation	
22	T	09 APR	Quantum bits and quantum entanglement, and the Bell states-EPR pairs	
23	H	11 APR	Single Qubit gate, Multiple Qubit, Quantum Circuits	
24	T	16 APR	The no-cloning theorem	
25	H	18 APR	Quantum Teleportation and fidelity	
26	T	23 APR	Entanglement quantitation; Quantum theory of a photon beam splitter;	