

# SYLLABUS - PHYS 460 [PHYS 560] Quantum Mechanics (3 unit) Fall 2016

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*Northern Illinois University*

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Class meets - MonWedFri at 10:00-10:50 am in LaTourette Hall 227

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<http://sites.google.com/site/profcthompson/home>

<http://www.niu.edu/cthompson>

Office hours - Monday 11:00am-12:30pm, but preferred arrangement is by appointment.

Textbook -

Useful references for the course - see section II C.

In-Class Midterm will be scheduled Wednesday October 12.

Final in-class exam is Monday December 5, 10-11:50 a.m., Final is cumulative.

This syllabus is a guide. Every attempt is made to provide an accurate overview of the course. However, circumstances and events may make it necessary for the instructor to modify the syllabus during the semester. Changes to the syllabus will be noted on the course web page, and/or by announcements in class.

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## I. CLASS INFORMATION AND CONTEXT

Catalog descriptions:

**PHYS 460 [560]. Quantum Physics (3 credit):** *Schrodinger wave equation, eigenvalues and eigenfunctions, methods of approximation and applications to the square well, the harmonic oscillator, and hydrogen-like atoms. PRQ 460: PHYS 300 and PHYS 370 and PHYS 383. [PRQ 560: PHYS 300 and PHYS 370, or consent of department.]*

**PHYS 461[561] Modern Physics (3 credit).** *Applications of quantum physics to atoms, molecules, solids, nuclei, and elementary particles. PRQ 461: PHYS 460 or consent of department. [PRQ 561: PHYS 560 or consent of department.]*

The two semester course (PHYS 460 and PHYS 461) is the senior-level undergraduate course of quantum for physics majors. The first semester is required for the professional physics emphasis, **strongly recommended** for the other emphases (applied physics and physics education). PHYS 460(461) meets simultaneously with PHYS 560 (561) (grad credit).

Graduate level course PHYS 560(561) is suitable as a good quantum physics course for interdisciplinary studies (math, chemistry, engineering). It also is suitable for graduate students needing a refresher course before tackling the standard graduate PHYS 660/661 quantum sequence required for the MS and PhD physics degrees.

Lectures for PHYS 460(461) meet at same time as for PHYS 560(561). The expectation for the graduate credit course is that the student develops and demonstrates a deeper and more sophisticated mastery of the topics. To achieve this and to assess this, additional selected advanced problems on the homework are required for graduate credit. The tests and quizzes for PHYS 560/561 will incorporate subsets that include more advanced problems.

## II. TOPICS AND RESOURCES

### A. PHYS 460 [PHYS 560] typical topics

- momentum and position, operator notation
- Eigenstates, eigenfunctions, and how they apply
- Hermitian operators, hermiticity in operator and integral notation
- Schrodinger equation and its use in 1 D (and some 3D)
- Bound systems such as simple harmonic oscillator, square well (infinite and finite)
- solutions in transport systems
- 3D potentials - central force
- angular momentum (orbital) - operator and differential treatment
- spin
- Fermi and Bose particles - multiple particles
- Approximation methods for time independent QM

- Approximation methods for time-dependent QM

#### B. PHYS 461 [PHYS 561] typical topics

Typical topics are selected from among the following.

- Atomic Spectroscopy
- Emission, Absorption, and Lasers
- Quantum Statistics
- Quantum physics applied in biology, chemistry, or applied physics
- Band theory of matter
- Cooperative phenomena - Superconductivity, Magnetism
- Transport
- Nuclear Physics and Nuclear Processes
- Particle Physics and High Energy Physics

#### C. Suggestions for useful references

Books that are useful for Phys 460 (Phys 560) class can be found on ebay and Amazon and in used bookstores. Books titled Modern Physics tend to be for a slightly lower level class related to the 2 year intro sequence. If the title combines Modern Physics and Quantum Mechanics - it is likely for an advanced course as this one. A text that says Quantum Mechanics or Quantum Physics may be appropriate or may be rather more advanced. It is usually pretty clear from reading the preface whether the book is designed for an introductory (Freshman/Sophomore) semester sequence, for this advanced undergraduate/refresher grad course or for a core MS/PhD graduate program course. Within a particular level, the fundamental topics covered will be similar but at different mathematical complexity - but how the topics are put together will be different depending on the pedagogical vision of the author.

The second semester of the course (PHYS 461/561) (e.g., applications of QM) sees important differences in level of treatment of some topics included in books published 20-30 years ago and now. Some 'applications' or examples go in and out of fashion. Also, as research has advanced in the various areas, authors will attempt to evolve the pedagogy so that students more quickly appreciate and work in new areas. Or, because it is newly fashionable topic, they may simply attempt to bring in a bit of enrichment to hook a student's interest.

A random selection of books that have material at the right level, (arranged by date of publication) - these happen to be ones I have.

- *Introduction to Quantum Mechanics in Chemistry, Materials Science, and Biology*, S. M. Blinder (2011), Elsevier Press Complementary Science Series.

- *Quantum Mechanics - Foundations and Applications*, D. G. Swanson (2007), Taylor and Francis (CRC Press).
- *Quantum Physics*, S. Gasiorowicz (2003), 3rd edition, Wiley.
- *Introductory Quantum Mechanics*, R. L. Liboff (2003), 4th edition, Addison Wesley Press. *theoretical, respected*,
- *Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles*, R. Eisberg and R. Resnick, 2nd edition, Wiley.
- *Modern Physics and Quantum Mechanics* E. E. Anderson (1971), 1st edition, W. B. Saunders Co.
- *Basic Quantum Mechanics*, R. L. White (1966), 1st edition, McGraw Hill Book Co.
- *Principles of Modern Physics*, R. B. Leighton (1959), 1st edition, McGraw Hill Book Co.

### III. FALL 2016 PHYS 460-PHYS 560 WEEKLY TOPICAL LIST

The weekly topic list is given in Table I.

### IV. GRADING AND GRADING POLICIES

Every effort will be made to keep the website up to date. However, students are responsible for any issues that occur if they miss in-class announcements that affect grading, exam topics, homework deadlines, problem hints, problem changes and similar items.

#### A. Homework deadlines and extra credit

Homework may be turned in electronically or in class. Homework more than 1 week late will not be counted for credit unless advance arrangements were made with the instructor.

#### B. Journal Club

At times announced in class, - student will be given choice of several articles from the archival, refereed, literature that uses concepts or topics of lectures. Admittedly, since these courses are foundational, the topics will likely not be the focus of article, but will more likely be necessary in explaining or understanding some portion of the work. Student must read the article, and hand in the following for the Journal Club credit 1) a short description in their own words for what/how topics are relevant (which also shows that the students has read the article) 2) with reflection on whether other background/topics in the article relate to other physics course material 3) answering any specific questions about the article posed by the instructor.

TABLE I. Topical List by week for PHYS 460 [PHYS 560]

Week	Topic	Readings	other
ONE	I: Introduction; II: Waves and quantum mechanics;	Ch1 , Ch 2	Check Appendix A and B
TWO	II: Waves and quantum mechanics;	Ch 2	
THREE	III: The Time dependent Schrodinger equation; (M=Holiday)	Ch 3	(Monday Labor Day Holiday)
FOUR	III: The Time dependent Schrodinger equation; IV: Functions and operators;	Ch 3, Ch 4	Check Appendix C (particularly divergence)
FIVE	IV: Functions and operators;	Ch 4	
SIX	V: Operators and QM;	Ch 5	
SEVEN	VI: Approximation Methods;	Ch 6	
EIGHT	VI: Approximation Methods; (W=MIDTERM (weeks-1-7))	Ch 6	(MIDTERM 2016-Oct-12)
NINE	VII: Time Dependent Perturb;	Ch 7	
TEN	VII: Time Dependent Perturb; IX: Angular Momentum;	Ch 7, Ch 9	
ELEVEN	IX: Angular Momentum; X: Hydrogen atom;	Ch 10	
TWELVE	X: Hydrogen atom; XII: Spin;	Ch 10, Ch 12	
THIRTEEN	XIII: Identical Particles;	Ch 13	
FOURTEEN	XV: Harmonic oscillators and photons; (F=Holiday)	Ch 15	(Friday Thanksgiving Holiday)
FIFTEEN	XV: Harmonic oscillators and photons; XI: Methods for 1-D problems;	Ch 15, Ch 9 (skip 9.4);	
SIXTEEN	FINAL EXAM WEEK		

We expect students will want to look into references that the article cites. While we try to choose accessible articles, we do not expect students to understand everything covered in the article.

Students may work together in teams to study and discuss an article. Good discussion and arguments are great. However, the short description should be individually written and acknowledgement made of the discussion group members and their roles.

When time permits, students will also be selected to give a short informal oral presentation on their articles.

### C. Exams

Take home Midterm is during 8th week. There will also be in-class component on Wednesday, October 12, 2016. Final in-class exam is Monday December 5, 10-11:50 a.m., Final is cumulative.

## D. Scoring of exams and homework, and final grade determinations

TABLE II. Typical Scoring methods

Homework:	85% A(4) 75% B(3) 65% C(3) 55% D(1)
Quizzes and in class exercises:	85% A(4) 75% B(3) 65% C(3) 55% D(1)
MIDTERM Exam:	80% A(4) 70% B(3) 60% C(3) 50%D(1)
FINAL Exam:	80% A(4) 70% B(3) 60% C(3) 50%D(1)
ATTENDANCE:	More that three (3) unexcused absences is an automatic F.

TABLE III. Final Course Grade Weighting

Homework	Quizzes/inclass	Midterm	Journal Club	Final exam	>3 unexcused absences
30%	10%	25%	10%	25%	[100%] automatic F in course

Graduate students and undergraduates may receive  $\pm$  grades. Final Letter grade for course is calculated similar to a 'gpa' from the letter grades using the weightings listed above. Score calculated above is assigned to final letter grade for course as follows - 3.81 (A), 3.48 (A-), 3.15 ( B+), 2.81 (B), 2.48 (B-), 2.15 (C+), 1.81 (C), 0.81 (D), <0.81 (F).

## V. STANDARD POLICIES AND PROCEDURES - THE FINE PRINT

1. Cheating will not be tolerated, and will be dealt with according to the NIU Student Code of Conduct.
2. Group Studying Policy - Homework studying may be done in groups and students are encouraged to seek help.
3. Group Work Policy - students should be comfortable acknowledging and citing sources that are used whether in writing a paper, developing research ideas, or getting significant help on answering or understanding answers on working problems. Be transparent and honest. Acknowledge (in writing) sources who helped significantly, in particular, if the homework would not have been done on time and correctly without that help.
4. EXAMS: If emergency medical crisis or family crisis interferes with an EXAM, contact Professor Thompson or the physics office by phone, mail, or email, when practical. Without compromising your privacy, give enough specific information to Professor Thompson to let her assess the situation and start developing plans for accommodation. Any realistic timeline is very helpful (i.e., is this a trauma requiring several weeks or more to overcome, or was this just a very scary event but with a quick recovery? ) (Cramming the night before and oversleeping is not considered an scary emergency, nor is running out of gas).
5. For the non-emergency 'stupid' things (which do happen, regrettably) do not panic. If the exam has already started, please contact the Physics office as soon as possible at 815-753-1772. Leave contact information, short assessment of situation and the expected timeline for getting to the department as soon as possible. Reality check - students who rarely show up in class or complete the homework do not get much good-faith accommodation for non-emergency situations.
6. If you need an disability 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](mailto:drc@niu.edu). Your success as a student is important. Please contact me early in the semester to help me plan and coordinate my part.
7. How to get an excused absence - Contact Professor Thompson as soon as practical for illness related absences. For any other absences due to work or class schedule changes, department, student club, or class activities, personal commitments (wedding) etc) - - please handle these requests IN ADVANCE of the event and bring them to Thompson's attention in writing. Please compose a formally written summary of relevant information and request and schedule a time to discuss it with Thompson. Summary should include student name/id, course and dates affected, concise description of request with supporting information such as faculty mentor responsible for any NIU-club/course/activity related absence. Include discussion of what will be impact on coursework and provide proposed plan to provide effort to cover missed work or materials. textitThompson reserves the right to count an absence as unexcused.
8. Incompletes and procrastination: Grades of Incompletes (I) may be given at the discretion of the instructor when serious unforeseen circumstances arise causing a chronic but temporary disruptions of the student's ability to concentrate at his or her usual level of performance. This can happen to anyone. So please, be proactive, be professional and be realistic.

Examples might be illness lasting two or three weeks and recovery, or the normal coping response to a physical or emotional trauma such as an assault, the death or illness of a close family member, divorce, breakup. These can really throw off any human! Please be proactive and do not 'tough it out' when special situations arise.

Note that an I (incomplete) is not used to accommodate 'chronic' procrastination or poor performance due to poor schedule planning, inability to develop good study habits, ignorance, or immaturity, or bad attitude.

9. For medical withdrawals, (requests to college to be dropped from a class (after the deadline for withdraw has passed) - the Withdraw Pass (WP) or Withdraw Fail (WF) grade will usually be determined by the pro-rated grade that student had achieved by week eight in the semester.

This syllabus is a guide and every attempt is made to provide an accurate overview of the course. However, circumstances and events may make it necessary for the instructor to modify the syllabus during the semester and may depend, in part, on the progress, needs, and experiences of the students.