

Course Information

Course Number:	PHYS 414
Course Title:	Quantum Mechanics II
Section:	200 and 500
Time:	TR 12:45-2:00
Location:	109 MPHY
Credit Hours:	3

Instructor Details

Instructor:	Joseph Ross
Office:	448 MPHY (office in Mitchell Physics) and B03 Cain (research lab)
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Office Hours:	M 4-6 in B03 Cain; T 2:15-3 and R 11-12:15 in 448 MPHY. Other than these times, I am often in my lab rather than my office. Please drop by any time I am in, but for extended questions outside of office hours it is usually best to email me to arrange a time. [<i>Also watch for announcements in case I change office hours locations from one building to the other in the future.</i>]

Course Description

This course is the continuation of Phys 412, which together provides a survey of non-relativistic quantum mechanics. While Phys 412 focused on foundational topics in quantum mechanics, including the wave equation and wave mechanics in one and three dimensions, Phys 414 focuses on applications of quantum mechanics, including approximation methods appropriate for analyzing time-independent and time-dependent phenomena, as well as additional topics including magnetic interactions, scattering theory, and the role of symmetry in quantum mechanics.

Course Prerequisites

PHYS 412, or equivalent with instructor approval.

Honors Course Section

The honors section of this course (section 200) has the same meeting times and exams/homework. In addition, to take this course under honors credit requires an extra research paper. This involves investigating a topic related to this course beyond what is covered in the textbook and regular lectures, preparing a paper on this subject summarizing the results. The paper should include a description of some of the relevant physics, showing how the results connect to what is covered in class. You should include at least five references to recent scientific papers showing one or more current research directions related to your topic. I will provide suggestions for topics, and you need to discuss this with me by Nov. 10, and have at least some of the literature references identified by this time. The written paper will be due by the last class day, and I will also meet with you individually and have you explain your findings to me at the end of the term.

Course Learning Outcomes

Students in this course will:

- Learn to apply approximation methods for the quantum behavior of a various systems, including WKB theory for tunneling and analysis of bound states, and the variational method.
- Become familiar with symmetry properties in quantum mechanics, and their relationship to conserved quantities, as well as symmetry relations for the selection rules of transitions between atomic states.
- Gain an understanding of the role of magnetic fields in quantum phenomena, and their connection to spin and orbital behavior, and the fine and hyperfine energy splittings in atomic spectra.
- Learn about the behavior of quantum systems under the influence of time-dependent fields, including the application of AC fields and induced transformation between quantized levels, as well as the response to adiabatic changes in system parameters.
- Develop an understanding of the quantum theory of scattering of particles and other quantum systems.
- Honors students in addition will develop a more detailed understanding of a chosen quantum-mechanics-related topic of current research interest, and will become familiar with some of the recent publications related to this topic in the scientific literature, and open questions in this area.

Textbook and/or Resource Materials

Griffiths & Schroeter, *Introduction to Quantum Mechanics (3rd ed)*; McIntyre, *Quantum Mechanics: A Paradigms Approach*.

Grading Policy

- *Overall course grade will be based on the following scheme:*
 - **Homework 33%**
 - **Midterm Exam 33%**
 - **Final Exam 33%.**
- *Assignment of final grades according to point totals calculated using the percentages above is expected to follow the scale, 80-100 A, 70-80 B, 60-70 C, 50-60 D, <50 F.*
- *For Honors students the final paper will be accorded 10%, with other items adjusted correspondingly, so that the homework and two exams each represent 30% of the grade.*

Late Work Policy

- *Late homework turned in after the due date but before the solutions are given out will be awarded $\frac{1}{2}$ credit. This does not apply in the case of homework that is late due to an excused absence (approved by me).*
- *After solutions are posted, it will still be possible to get $\frac{1}{3}$ credit for homework turned in if I am convinced that the work was not copied from the solutions.*

Course Schedule

There are two course exams, at the pre-arranged times as follows: **Tuesday Oct. 17, 7:30 PM, and Final Exam, Tuesday Dec. 12, 8 AM.** Note that the final exam is in the standard 2-hour finals-time slot for our lecture time.

The lecture schedule below includes sections of the Griffiths and Schroeter (G&S) and McIntyre texts. The times spent on each topic are my best estimate and could change.

- Week 1, Aug 22-24: Perturbation theory applications: atomic states and hyperfine interactions. G&S sects. 7.4-5, parts of McIntyre ch 11-12.
- Week 2, Aug 29-31: Continued hyperfine interactions; identical particles and atoms. G&S section 5.2, parts of McIntyre ch. 13.
- Week 3, Sep 5-7: Variational principle & applications to atoms and molecules - G&S ch. 8.
- Week 4, Sep 12-14. Variational principle & applications cont'd; Unitary operators review. G&S appendix A4-A5;
- Week 5, Sep 19-21. Symmetry and Conservation laws in QM - G&S chapter 6.
- Week 6, Sep 26-28. Symmetry and Conservation laws continued.
- Week 7, Oct 3-5. WKB theory. Applications to bound states and tunneling. G&S ch. 9.
- Week 8, Oct 12. WKB theory continued. (**Fall break, short week**)
- Week 9, Oct 17-19. Scattering theory; Born approximation, partial waves. G&S chapter 10.
Evening exam, Oct 17. topics through WKB theory, details in class.
- Week 10, Oct 24-26. Scattering theory cont'd, also begin time-dependent perturbation theory. G&S chapter 11; McIntyre ch. 14.
- Week 11, Oct 31-Nov 2. Time-dependent perturbation theory. Also see McIntyre sect. 3.4.
- Week 12, Nov 7-9. Time-dependent perturbation theory continued; spontaneous radiation; Fermi golden rule, selection rules (with material from G&S 6.7).
- Week 13, Nov 14-16. Adiabatic approximation and geometric phase, also magnetic Hamiltonian and Aharonov-Bohm effect (with G&S section 4.5). Periodic symmetry (G&S 5.3 and 6.2.2; parts of McIntyre ch. 15.)
- Week 14, Nov 21. periodic symmetry and crystals. **Thanksgiving break Nov 23.**
- Week 15, Nov 28-30. Bell's theorem (G&S chapter 12); as time permits, topics in quantum computing and quantum communication (McIntyre 16.2). **Last TR class day, Nov. 30.**

University Policies

The policies and information below this point are those that are common to all Texas A&M courses.

Attendance Policy

The university views class attendance and participation as an individual student responsibility. Students are expected to attend class and to complete all assignments.

Please refer to [Student Rule 7](#) in its entirety for information about excused absences, including definitions, and related documentation and timelines.

Makeup Work Policy

Students will be excused from attending class on the day of a graded activity or when attendance contributes to a student's grade, for the reasons stated in Student Rule 7, or other reason deemed appropriate by the instructor.

Please refer to [Student Rule 7](#) in its entirety for information about makeup work, including definitions, and related documentation and timelines.

Absences related to Title IX of the Education Amendments of 1972 may necessitate a period of more than 30 days for make-up work, and the timeframe for make-up work should be agreed upon by the student and instructor" ([Student Rule 7, Section 7.4.1](#)).

"The instructor is under no obligation to provide an opportunity for the student to make up work missed because of an unexcused absence" ([Student Rule 7, Section 7.4.2](#)).

Students who request an excused absence are expected to uphold the Aggie Honor Code and Student Conduct Code. (See [Student Rule 24](#).)

Academic Integrity Statement and Policy

"An Aggie does not lie, cheat or steal, or tolerate those who do."

"Texas A&M University students are responsible for authenticating all work submitted to an instructor. If asked, students must be able to produce proof that the item submitted is indeed the work of that student. Students must keep appropriate records at all times. The inability to authenticate one's work, should the instructor request it, may be sufficient grounds to initiate an academic misconduct case" ([Section 20.1.2.3, Student Rule 20](#)).

You can learn more about the Aggie Honor System Office Rules and Procedures, academic integrity, and your rights and responsibilities at aggiehonor.tamu.edu.

Americans with Disabilities Act (ADA) Policy

Texas A&M University is committed to providing equitable access to learning opportunities for all students. If you experience barriers to your education due to a disability or think you may have a disability, please contact the Disability Resources office on your campus (resources listed below) Disabilities may include, but are not limited to attentional, learning, mental health, sensory, physical, or chronic health conditions. All students are encouraged to discuss their disability related needs with Disability Resources and their instructors as soon as possible.

Disability Resources is located in the Student Services Building or call (979) 845-1637 or visit disability.tamu.edu.

Title IX and Statement on Limits to Confidentiality

Texas A&M University is committed to fostering a learning environment that is safe and productive for all. University policies and federal and state laws prohibit gender-based discrimination and sexual harassment, including sexual assault, sexual exploitation, domestic violence, dating violence, and stalking.

With the exception of some medical and mental health providers, all university employees (including full and part-time faculty, staff, paid graduate assistants, student workers, etc.) are Mandatory Reporters and must report to the Title IX Office if the employee experiences, observes, or becomes aware of an incident that meets the following conditions (see [University Rule 08.01.01.M1](#)):

- The incident is reasonably believed to be discrimination or harassment.
- The incident is alleged to have been committed by or against a person who, at the time of the incident, was (1) a student enrolled at the University or (2) an employee of the University.

Mandatory Reporters must file a report regardless of how the information comes to their attention – including but not limited to face-to-face conversations, a written class assignment or paper, class discussion, email, text, or social media post. Although Mandatory Reporters must file a report, in most instances, a person who is subjected to the alleged conduct will be able to control how the report is handled, including whether or not to pursue a formal investigation. The University's goal is to make sure you are aware of the range of options available to you and to ensure access to the resources you need.

Students wishing to discuss concerns in a confidential setting are encouraged to make an appointment with [Counseling and Psychological Services \(CAPS\)](#).

Students can learn more about filing a report, accessing supportive resources, and navigating the Title IX investigation and resolution process on the University's [Title IX webpage](#).

Statement on Mental Health and Wellness

Texas A&M University recognizes that mental health and wellness are critical factors that influence a student's academic success and overall wellbeing. Students are encouraged to engage in healthy self-care by utilizing available resources and services on your campus.

Students who need someone to talk to can contact Counseling & Psychological Services (CAPS) or call the TAMU Helpline (979-845-2700) from 4:00 p.m. to 8:00 a.m. weekdays and 24 hours on weekends. 24-hour emergency help is also available through the 988 Suicide & Crisis Lifeline (988) or at [988lifeline.org](https://www.988lifeline.org) [Links to an external site.](#)