



THE UNIVERSITY OF  
**TENNESSEE**  
KNOXVILLE

**BIG ORANGE. BIG IDEAS.**

**PHYS 252**  
**Quantum Physics and Applications,**  
**Fall 2023**

University of Tennessee, Knoxville

**Meeting Time and Place:** Nielsen 203 Monday and Friday 9:10 – 11:55 AM

**Office Hours:** Monday/Friday 12:00 – 1:00 PM, by appointment or whenever you find me at my office.

**Course Credit Hours:** 4

**Faculty Contact Information**

Dr. Elias Kokkas: Nielsen 616

Email: [ikokkas@vols.utk.edu](mailto:ikokkas@vols.utk.edu)

Webpage: TBD

**Course Description:** Explores the fundamentals of quantum physics and applications to solid state physics, nuclear physics, particle physics, and cosmology. Topics covered include: The nature of photons; Wave particle duality; Application of the Schrödinger Equation to simple steps and barriers; and Models of single- and multi-electron atoms. This course includes a laboratory component that may be incorporated into the class time in a studio physics modality. Basic scientific computing will be incorporated into the course.

Prerequisites: PHYS 231 or 251 with a C or better and MATH 142 with a C or better.

**Value Proposition:** This course covers the basics relating to the nature of quantum systems, with some applications, presented at a level appropriate for sophomore-level physics and engineering students. The purpose of the course is both to introduce students broadly to concepts related to quantum physics, and to prepare them for PHYS 411 “Introduction to Quantum Mechanics I”,

PHYS 341 “Introduction to Nuclear Physics”, PHYS 342 “Structure of Matter”, and PHYS 461 “Modern Physics Laboratory”.

**Learning Environment:** The course incorporates lectures, and in-class activities, which may be hands-on laboratories (experiments), or computational investigations. Students are responsible for reading the material ahead of class sessions and will be ready to discuss in class. When there are in-class activities or laboratories, students will work on in pairs, or small groups and will prepare a single slide with a short summary of the in-class activity and findings to present in the next class. In the days without in-class activities or laboratories, exercises/quizzes will be given during the lecture, which will count towards participation.

**Course Communications:** Communication outside of class times will be through UTK email and Canvas. Please monitor your UTK email and Canvas regularly. For technical issues, contact the OIT HelpDesk via phone (865) 974-9900 or online at <http://help.utk.edu/>.

**How to Be Successful in This Course:** Being organized and keeping up with reading assignments is essential to success in this course. Come to class prepared to discuss the material and to work with other students. If you’re willing to work and learn this should be a really fun course.

**Texts/Resources/Materials:**

The textbook for this course is “Modern Physics” by Kenneth Krane, published by Wiley.

Much of the material is covered in the OpenStax University Physics Book Volume 3 at a slightly lower level. Volumes 1 and 2 may be useful to review material related to waves, optics, and special relativity. These books are available in paper copy, or digitally:

<https://openstax.org/details/books/university-physics-volume-1>

<https://openstax.org/details/books/university-physics-volume-2>

<https://openstax.org/details/books/university-physics-volume-3>

**Homework** problem sets will be posted on canvas. There will be approximately eight sets of homework problems throughout the course.

**Course Requirements, Assessments, and Evaluations:**

The final grade will be assigned from the weighted average based on the following *provisional* grading scale.

A	90 and above
A-	87 and above
B+	83 and above
B	80 and above
B-	77 and above
C+	73 and above
C	70 and above
C-	67 and above

D+	63 and above
D	60 and above
D-	57 and above
F	below 57

### Grade Breakdown

Participation	5%
Homework	25%
Labs/ in class activities	25%
Exams	45% (15% each for three exams)

### Late Policy

Worked handed in late will incur a 10% penalty with an additional 5% penalty after the first day, up to a maximum of 50%

### Modules:

<b>Module 1</b>	<b>Photons</b>	Photoelectric effect, Compton scattering.
	<b>Wavelike Properties of Particles</b>	De Broglie hypothesis, Heisenberg uncertainty principle, wave packets.
	<b>The Schrödinger Equation</b>	Boundaries, potential wells, the simple harmonic oscillator.
<b>Module 2</b>	<b>Models of the Atom</b>	Scattering atoms, Thomson model, Rutherford atom, Bohr model.
	<b>The Hydrogen Atom</b>	1-D atom, wave functions of the H atom, intrinsic spin, spectroscopic notation.
	<b>Many-Electron Atoms</b>	Pauli exclusion principle, electronic states, outer electrons, inner electrons.
<b>Module 3</b>	<b>Statistical Physics</b>	Classical, Fermi-Dirac, and Bose-Einstein statistics.
	<b>Solid-state Physics</b>	Crystals, band theory, superconductivity, semiconductors.
<b>Module 4</b>	<b>Nuclear Structure</b>	Gross properties of nuclei, nuclear force, radioactive decay.
	<b>Nuclear Reactions</b>	Fission, fusion, nucleosynthesis.
<b>Module 5</b>	<b>Elementary Particles</b>	Forces of nature, the standard model.
	<b>Cosmology</b>	Expansion of the Universe, the cosmic microwave background, black holes.

The content may vary depending on available time with the possibility of covering more in the cosmology topic if time allows.

### Tentative Schedule of Lectures:

Day	Date	Topic	Activity	Homework
Friday	8/25/23	Introduction	1: Exp. Uncertainty EXP	
Monday	8/28/23	Photons		
Friday	9/1/23	Particle-Wave		
Monday	9/4/23	LABOR DAY	LABOR DAY	
Friday	9/8/23	Particle-Wave	2: Counting Statistics EXP	HW 1 DUE
Monday	9/11/23	Schrödinger Eqn.		
Friday	9/15/23	Schrödinger Eqn.	3: Normalizing WF & Complex Numbers	
Monday	9/18/23	Atomic Models		HW 2 DUE
Friday	9/22/23	Atomic Models	4: Balmer Series EXP	
Monday	9/25/23	Hydrogen Atom		
Friday	9/29/23	Hydrogen atom and HW 1 & 2 Review	5: Models of Hydrogen Atom	HW 3 DUE
Monday	10/2/23	EXAM 1 (75 mins)		
Friday	10/6/23	H Atom /Many e- Atom		
Monday	10/9/23	FALL BREAK	FALL BREAK	
Friday	10/13/23	Many e- Atom	6: Bound State in a Potential	HW 4 DUE
Monday	10/16/23	Statistical Physics		
Friday	10/20/23	Statistical Physics	7: Micro and Macro States	
Monday	10/23/23	Solid State		HW 5 DUE
Friday	10/27/23	Solid State	Review HW 4 & 5	
Monday	10/30/23	Review HW 4 & 5	8: Quantum dots and LEDs EXP	HW 6 DUE
Friday	11/3/23	EXAM 2 (75 mins)		
Monday	11/6/23	Nuclear Structure		
Friday	11/10/23	Nucl. Structure /Reactions		
Monday	11/13/23	Nuclear Reactions	9: Half-life of $^{137m}\text{Ba}$ EXP	HW 7 DUE
Friday	11/17/23	Elementary Particles		
Monday	11/20/23	Elementary Particles	10: Attenuation of radiation EXP	
Friday	11/24/23	THANKSGIVING	THANKSGIVING	
Monday	11/27/23	Cosmology		HW 8 DUE
Friday	12/1/23	Cosmology	11: CERN	
Monday	12/4/23	Review HW +Recitation		
TBD	TBD	FINAL EXAM (90 mins)		

**University Policies:**

**Academic Integrity:** “An essential feature of the University of Tennessee, Knoxville is a commitment to maintaining an atmosphere of intellectual integrity and academic honesty. As a student of the university, I pledge that I will neither knowingly give nor receive any inappropriate assistance in academic work, thus affirming my own personal commitment to honor and integrity.”

**University Civility Statement:** Civility is genuine respect and regard for others: politeness, consideration, tact, good manners, graciousness, cordiality, affability, amiability and courteousness. Civility enhances academic freedom and integrity, and is a prerequisite to the free exchange of ideas and knowledge in the learning community. Our community consists of students, faculty, staff, alumni, and campus visitors. Community members affect each other’s well-being and have a shared interest in creating and sustaining an environment where all community members and their points of view are valued and respected. Affirming the value of each member of the university community, the campus asks that all its members adhere to the principles of civility and community adopted by the campus: <http://civility.utk.edu/>

**Physics and Astronomy Civility Statement:** As a department, we are committed to creating an environment that welcomes all people, regardless of their identities. We value the diversity that enriches our department. We understand the importance of free and open dialogue that includes the free exchange of ideas. We do not tolerate uncivil speech or any form of discourse that infringes on others’ rights to express themselves, or has a negative impact on their education, or work environment. We actively promote an environment of collegiality and an atmosphere of mutual respect and civility. We understand that respect includes being considerate of others’ feelings, circumstances, and their individuality. We recognize the necessity of a civil community in realizing the potential of individuals in teaching, learning, research, and service. We believe these values extend beyond the department into our work within physics regionally, nationally, and internationally, as well as work and studies in the university, and the broader community. We encourage all members of the department to intervene and report any incidents involving bigotry, or that violate the university code of conduct.

**Reporting:** Anyone who experiences or observes any such incident is encouraged to report it to the Department Head or one of the Associate Heads. Students can also speak to any faculty or staff member with whom they feel comfortable. Incidents that involve sexual harassment or stalking will be reported to the office of Title IX under mandatory reporting requirements.

Additional resources and reporting available at: <http://www.phys.utk.edu/about/civility-community.html>

**Disability Services:** “The University of Tennessee, Knoxville, is committed to providing an inclusive learning environment for all students. If you anticipate or experience a barrier in this course due to a chronic health condition, a learning, hearing, neurological, mental health, vision, physical, or other kind of disability, or a temporary injury, you are encouraged to contact Student Disability Services (SDS) at 865-974-6087 or [sds@utk.edu](mailto:sds@utk.edu). An SDS Coordinator will meet with you to develop a plan to ensure you have equitable access to this course. If you are already registered with SDS, please contact your instructor to discuss implementing accommodations included in your course access letter.”

**Your Role in Improving Teaching and Learning Through Course Assessment:**

At UT, it is our collective responsibility to improve the state of teaching and learning. During the semester, you may be requested to assess aspects of this course either during class or at the completion of the class. You are encouraged to respond to these various forms of assessment as a means of continuing to improve the quality of the UT learning experience.

**Key Campus Resources for Students:**

- [Center for Career Development](#) (Career counseling and resources; HIRE-A-VOL job search system)
- [Course Catalogs](#) (Listing of academic programs, courses, and policies)
- [Hilltopics](#) (Campus and academic policies, procedures and standards of conduct)
- [OIT HelpDesk](#) (865) 974-9900
- [Schedule of Classes/Timetable](#)
- [Student Health Center](#) (visit the site for a list of services)
- [Student Success Center](#) (Academic support resources)
- [Undergraduate Academic Advising](#) (Advising resources, course requirements, and major guides)
- [University Libraries](#) (Access to library resources, databases, course reserves, and services)

If you need to miss class for illness, please email: [ikokkas@vols.utk.edu](mailto:ikokkas@vols.utk.edu) as soon as possible. You can find COVID 19 information and updates at [utk.edu/coronavirus](http://utk.edu/coronavirus).

*The instructor reserves the right to revise, alter or amend this syllabus as necessary. Students will be notified in writing / email of any such changes.*

*Updated August 10, 2023*