MODERN PHYSICS

Phys 231 Spring 2020

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Office Hours:	M 10 – 11am, T 2 – 3pm, W 1 – 2pm, F 10 – 11am, F 2 – 3 pm
Class Meetings:	MWF 11:00am – 11:50am, DH 212
Course Website:	http://www.coloradomesa.edu/~dacollin/teaching/2020Spring/Phys231/index.html
Required Text:	R. Harris, *Modern Physics,* Pearson (2008).
Prerequisites:	Phys 132/132L, and Math 253

Overview

Phys 231 is an overview of modern physics with a strong emphasis on quantum mechanics and its applications. Quantum mechanics 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 mechanics in some form. Quantum mechanics 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 physics.

Assignments

An undergraduate student should expect to spend on this course 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 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:	**21 February 2020**
Exam 2:	**30 March 2020**
Exam 3:	**27 April 2020**

   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 **13 May 2020**. The final will last one hour and 50 minutes and be comprehensive and closed book although a formula sheet will be allowed. Calculators will be allowed.

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 and well justified. 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	30%
Class Exams	35%
Final Exam	35%

The following final numerical scores will guarantee letter grades:

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

Policies

1. **Helpful Resources:** The Tutorial Learning Center (TLC) is a *free* academic service for all CMU students. Tutors are available in Houston Hall 113 on a walk-in basis for many courses. More information is available at www.coloradomesa.edu/tutoring or 248-1392.

   In coordination with Educational Access Services, reasonable accommodations will be provided for qualified students with disabilities. Students must register with the EAS office to receive assistance. Please meet with the instructor the first week of class for information and/or contact Dana VandeBurgt, the Coordinator of Educational Access Services, directly by phone at 248-1801, or in person in Houston Hall, Suite 108.

2. **Withdrawals:** There are several ways to drop this course. The deadline for dropping without penalty is **5 February 2020.** Please consult the CMU academic calendar and catalog for more details about adding and dropping courses.

3. **Attendance:** Attendance policies are described in the CMU catalog. You are expected to attend all the class meetings. In case of illness or other emergencies you must be able to produce the appropriate documentation. There are other circumstances under which you can be excused but you must discuss these with me in advance. If you miss a class or lab for a valid reason, turn in any assignments due before the start of the next class. Assignments turned in beyond your return to class will not be accepted.

   If there is an unavoidable conflict with one of the class exams or the final exam, please discuss it with me as soon as possible. In general I will assume that the final exam will have priority, since you know the dates of the exam.

4. **Academic integrity:** You are expected to present your own work in assignments, exams and quizzes. Fabrication of data, plagiarism, and copying from anyone else, 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 CMU catalog.

Objectives

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

1. Describe Millikin's oil drop experiment.
2. Demonstrate familiarity with the shortcomings of classical physics when applied to blackbody radiation and the Rayleigh-Jeans equation.
3. Solve Planck's law problems.
4. Demonstrate familiarity with the photoelectric effect, the Compton effect and Rutherford scattering.
5. Describe Rutherford's nuclear model.
6. Describe the Bohr model of the hydrogen atom.
7. Describe the correspondence principle
8. State the de Broglie relations
9. Demonstrate familiarity with the nature of wave-particle duality.
10. Demonstrate familiarity with wave packets and describe the difference between group and phase velocities.
11. Describe the probabilistic interpretation of the wave function.
12. Demonstrate familiarity with the Heisenberg uncertainty principle.
13. Solve the one-dimensional, time-independent Schrödinger equation for the infinite square well potential and the harmonic oscillator.
14. Demonstrate familiarity with the finite square well potential.
15. Demonstrate familiarity with expectation values and operators.
16. Solve the three-dimensional, time-independent Schrödinger equation for the infinite square well potential.
17. Demonstrate familiarity with quantization of angular momentum and energy in the hydrogen atom and electron spin.

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. This requires translating back and forth between physical and mathematical problems and using appropriate mathematics to aid in the analysis of the scenario.

Schedule

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

Week	Dates	Topic
1	1/21– 1/24	Blackbody radiation, photoelectric effect (Ch. 3.1 – 3.2).
2	1/27 – 1/31	Photoelectric effect, Compton effect, Rutherford atom (Ch. 3.2 – 3.4).
3	2/3 – 2/7	Particle diffraction and interference, de Broglie relationship, (Ch. 3.6, 4.1 – 4.2).
4	2/10 – 2/14	Matter waves, Bohr model (Ch. 4.4 – 4.6).
5	2/11 – 2/19	Probability, Wavefunctions (Ch. 4.3).
5	2/21	**Class Exam I**.
6	2/24 – 2/28	Measurement probabilities, uncertainty relations, wavepackets (Ch 4.7, 5.8).
7	3/2 – 3/6	Schrödinger equation (Ch 5.1 – 5.4).
8	3/9 - 3/13	Confined particles (Ch 5.5 – 5.8).
9	3/16– 3/20	Spring break (no classes).
10	3/23 – 3/27	Time evolution, wavepackets (5.8 – 5.9).
11	3/30	**Class Exam II**.
11	4/1 – 4/3	Step potentials, tunneling (Ch. 6.1 – 6.3).
12	4/6 – 4/10	Quantum physics in three dimensions, hydrogen atom (Ch. 7.1 – 7.2).
13	4/13 – 4/17	Hydrogen atom, angular momentum (Ch 7.3 – 7.7).
14	4/20 – 4/24	Spin, identical particles (Ch 8.1 –8.4).
15	4/27	**Class Exam III**.
15	4/29 – 5/1	Selected topics TBA.
16	5/4 – 5/8	Selected topics TBA.