PHYS 252
Quantum Physics and Applications,
Spring 2023

University of Tennessee, Knoxville

Meeting Time and Place: Lecture Nielsen 304 Tuesday/Thursday 2:30 – 3:45 pm
Activities Nielsen 203 either Tuesday or Thursday 4:00 – 5:15 pm
Office Hours: Tuesday and Thursday 4:00 – 5:00 pm.
Course Credit Hours: 4

Faculty Contact Information

Dr. Kate Jones: Nielsen 407B
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Webpage: http://www.phys.utk.edu/people/faculty/jones.html

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, 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.

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 six 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 PROVISIONAL

Homework	25%
Exams	45% (15% each for three exams)
Labs/ in class activities	30%

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:

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

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
Tuesday	1/24/23	Intro	Exp.: Experimental Uncertainty	
Thursday	1/26/23	Photons		
Tuesday	1/31/23	Particle-Wave		
Thursday	2/2/23	Assessment and Particle-Wave	Expt.: Counting Statistics	
Tuesday	2/7/23	Schrödinger Eqn.	Normalizing WF & Complex Numbers	HW 1 due
Thursday	2/9/23	Schrödinger Eqn.		
Tuesday	2/14/23	Atomic Models	Expt.: Balmer Series	
Thursday	2/16/23	Atomic Models		
Tuesday	2/21/23	Hydrogen Atom	Models of Hydrogen Atom	HW 2 due
Thursday	2/23/23	Review HW 1 & 2 and Hydrogen atom		
Tuesday	2/28/23	Exam 1 1hr 15 minutes		
Thursday	3/2/23	Hydrogen Atom and Many e- Atom	Bound State in a Potential	
Tuesday	3/7/23	Many e- Atom		
Thursday	3/9/23	Molecular Structure	NMR	
Tuesday	3/14/23	SPRING BREAK		HW 3 due
Thursday	3/16/23	SPRING BREAK		
Tuesday	3/21/23	Molecular Structure	NMR	
Thursday	3/23/23	Solid State	Micro and Macro States	
Tuesday	3/28/23	Solid State		HW 4 due
Thursday	3/30/23	Review HW 3 & 4 + buffer	Expt.: Quantum dots and LEDs	
Tuesday	4/4/23	Exam 2 1hr 15 minutes		
Thursday	4/6/23	NO CLASS		
Tuesday	4/11/23	Nuclear Structure	Expt.: Quantum dots and LEDs	
Thursday	4/13/23	Nuclear Structure	Expt.: Half-life of ^{137m}Ba	
Tuesday	4/18/23	Nuclear Reactions		HW 5 due
Thursday	4/20/23	Nuclear Reactions	Expt.: Attenuation of radiation	
Tuesday	4/25/23	Elementary Particles		
Thursday	4/27/23	Elementary Particles	Alpha Decay	
Tuesday	5/2/23	Cosmology		HW 6 due
Thursday	5/4/23	Cosmology	CERN HEP	
Tuesday	5/9/23	Review/Buffer		
Weds	*5/17/23*	*Final Exam 1:00 pm 1hr 30 minutes*		

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. 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: kgrzywac@utk.edu as soon as possible.
You can find COVID 19 information and updates at *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 January 5, 2023