MODERN PHYSICS

Phys 231 Spring 2026

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Office Hours:	M 10 – 11am, T 1 – 2pm, W 9 – 10am, Th 3:30 – 4:30pm, F 2 – 3pm
Class Meetings:	MWF 1:00pm – 1:50pm, WS 113
Course Website:	Phys 231 Website, Spring 2026
Required Text:	Gary N. Felder and Kenny M. Felder, *Modern Physics,* Cambridge (2023).
Prerequisites:	Phys 132/132L, and Math 253.

Overview

Phys 231 is an overview of modern physics emphasizing quantum theory and its applications. Quantum theory was developed in the early twentieth century in response to several observed phenomena which could not be described by classical physics. This theory successfully solved many outstanding problems, particularly those related to physics at the microscopic level, and currently provides the broadest understanding of the physical world at the most fundamental levels. A majority of physics research activity today involves quantum theory in some form. Quantum theory is essential for understanding how elements of modern technology such as lasers, semiconductors, superconductors, nuclear reactors, and magnetic resonance operate. It also gives rise to many apparently bizarre phenomena, which are completely counter-intuitive and inexplicable from your everyday classical perspective. Almost a century after its invention, experts still do not agree on the interpretation of such fundamental features as measurement or preparation of a quantum system.

The course covers:

1. Historical quantum physics phenomena.
2. Particle diffraction and matter waves.
3. Particle wavefunctions, measurements and probabilties.
4. One dimensional Schrödinger equation and applications such as confined particles.
5. Three dimensional Schrödinger equation, angular momentum and the hydrogen atom.
6. Identical particles.
7. Spin-1/2 particles.

8. Selected applications of quantum theory.

Assignments

An undergraduate student should expect to work a minimum of two hours outside the classroom for every hour in the classroom. The outside hours may vary depending on the number of credit hours or type of course. More details are available from the faculty member or department office and in CMU's Curriculum Policies and Procedures Manual.

1. **Homework:** There will typically be one homework assignment per week. This will be due by 5pm on the date indicated on the assignment. It is in your best interests to work by yourself on the homework problems but collaboration is acceptable. You can discuss the broad outlines of problem solutions with your colleagues at CMU but must write your final solutions independently. You are also encouraged to consult me for help with homework problems.

Exams and Quizzes

1. **Class Exams:** There will be two exams during class on the following days:

   Exam 1: February 20, 2026
   Exam 2: March 30, 2026
   Exam 3: May 1, 2026

   Exams will be closed book and closed notes although you will be able to bring a formula sheet. Calculators will be allowed.

2. **Final Exam:** There will be a final exam at **1:00pm on Wednesday, May 13, 2026**. The final will consist of a single exam done outside of class. Students will have two hours to complete the exam and submit it electronically.

Grades

Individual assignments and exams will be graded using suitable scales. In general, to get full credit (100%) for a problem your solution must be correct with complete explanations and calculations. Partial credit will be given for incomplete or partly correct solutions. No credit (0%) will be given for problems not attempted, assignments not turned in or quizzes and exams missed without good reason.

The numerical grades for each component will be totaled and a final numerical grade will be computed according to the following distribution.

Homework	25%
Class Exams	45%
Final Exam	30%

The following final numerical scores will guarantee letter grades:

90%	A
80%	B
70%	C
60%	D

Policies

1. **Helpful Resources:** The Center for Academic Support (CAS) provides FREE tutoring and writing support across all disciplines to CMU and CMU Tech students in a variety of subject areas. Peer tutors are available to support your learning and help you with your questions. CAS offers four different tutoring options to students: in-person tutoring (one-on-one), online tutoring, group tutoring, and writing help. Check out the CAS website or or email tutoring@coloradomesa.edu with any questions.

   In coordination with Educational Access Services, reasonable accommodations will be provided for qualified students with disabilities. Students should contact Educational Access Services at 970-248-1856 or Houston Hall 108 as soon as possible. Please visit Educational Access Services for additional information.

2. **Attendance:** Attendance policies are described in the Maverick Guide. You are expected to attend all the class meetings and attendance will be recorded. In case of an absence due to illness, another emergency, or a conflicting CMU-sanctioned event, you must be able to produce the *appropriate documentation from someone other than you* that attests to the conflict or absence. If you miss a class for a *documented* valid reason, turn in any assignments due within two business days after the end of the documented absence period. If you miss more than half of the class meetings in the first week of the semester, you will be dropped from the course.

   The dates of the class and final exams are set at the beginning of the semester and these have priority over any other events. If you have a conflicting event with these **that was scheduled before the start of the semester,** you must notify the instructor about this prior to 5:00pm on **Friday, January 23, 2026**, provide documentation from someone other than you that attests to the event and I will arrange an alternative test time. If you notify the instructor about a conflict after **Friday, January 23, 2026**, the possibility of taking the test at an alternative time will depend on the nature of the conflict (e.g. illness, other emergencies, or CMU-sanctioned event). In this case you must explain the nature of the conflict to the instructor, provide documentation from someone other than you that attests to the conflict and the instructor will decide whether the absence warrants an alternative testing time or arrangement. Alternative testing times will be decided by the instructor.

3. **Withdrawals:** There are several ways to drop this course. The deadline for dropping without penalty is **February 4, 2026.** Please consult the CMU academic calendar and catalog for more details about adding and dropping courses.

4. **Electronic Equipment Use:** The only electronic equipment that can be used during exams are calculators. During exams you will not be allowed to use electronic equipment that allows you to communicate with the internet, other people or to store information, e.g. tablets, computers, phones. The only exceptions are for students who have a documented disability and need a particular device as part of their disability accommodation.

5. **Academic Integrity:** You are expected to present your own work in assignments, exams and quizzes. Fabrication of data, plagiarism, and copying from any source, particularly in closed book exams, are serious violation of academic norms. CMU has extensive policies on these matters and penalties for infringement can be severe. For more details, consult the academic integrity policies in the Maverick Guide.

   You are prohibited from using sources, of any type, which provide solutions to homework assignment or exam problems. These include AI sources that generate solutions to homework problems. Students who are discovered to have submitted any assignment or exam problem to any such service that provides solutions or have used any such service to obtain or view solutions to any assignment or exam problem will receive zero credit for that entire assignment and the instructor will submit a Report of Academic Dishonesty with the Office of Academic Affairs. Additional penalties may be levied in such cases.

Learning Outcomes

Upon completion of this course, a student should be able to:

1. Translate between verbal and mathematical descriptions of physical situations and apply mathematical reasoning, using probability, integration, and differential equations, to analyze these situations.
2. Describe and examine key early quantum phenomena such as blackbody radiation, the photoelectric effect, the Compton effect, particle diffraction and atomic spectra.
3. Apply energy quantization to determine how quantum systems absorb and emit electromagnetic radiation.
4. Describe the Bohr model of the hydrogen atom and use it to predict atomic spectra.
5. Determine and relate probabilities, expectation values and uncertainties for measurement outcomes.
6. Use the wavefunction model, including superpositions of wavefunctions, to describe the outcomes and statistics of measurements on quantum systems.
7. Solve wavefunctions for free particles.
8. Solve the Schrödinger equation in one dimension for a particle in an infinite well and for the one-dimensional harmonic oscillator.
9. Solve the Schrödinger equation one dimension for step and barrier potentials and interpret the solutions.
10. Solve the Schrödinger equation for the hydrogen atom and interpret the solutions using angular momentum.

This course contributes to the fulfillment the following program learning objectives for the BS in Physics degree. A student will have demonstrated the ability to:

1. Show fluency with the major fields of physics (classical mechanics, electromagnetism, statistical physics and quantum theory).
2. Use mathematical representations to analyze physical scenarios.
3. Reflect on ethical, social and civic issues in physics.

Schedule

The following schedule is tentative, except for the dates of the class exams.

Week	Dates	Topic
1	1/21– 1/23	Photoelectric effect (Ch. 3.1 – 3.3, 3.5).
2	1/26 – 1/30	Compton effect, Rutherford atom, wave and particle picture of light (Ch. 3.1 – 3.3, 3.5).
3	2/2 – 2/6	Waves, interference, complex numbers .
4	2/9 – 2/13	Particle interference, matter waves (Ch 4.2).
5	2/16 – 2/18	Bohr model, probability (Ch 4.1).
5	2/20	**Class Exam I**.
6	2/23 – 2/27	Probability, waves for particles in one dimension (Ch 5.1, 5.2).
7	3/2 – 3/6	Waves for particles in one dimension (Ch 5.2).
8	3/9 - 3/13	Schödinger equation in one dimension, infinite wells (Ch 5.3).
–	3/16 – 3/20	**Spring Break** (no classes).
9	3/23 – 3/25	Harmonic oscillator, time evolution (Ch 5.4, 6.6).
10	3/30	**Class Exam II**.
10	4/1 – 4/3	Free particles, momentum (Ch 6.1– 6.3).
11	4/6 – 4/10	Step potentials, tunneling (Ch 6.5).
12	4/13 – 4/17	Quantum physics in three dimensions, hydrogen atom (Ch 7.2 – 7.3).
13	4/20 – 4/24	Hydrogen atom, angular momentum (Ch 7.4).
14	4/27 – 4/29	Hydrogen atom, spin (Ch 7.5).
14	5/1	**Class Exam III**.
15	5/4 – 5/8	Identical particles (Ch 8.1 – 8.3).