

COURSE AND INSTRUCTOR INFORMATION

Course: PHY 425 (Quantum Mechanics II)

Lecture Time & Location: MWF: 1 – 1:50 pm in **SECC 209**

Instructor: Anil K. Kandalam (Dr. Kandalam or Dr. K)

Office Location: Science and Engineering Center and Commons (**SECC**), 360

Email: akandalam@wcupa.edu

Office Hours: Monday, Wednesday, Friday: 9:00 am – 10:00 am

Thursday: 8:00 am – 9:00 am, 11:00 am – 12:00 noon OR by appointment

COURSE DESCRIPTION

This course is the second-semester *Quantum Mechanics* course. The following fundamental topics will be covered: Time-independent Perturbation Theory, the Variational Principle, the WKB approximation, time-dependent Perturbation theory, and advanced topics.

REQUIRED COURSE MATERIALS

Textbook: *Introduction to Quantum Mechanics*, David J. Griffiths & Darrell F. Schroeter, 3rd Edition (Pearson)

Reference books for additional reading:

Introductory Quantum Mechanics, Richard Liboff (Addison-Wesley)

Quantum Mechanics, Eugen Merzbacher (Wiley)

Quantum Mechanics for Scientists and Engineers, David A. Miller (Cambridge)

Note: In some lectures, I will cover certain topics in class that are not discussed in Griffiths. They will be taken from the “Reference books” listed above.

EXPECTATIONS

This is a challenging course. Not only are the concepts challenging, but there is a lot of math. You will be using topics from calculus, linear algebra, differential equations, and concepts from mathematical physics. Given the complexity of this course as well as the required mathematical background, you will have to put in a substantial amount of effort. You cannot rely on your time in class and the associated lectures alone to master the topics presented. You will have to spend a great deal of time outside class reading the material covered in the text, studying the examples provided, and working on the problem sets. If you have not done this up to now in your other classes, please be forewarned. Don't hesitate to ask me or other professors for help in the material that you have trouble understanding. **DO NOT fall behind in this class!**

West Chester University's Covid-19 Classroom Protection Requirements

We, as a community of educators and learners, should work together to create a culture that protects our most precious resource: each other. As such, it is the expectation of all members of the University community to continue to do their part to protect the health and safety of others. In our classrooms where the university's primary function is carried out, the following protocols are being implemented:

- Unless otherwise directed by the faculty member, students must wear a cloth or disposable face mask that covers both the nose and mouth the entire time they are in class.
 - Face shields and gaitors do ***not*** meet the university's mask requirement.
- Eating and drinking in the classroom are only permitted if they are medically necessary.
 - Please work with the Office of Services for Students with Disabilities to notify the university and your professors of this necessity.

We want you to succeed in this class, but we will have to ask you to leave if you do not follow these guidelines, so please – make the most of this opportunity and help keep our campus safe.

LEARNING OUTCOMES

Program (B. S. Physics) student learning outcomes:

Physics 425 fulfills the goal of students' knowledge and understanding of the concepts and principles of physics as outlined in the departments program assessment.

Course-specific learning outcomes:

Outcome 1: Students will demonstrate the ability to explain the wave functions of bosons and fermions.

Outcome 2: Students will demonstrate an ability to interpret and explain the exchange forces in distinguishable and identical particles.

Outcome 3: Students will demonstrate an ability to apply the time-independent Perturbation theory for degenerate and non-degenerate systems.

Outcome 4: Students will demonstrate an understanding of the fine structure of Hydrogen atom, the effect of external electric and magnetic fields on an atom (Stark and Zeeman Effects, respectively).

Outcome 5: Students will demonstrate an understanding of the Variational Principle and apply it to the Helium atom.

Outcome 6: Students will demonstrate an understanding of WKB approximation.

Outcome 7: Students will demonstrate an ability to apply the time-dependent Perturbation theory towards the electromagnetic radiation and the selection rules associated with this radiation.

ASSESSMENT OF LEARNING OUTCOMES

Learning goals and outcomes will be assessed via weekly homework problem sets, in-class and take-home exams and the final exam.

COURSE COMPONENTS

Pre-class Reading: You must read before coming to the class. Since, we have limited lecture time, we must focus on the more challenging concepts in the course. Thus, it is critical that you come to lecture knowing the basic elements which we will build on in lecture that day. You need to think deeply about the content and might need to read certain section multiple times.

Lecture: I attempt to make the lecture as informal as possible. I encourage questions during the class.

Problem Sets: There will be one problem set (almost) each week. Working the problem sets is very important for mastering this subject. Generally, they will be given out on Mondays and due

the following week's Monday in class. **A large fraction of the learning in this course takes place working on these homework problems, so it is essential that you put a substantial effort into these assignments.**

Late work is not accepted except by prior arrangement with the instructor. Working to deadlines is an aspect of personal responsibility and, as such, it is an important skill to develop. All problem sets will be graded (*to varying degrees*) and returned. If you fail to turn in a problem-set because of absences (excused or unexcused) then you will receive a zero for the problem-set grade. **The problem sets will be graded only roughly.** It is your responsibility to check your work with the solution set.

EVALUATION

The final grade for this course will be based on the following:

- Problem Sets16%
- Exams (3 @ 22% each)64%
- Final exam.....20%

Letter grades will be assigned on the following scale. However, I reserve the right to adjust the weights of individual components, or the scale to account for unforeseen circumstances.

93 – 100 %	A	73 – 76 %	C
90 – 92 %	A–	70 – 72 %	C–
87 – 89 %	B+	67 – 69 %	D+
83 – 86 %	B	63 – 66 %	D
80 – 82 %	B–	60 – 62%	D–
77 – 79 %	C+	59% or lower	F

GRADING COMPONENTS AND POLICIES

Problem Sets: You are encouraged to work together/collaborate on problem sets, but the work that you hand in must be your own and must reflect your own understanding of the material. The best balance between working alone and working with other people is to (i) first work on the problem sets alone. If you are stuck on a problem, then (ii) work with other students and then (iii) complete the problem alone where you can collect your thoughts in peace. Make sure that you understand the solution to each problem that you turn in. If step (ii) does not help, you can always get hints from me during my office hours. **Please do not ask from help/hints via. e-mail.** Please indicate the names of people you have collaborated with for a problem set.

Here's a handy rule of thumb: if you can do the problem without referring to any notes, then you understand the concept and the problem-solving approach. Try a similar problem and prove it to yourself.

Regular Exams: There are a total of three exams that will be given in the semester. Two of these exams are in-class, while one exam is a take-home exam. **No grades will be dropped** and there are no-make up exams. The exceptions, however, are limited to the absences related to University Sanctioned Events (see below). If you miss an exam for a University Sanctioned Event, you must notify me in advance so that we can arrange for you to take the exam in a manner consistent with its integrity. You must also provide some form of documentation (performing arts program, competition schedule etc).

Final Exam: The final exam is a cumulative exam and is MANDATORY. The date and time of the final exam for this course set by the Registrar's office is **Friday, May 13, 2022, from 10:30 am – 12:30 pm**

You should plan to be available for the entire finals week. We have in past semesters had to reschedule finals due to weather related events.

ATTENDANCE POLICY

A regular attendance to the lectures is an important part of this course and I highly recommend it. This is your chance to ask questions, see examples and get help in solving problems. I am here to guide you through the material. Attendance will benefit your understanding and therefore grade. However, I do not give an attendance grade. Students must understand that they are responsible for all material covered and assigned during their absences (excused and unexcused) and that they are responsible for the academic consequences of their absences.

CONTACT POLICY

Please include ***PHY425*** in the subject line of any e-mail. I try to respond to e-mail within 24hrs. Although I will try to answer all questions directed to me by e-mail, most problems related to course content are best discussed during office hours.

ACADEMIC INTEGRITY & CONDUCT

I have a zero-tolerance policy for breaches of academic integrity. Breaches of academic integrity will be investigated, and sanctions imposed to the full extent available under university policy. It is the responsibility of each student to adhere to the university's standards for academic integrity. Violations of academic integrity include any act that violates the rights of another student in academic work, that involves misrepresentation of your own work, or that disrupts the instruction of the course. Other violations include (but are not limited to): cheating on assignments or examinations; plagiarizing, which means copying any part of another's work and/or using ideas of another and presenting them as one's own without giving proper credit to the source; selling, purchasing, or exchanging of term papers; falsifying of information; and using your own work from one class to fulfill the assignment for another class without significant modification. Proof of academic misconduct can result in the automatic failure and removal from this course. For questions regarding Academic Integrity, the No-Grade Policy, Sexual Harassment, or the Student Code of Conduct, students are encouraged to refer to the Department Undergraduate Handbook, the Undergraduate Catalog, the Ram's Eye View, and the University website at www.wcupa.edu.

EXECUSED ABSENCES POLICY

If you are participating in a university sanctioned event during one of our scheduled exams you must notify me in advance. You must provide some form of documentation. We can then arrange for you to take the exam in a manner consistent with exam integrity. Students are advised to carefully read and comply with the excused absences policy, including absences for university-sanctioned events, contained in the WCU Undergraduate Catalog. In particular, please note that the "responsibility for meeting academic requirements rests with the student," that this policy does not excuse students from completing required academic work, and that professors can require a "fair alternative" to attendance on those days that students must be absent from class in order to participate in a University-Sanctioned Event.

STUDENTS WITH DISABILITIES

If you have a disability that requires accommodations under the Americans with Disabilities Act (ADA), please present your letter of accommodations and meet with me as soon as possible so that I can support your success in an informed manner. Accommodations cannot be granted retroactively. If you would like to know more about West Chester University's Services for Students with Disabilities (OSSD), please visit them at 223 Lawrence Center. Their phone number is 610-436-2564, their fax number is 610-436-2600, their email address is ossd@wcupa.edu, and their website is at

<https://www.wcupa.edu/universityCollege/ossd/>. In an effort to assist students who either receive or may believe they are entitled to receive accommodations under the Americans with Disabilities Act and Section 504 of the Rehabilitation Act of 1973, the University has appointed a student advocate to be a contact for students who have questions regarding the provision of their accommodations or their right to accommodations. The advocate will assist any student who may have questions regarding these rights. The Director for Equity and Compliance/Title IX Coordinator has been designated in this role. Students who need assistance with their rights to accommodations should contact them at 610-436-2433.

COURSE SCHEDULE: Following is a tentative lecture outline for this course. *I reserve the right to adjust this schedule* as necessary during the semester to ensure a satisfactory learning experience.

	Date	Topic
1	M Jan. 24	Ch. 4: Spin
2	W Jan. 26	Ch. 4: Spin
3	F Jan. 28	Ch. 4: Addition of Angular Momentum
4	M Jan. 31	Ch. 5: Two-Particle Systems
5	W Feb. 2	Ch. 5: Two-Particle Systems
6	F Feb. 4	Ch. 5: Two-Particle Systems
7	M Feb. 7	Ch. 5: Atoms
8	W Feb. 9	Ch. 7: Non-degenerate time-independent perturbation theory
9	F Feb. 11	Ch. 7: Non-degenerate time-independent perturbation theory
10	M Feb. 14	Ch. 7: Degenerate perturbation theory
11	W Feb. 16	Ch. 7: Degenerate perturbation theory
12	F Feb. 18	Ch. 7: Degenerate perturbation theory
13	M Feb. 21	Ch. 7: Fine Structure of Hydrogen Atom
14	W Feb. 23	Ch. 7: Fine Structure of Hydrogen Atom
15	F Feb. 25	Ch. 7: Fine Structure of Hydrogen Atom
16	M Feb. 28	Ch. 7: The Zeeman Effect
17	W Mar. 2	Ch. 7: The Zeeman Effect
18	F Mar. 4	Ch. 7: The Zeeman Effect
19	M Mar. 7	Ch. 7: Hyperfine Splitting
20	W Mar. 9	Ch. 7: Hyperfine Splitting
21	F Mar. 11	Test 1: Chapters 4.4, 5 & 7
	M Mar. 14 W Mar. 16 F Mar. 18	SPRING BREAK
22	M Mar. 21	Ch. 8: The Variational Principle: Theory
23	W Mar. 23	Ch. 8: The Variational Principle: Theory
24	F Mar. 25	Ch. 8: The Variational Principle: Theory
25	M Mar. 28	Ch. 8: Helium Atom
26	W Mar. 30	Ch. 8: Helium Atom
27	F Apr. 1	Ch. 8: The Hydrogen Molecule Ion
28	M Apr. 4	Ch. 8: The Hydrogen Molecule Ion
29	W Apr. 6	Ch. 9: The WKB Approximation
30	F Apr. 8	Ch. 9: The WKB Approximation (Take home exam: Test 2: Chapters 8 & 9)
31	M Apr. 11	Ch. 9: The WKB Approximation
32	W Apr. 13	Ch. 11: Two-level Systems
33	F Apr. 15	Ch. 11: Two-level Systems

	Date	Topic
34	M Apr. 18	Ch. 11: Two-level Systems
35	W Apr. 20	Ch. 11: Two-level Systems: Sinusoidal Perturbations
36	F Apr. 22	Ch. 11: Emission and Absorption of Radiation
37	M Apr. 25	Ch. 11: Absorption, Stimulate Emission, and Spontaneous Emission
38	W Apr. 27	Ch. 11: Incoherent Perturbations
39	F Apr. 29	Ch. 11: Spontaneous Emission
40	M May 2	Ch. 11: Spontaneous Emission
41	W May 4	Ch. 11: Selection Rules
42	F May 6	TEST 3: Chapters 9 & 11
FINAL EXAM: Friday, May 13, 2022, from 10:30 am – 12:30 pm		

E-MAIL POLICY STATEMENT

It is expected that faculty, staff, and students activate and maintain regular access to University provided e-mail accounts. Official university communications, including those from your instructor, will be sent through your university e-mail account. You are responsible for accessing that mail to be sure to obtain official University communications. Failure to access will not exempt individuals from the responsibilities associated with this course.

INCLUSIVE LEARNING ENVIRONMENT AND ANTI-RACIST STATEMENT

Diversity, equity, and inclusion are central to West Chester University’s mission as reflected in our [Mission Statement](#), [Values Statement](#), [Vision Statement](#) and [Strategic Plan: Pathways to Student Success](#). We disavow racism and all actions that silence, threaten, or degrade historically marginalized groups in the U.S. We acknowledge that all members of this learning community may experience harm stemming from forms of oppression including but not limited to classism, ableism, heterosexism, sexism, Islamophobia, anti-Semitism, and xenophobia, and recognize that these forms of oppression are compounded by racism.

Our core commitment as an institution of higher education shapes our expectation for behavior within this learning community, which represents diverse individual beliefs, backgrounds, and experiences. Courteous and respectful behavior, interactions, and responses are expected from all members of the University. We must work together to make this a safe and productive learning environment for everyone. Part of this work is recognizing how race and other aspects of who we are shape our beliefs and our experiences as individuals. It is not enough to condemn acts of racism. For real, sustainable change, we must stand together as a diverse coalition against racism and oppression of any form, anywhere, at any time.

Resources for education and action are available through WCU’s [Office for Diversity, Equity, and Inclusion](#) (ODEI), DEI committees within departments or colleges, the student [ombudsperson](#), and centers on campus committed to doing this work (e.g., [Dowdy Multicultural Center](#), [Center for Women and Gender Equity](#), and the [Center for Trans and Queer Advocacy](#)).

Guidance on how to report incidents of discrimination and harassment is available at the University’s [Office of Diversity, Equity and Inclusion](#).

REPORTING INCIDENTS OF SEXUAL VIOLENCE

West Chester University and its faculty are committed to assuring a safe and productive educational environment for all students. In order to comply with the requirements of Title IX of the Education Amendments of 1972 and the University’s commitment to offering supportive measures in accordance with the new regulations issued under Title IX, the University requires faculty members to report incidents of

sexual violence shared by students to the University's Title IX Coordinator. The only exceptions to the faculty member's reporting obligation are when incidents of sexual violence are communicated by a student during a classroom discussion, in a writing assignment for a class, or as part of a University-approved research project. **Faculty members are obligated to report sexual violence or any other abuse of a student who was, or is, a child (a person under 18 years of age) when the abuse allegedly occurred to the person designated in the University Protection of Minors Policy.** Information regarding the reporting of sexual violence and the resources that are available to victims of sexual violence is set forth at: <https://www.wcupa.edu/admin/diversityEquityInclusion/sexualMisconduct/default.aspx>

EMERGENCY PREPAREDNESS

All students are encouraged to sign up for the University's free WCU ALERT service, which delivers official WCU emergency text messages directly to your cell phone. For more information, visit www.wcupa.edu/wcualert. To report an emergency, call the Department of Public Safety at 610-436-3311.