

# SYLLABUS - PHYS 460 [PHYS 560] Quantum Mechanics (3 unit) Fall 2017

C. Thompson<sup>1</sup>

*Northern Illinois University*

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Class meets - MonWedFri at 10:00-10:50 am in Faraday Hall 237

Professor C. Thompson (815-753-1772)- cthompson@niu.edu - LaTourette Hall 207

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

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

Office hours - Monday 11:00am-12:15pm, but preferred arrangement is by appointment.

Textbook -

Useful references for the course - see section ??.

Two In-Class exams are scheduled (Wed, Oct 4, Fri, Nov 17).

Final in-class exam is Mon. December 11, 2017 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.

## CONTENTS

### 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 upper-level UG 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 (grad refresher 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. Some are designed for a year long course at level of Phys 460/560.

- *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.
- *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 2017 PHYS 460-PHYS 560 WEEKLY TOPICAL LIST

The weekly topic list is given in Table ??.

TABLE I. Topical List by week for PHYS 460 [PHYS 560] (v1)

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; (M=Holiday)	Ch 2	(Monday Labor Day Holiday)
THREE	III: The Time dependent Schrodinger equation;	Ch 2, Ch 3	
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; (W=EXAM)	Ch 5	October 4 in-class exam Ch 1-4
SEVEN	VI: Approximation Methods;	Ch 6	
EIGHT	VI: Approximation Methods;	Ch 6	
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 9, Ch 10	
TWELVE	X: Hydrogen atom; XII: Spin; (F=EXAM)	Ch 10, Ch 12	Nov 17 in-class exam Ch (1-4),5-7, 9
THIRTEEN	XIII: Identical Particles; (W,F=Holiday)	Ch 13	(Wed/Fri Thanksgiving Holiday)
FOURTEEN	XV: Harmonic oscillators and photons;	Ch 13, Ch 15	
FIFTEEN	XV: Harmonic oscillators and photons; if time permits XI: Methods for 1-D problems;	Ch 15, (Ch 11)	
SIXTEEN	FINAL EXAM WEEK (Phys 460/560 Final Cumulative)	Mon. December 11, 2017	10-11:50 a.m.

### 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 as a PDF or in class. Homework more than 1 week late will not be counted for credit unless advance arrangements were made with the instructor.

If scanned to turn in, PLEASE DO NOT TURN IN multiple jpegs (e.g., scanned with phone with each page a different picture unless merely trying to document that the work was done (to avoid 'late' penalties). Take the time to create a single PDF document (e.g., at worst, put the jpeg scanned images as pages into a single powerpoint or word document and convert to pdf.

## B. Exams

There will also be two in-class exams. EXAM ONE on Wednesday, October 4, 2017, EXAM TWO on Friday November 17, 2017). Final in-class exam is Monday December 5, 10-11:50 a.m., Final is cumulative.

For the final exam date and time, we follow the NIU final exam official schedule at <http://www.reg.niu.edu/regrec/dates/schedules/standardexams.shtml>. In case of typos in this syllabus, the NIU exam schedule should be considered as the correct source.

## C. 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)
Exams (in class and out of class):	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	Exams	Final exam	>3 unexcused absences
30%	20%	25%	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 - 3.82 (A), 3.49 (A-), 3.16 ( B+), 2.82 (B), 2.49 (B-), 2.16 (C+), 1.82 (C), 0.82 (D), <0.82 (F).

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

1. 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. Your success as a student is important. Please contact me early in the semester to help me plan and coordinate my part.
2. Cheating will not be tolerated, and will be dealt with according to the NIU Student Code of Conduct.
3. Group Studying Policy - Homework studying may be done in groups and students are encouraged to seek help - but see the next item for being honest and transparent about help.
4. Group Work Policy - students should be comfortable acknowledging resources 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.
5. 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).
6. For the non-emergency 'stupid' things, 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 with many absences and/or many late and missing homeworks do not get much good-faith accommodation for non-emergency situations.

7. Unexcused and excused absences. Frankly, there are three unexcused absences allowed before automatic F kicks in. Since the class schedule is known far in advance, Thompson considers this policy more than sufficient for any mature adult student to use to balance any last-minute choices between important professional or personal commitments or simple cold/flu/migraine/study-for-another-class events, per semester.

If these are not enough, then what is your problem? Are you simply someone who isn't reliable?

Contact Professor Thompson as soon as practical for illness-related absences which are handled differently than discussed below.

For any other absences (that will need more than three days that you can choose for yourself) due to research commitments, other class or club activities, conference travel, personal commitments (travel to wedding, funeral, family reunions) etc) - please handle these requests **IN ADVANCE** and with **ALL** relevant information **IN WRITING** (email OK) of the event and how you plan to handle the missed work or if accommodations are needed. What is relevant information? Relevant information is: student name/id, the course number and dates affected, a concise description of request with supporting information. Include discussion of what will be impact on coursework and provide your proposed plan to cover missed work or materials. For research/conference travel/student club or course activity, include the name and contact information of the faculty mentor responsible or supervising.

If you do not receive a written or formal email confirmation from Thompson **prior to your absence**, then the absence was not excused. *Thompson 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 several weeks *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 severe illness or chronic illness flare-up, 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.

Important note: Grade of Incomplete turns automatically into an F if the work is not completed after a short specified period of time after the semester ends. This maximum time period limit is set via University policy, not the instructor although the instructor can specify a shorter time period to complete the work. If the disruption to the student's abilities are long term (longer than a few weeks), it is in the student's best interests to do a

medical withdrawal or a special withdrawal rather than an incomplete that will simply turn into an F later. See the college advisors (not the department) for withdrawals.

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.