



Modern Physics

PHYS 3710 – Fall 2024

Instructor Info



Dr. Andreas Papaefstathiou



Office Hrs: T & R 1:00-3:00 PM
or by appointment



My Office: Academic Building
260i, (Marietta Campus)



470-578-2702



<http://facultyweb.kennesaw.edu/apapaefs>



apapaefs@kennesaw.edu

Course Info



Prereq: Grade "C" or higher in
PHYS 2212 and PHYS 2212L



Tue & Thu



3:30-4:45 PM



Academic Building 322 (Marietta Campus)

Course Overview

We will introduce the two fundamental pillars of Modern Physics: Relativity and Quantum Physics. Our main objective is to gain a basic understanding of the physical laws and phenomena that will lead us to special relativity and quantum mechanics. We will strengthen our knowledge of Special Relativity and explore aspects of the Quantum Theory of wave/particle duality and its probabilistic interpretation. We will also examine the Schrödinger equation in detail, along with its solutions for simple potentials. We will then derive the properties of the one-electron atom, and apply quantum principles to atomic, molecular and nuclear structures.

Learning Objectives

At the completion of this course, you will be able to

- Use special relativity with four-vectors to analyze differences in the behavior of objects as observed in different inertial reference frames, and explain the equivalence of mass and energy.
- Describe the major aspects of the most important experiments that have led to the development of quantum theory.
- Explain the Rutherford model of the nucleus and the Bohr model of the atom.
- Discuss wave-particle duality and Heisenberg's uncertainty principle.
- Use Schrödinger's equation to solve various simple systems.
- Discuss the spin of the electron orbital and shells for atoms, quantum numbers, and Pauli's exclusion principle.

Required Text and Material

Main Textbook: *None*. Notes will be provided.

Auxiliary Textbooks (you do not have to buy these):

J. R. Taylor, C. D. Zafiratos and M. A. Dubson, *Modern Physics for Scientists and Engineers*, 2nd Edition.

P. Tipler and R. Llewellyn, *Modern Physics*.

J. R. Forshaw and A. G. Smith, *Dynamics and Relativity*.

D. Tong, *Electromagnetism and Relativity* (<https://www.damtp.cam.ac.uk/user/tong/em/e14.pdf>).

D. J. Griffiths and D. F. Schroeter, *Introduction to Quantum Mechanics*.

D. V. Schroeder, *Notes on Quantum Mechanics*. (<https://physics.weber.edu/schroeder/quantum/QuantumBook.pdf>)

D2L

I will use D2L for course information and announcements. You can access D2L via: <http://d2l.kennesaw.edu/>. To sign on, use your KSU username and password. **Please check D2L for announcements at least once or twice a day!**

If you haven't already, I suggest that you download the Pulse app on your phones (links for: iOS or Android), which connects to D2L for instant notifications!

Homework Assignments

Homework will be assigned during the lectures and posted on D2L. We will discuss solutions to problems in class and these will also be posted on D2L following the deadline.

Please only ask for extensions if you have a valid emergency reason. If you believe you do have a valid reason, **contact me via e-mail**.

Homework that will be handed in after the deadline, without prior agreement, will receive a grade of zero!

Please attempt the problems *early*, so that if you have any questions we can discuss them with sufficient time. Do not come with questions 30 minutes before the homework deadline!

Communication

Only use e-mail to contact me (i.e. not D2L) at apapaefs@kennesaw.edu.

Please make sure that the subject line starts with "PHYS3710". Please also use your KSU e-mail address.

I will return all e-mails in 36-hours during the week and within 48 hours over the weekends.

Evaluation and Grading Policies

15%	Homework
60%	Three Tests, 20% each
25%	Final Exam

Grades will follow the scale: A = 89.5-100; B = 79.5-89.4; C = 69.5-79.4; D = 60-69.4; F <60. Curving is at the discretion of the instructor.

The lowest-scoring homework assignment will be dropped.

Extra Credit: There will be extra credit in the assigned homework in the form of bonus questions. The bonus points will be summed up throughout all the homework assignments, and the achieved fraction will contribute up to 10% extra credit, in addition to the percentage achieved through Homework, Tests and the Final Exam.

In addition, the pre-/post-evaluation tests (conducted anonymously), will each provide a 1% extra credit to your final score.

You get points in tests and exams for:

- Correctly identifying the physics of the problem.
- Setting up correctly all the equations (and/or graphs/diagrams) for the specific physics situation described in the problem and commenting when necessary or relevant.
- Correctly identifying all unknown physical variables/observables to be determined.
- Correctly working out all the symbolic and differential calculus-based operations.
- Correctly working out all the algebraic calculations to determine the solution.

Exams and Make-up Policy

Four tests will be given this semester: three tests and a final exam. The test dates are on the attached course schedule. The final exam will be comprehensive. Each test can be a combination of conceptual questions and problem-solving, free response questions.

Make-up exams or tests will not be given. If you know ahead of time you have a conflict with an exam, let me know. If you miss an exam because of an illness (yours or a family member's) or some other unforeseeable event, contact me as soon as you can. You can e-mail me or leave a message with the Physics Department office at 470-578-4205. I may ask you for documentation showing the reason for missing the exam.

Course Dos and Don'ts

Please review these important points that will help you throughout the rest of your college career, and in your future careers.

- **Regular attendance is essential for success in this class.** If you miss a class, it is your responsibility to get the notes for missed lectures from another student. And please be on time!
- Occasionally, it may be necessary to make corrections, updates or changes to this syllabus. Corrections or changes to the syllabus will be announced on D2L and in class: **you are expected to check D2L for announcements regularly (i.e. at least once or twice a day.)**
- **Cellular telephones, pagers, and similar devices must be turned off or placed in silent mode during lectures.** Use of cell phones should be restricted to emergencies.
- **In class, please avoid conversations and other disruptions that may distract other students during the lecture. If you have questions or comments, direct them to me.**
- **Rude and disrespectful student behavior will not be tolerated and administrative actions will be taken.**
- **Deadlines are deadlines for a reason. As a college student, you must plan accordingly and use your time wisely. In the "real world" you are expected to submit work on time to your boss so that you keep your job. I expect the same.**

- If you have asked for an extension on your work and do not meet the guidelines for getting an extension, and are told “no”, do not continue to e-mail. No means no, and this is grounds for a referral to student conduct.
- Do not tell your professors or employers how to do their jobs. While you may not like your professor or employer, remember that they have more experience in and knowledge about the field than you. They are also your means for networking and finding gainful employment.
- Remember that your professional aptitude not only reflects on you as a student and employee, but as a person in general. Please be sure you understand these guidelines, and if you have any questions about appropriate communication or college-level problem-solving skills, let me know.

Withdrawal Policy

KSU wants you to know that students are responsible for managing their enrollment status in a class.

Non-attendance does not constitute a withdrawal.

The last day to withdraw without academic penalty is Friday, October 25th 2024, 11:45 p.m..

If you are thinking about dropping the course, please talk to me first. Most importantly, we want to find a way for you to succeed.

Students are solely responsible for managing their enrollment status in a class. Additional information on the withdrawal policy can be found at: <http://catalog.kennesaw.edu/content.php?catoid=51&navoid=3701#withdrawalfromclasses>.

The Academic Standing Appeal policy is explained at: https://appeals.kennesaw.edu/withdrawal_appeal.php.

Academic Integrity

Every KSU student is responsible for upholding the provisions of the Student Code of Conduct, as published in the Undergraduate and Graduate Catalogs. Section 5c of the Student Code of Conduct addresses the university’s policy on academic honesty, including provisions regarding plagiarism and cheating, unauthorized access to university materials, misrepresentation/falsification of university records or academic work, malicious removal, retention, or destruction of library materials, malicious/intentional misuse of computer facilities and/or services, and misuse of student identification cards. Incidents of alleged academic misconduct will be handled through the established procedures of the Department of Student Conduct and Academic Integrity (SCAI), which includes either an “informal” resolution by a faculty member, resulting in a grade adjustment, or a formal hearing procedure, which may subject a student to the Code of Conduct’s minimum one semester suspension requirement.

All students are responsible for knowing the information, policies and procedures outlined in the Kennesaw State University Codes of Conduct. The Code is available online at <http://scai.kennesaw.edu/>.

Accommodations for Students with Disabilities

KSU is here to help. Any student with a documented disability or medical condition needing academic accommodation of class-related activities should contact the Office of Student Disability Services (<https://sds.kennesaw.edu/>).

Other Policies

See the Student Handbook (<http://catalog.kennesaw.edu/>) and the Syllabus information (<https://cia.kennesaw.edu/instructional-resources/syllabus-policy.php>) for other policies and information.

KSU SMART Center

If you require tutoring assistance, the Science and Math Academic Resource and Tutoring (SMART) Center at KSU provides tutoring for all current KSU students in Math, Science, Engineering, Humanities, and Social Science courses. See <https://academicaffairs.kennesaw.edu/smart/index.php> for further details.

Illness

If you are feeling ill, please stay home and contact your health professional. In addition, please e-mail your instructor to say you are missing class due to illness.

Class Schedule (Tentative)

PART I: The Theory of Special Relativity

Week 1	Aug 13	<i>Chapter 1: A New Theory of Space and Time.</i> Introduction to Relativity. The speed of light. The Michelson-Morley experiment. Einstein's postulates.
	Aug 15	Time dilation, length contraction and simultaneity, The Lorentz transformations. The velocity-addition formula.
Week 2	Aug 20	<i>Chapter 2: Relativistic Mechanics.</i> Mass in Relativity. Relativistic Momentum. Relativistic Energy. Useful relations in Relativity. Conversion of mass to energy.
	Aug 22	Force in Relativity. Massless particles. When is Non-relativistic mechanics good enough?
Week 3	Aug 27	<i>Chapter 3: The Symmetries of Space and Time.</i> Symmetries in Physics. Rotations and Translations. Galilean symmetry.
	Aug 29	Lorentz Symmetry. four-vectors and Lorentz invariants. The wave four-vector. The energy-momentum four-vector. Space-time diagrams. Relativity and causality.
Week 4	Sep 3	<i>Chapter 4: Electromagnetism and Relativity.</i> Four-vectors revisited. Raising and lowering indices. Vectors, covectors and tensors. Conserved currents.
	Sep 5	Magnetism and Relativity. Gauge potentials and gauge transformations. The electromagnetic tensor.
Week 5	Sep 10	Boosted point charge. Lorentz scalars in electromagnetism. Maxwell's equations in four-vector form. The Lorentz force law.
	Sep 12	<u>TEST 1</u>

PART II: An Introduction to Quantum Mechanics

Week 6	Sep 17	<i>Chapter 5: Atoms.</i> Elements, atoms and molecules. Electrons, protons and neutrons. Atomic parameters. The atomic mass unit. Avogadro's number and the mole. Thomson's and Millikan's experiments. Rutherford's model of the nuclear atom.
	Sep 19	<i>Chapter 6: Quantization of Light.</i> Blackbody radiation and Planck's theory. The photoelectric effect. X-rays and Bragg diffraction. The Compton effect. Wave-particle duality.
Week 7	Sep 24	<i>Chapter 7: Quantization of Atomic Energy Levels.</i> Atomic spectra. The Balmer-Rydberg Formula. The problem of atomic stability. Bohr's explanation of the atomic spectra. The Bohr model of the Hydrogen atom.
	Sep 26	Properties of the Bohr atom. Hydrogen-like ions. X-ray spectra.
Week 8	Oct 1	<u>TEST 2</u>

	Oct 3	<i>Chapter 8: Matter Waves.</i> The De Broglie Hypothesis. The Quantum Wave Function. Sinusoidal waves.
Week 9	Oct 8	Wave packets and Fourier analysis. The Heisenberg uncertainty principle. Dirac Notation.
	Oct 10	<i>Chapter 9: The Schrödinger Equation in one Dimension.</i> Classical standing waves. Standing waves in Quantum Mechanics and stationary states. Particle in a rigid box.
Week 10	Oct 15	The time-independent Schrödinger equation. The rigid box again. The non-rigid box. The simple harmonic oscillator. Tunneling. The time-dependent Schrödinger equation.
	Oct 17	<i>Chapter 10: The Three-Dimensional Schrödinger Equation.</i> Partial derivatives.
Week 11	Oct 22	The two-dimensional square box. The two-dimensional central force problem.
	Oct 24	<u>TEST 3</u>
Week 12	Oct 29	The three-dimensional central-force problem.
	Oct 31	<i>Chapter 11: Electron Spin.</i> Spin angular momentum. Magnetic moments. The Zeeman effect.
Week 13	Nov 5	Hydrogenic wave functions. Hydrogen-like ions.
	Nov 7	Spin magnetic Moments. The anomalous Zeeman effect. Fine structure.
Week 14	Nov 12	<i>Chapter 12: Multielectron Atoms and the Pauli Exclusion Principle.</i> The independent-particle approximation.
	Nov 14	The Pauli exclusion principle. Fermions and Bosons.
Week 14	Nov 19	Ground states of the first few elements. The periodic table.
	Nov 21	LAST DAY OF CLASSES - REVISION
Week 17	Dec 5 (3:30 – 5:30 PM)	<u>FINAL EXAM</u>