# Physics 203 Modern Physics Spring 2020

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Class Mtgs: MWF 1:10-2:10 (TREX 272)
Office Hrs: Th 9-12
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**Course Description:**

Special relativity, particle properties of waves, wave properties of particles, Heisenberg uncertainty principle, Bohr theory, elementary quantum theory and its application to the hydrogen atom. We will also survey selected applications of special relativity and quantum mechanics.

**Textbooks:**

• *Modern Physics for Scientists and Engineers (4th ed.)* by Thornton and Rex,
ISBN-13: 978-1133103721

**Purpose of the Course:**

In 1880, physics consisted of Newtonian mechanics, electromagnetic theory and classical thermodynamics. Many physicists back in 1880 believed that classical physics could in principle explain *everything* in nature. In 1875, the physicist Kirchhoff reportedly said to a student, "Why do you want to study physics? Everything is done and understood!" Soon, though, problems began to surface. The Michelson-Morley raised the question of what medium light waves actually travel in. Calculations showed that the electric and magnetic fields in 'blackbody' cavities should contain an infinite amount of energy. Atomic spectral lines could not be well explained. And, when the atom was determined experimentally to contain a positive nucleus orbited by negative electrons, there was no good way to explain the stability of the atom. These problems could be solved only with revolutionary new physical ideas. Special relativity accurately describes the behavior of matter at high velocities, while quantum mechanics accurately describes its behavior at very small length scales. As velocities decrease, or the length scale increases, respectively, these two theories agree with the laws of classical physics. This semester, we will work hard at understanding these two theories, and their relevance for modern scientific research and technology.

**Specific Goals of the Course:**

1. Attain a clear understanding of the main concepts of special relativity and quantum mechanics.
2. Appreciate the problems within classical physics that led to the development of these theories.
3. Understand the relevance of the two theories to modern science and technology.

**Feedback and Evaluation:**

I will assign numerical grades to all your work. I *may* curve your final grades (upward), but otherwise you can expect to receive an “A” for 90-100, a “B” for 80-89, etc. I will assign +/- to your final grades by examining the distribution of grades. These are the categories and percentages that will be used:

| | | | |
|---|---|---|---|
| Preparation: | 10% | Participation: | 15% |
| Problem Sets: | 25% | Tests: | 20% |
| Final Exam (Presentation): | 10% | Lab: | 20% |

Preparation will consist of watching a pre-recorded lecture, and will be evaluated via straightforward quizzes given at the beginning of selected class periods. Preparation is important because it enables you to participate actively in the collective group problem-solving (see next item).

Participation will consist mainly of collective group problem-solving on several problems per class. I will be lecturing very little during class, and relying on your viewing of the pre-recorded lectures and your collective work on these problems to absorb the material. You will rotate through groups of two or three as the semester progresses, getting to work with all (or nearly all) other members in the class – valuable experience in learning to work with others with different problem-solving styles and personalities. You are not required to solve each problem in the time allotted, but to put in a strong effort, at which point the solution will be revealed and discussed. Note that MCSP write-ups (see below) also form a small portion of the participation grade (5 of the 15%).

Problem sets will be due at the start of class, and should reflect your individual effort, with collaboration only at the level of general concepts. Every effort will be made to return them within one week, and solutions will be posted online.

The three tests will involve problems similar in difficulty to those in the problem sets. They will include several conceptual questions, in short-answer format, as well as several calculation questions.

The final exam will consist of an oral presentation on an extension of the course material to an advanced topic in modern physics (likely drawn from the later chapters in our textbook), in four groups of either three or four students. One week (three class days) will be devoted to researching the project, and the final class day to preparing the presentation. Each group member should speak approximately an equal amount during the presentation, which takes place during our final exam period.

MCSP Colloquium Series:
The MCSP department offers a series of talks related to math, computer science and physics. Attendance for at least two of these talks is mandatory. Within one week of attending a talk, you must submit (via a link on Inquire) a one-page single-spaced paper reflecting on the discussion. This should be not only a summary of the content, but also a personal reflection on the experience of the talk.

Laboratory:
The PHYS 203 lab component is taught in a separate meeting by a different instructor (Matt Fleenor), and will complement and ground the material being covered in this course.

**Attendance Policy:** Attendance is very important, especially given the interactive group nature of the in-class experience. You must notify me in advance if you must miss class for a valid reason (an excused absence). Any student who misses a total of five classes unexcused will be dropped from the course with a grade of DF. A warning email (cc'd to your advisor and the registrar) will be sent after the fourth unexcused absence occurs. If a student shows up for class 20 minutes late, leaves in the middle of class, or is caught repeatedly texting/checking emails/browsing the Internet during class, that student will be given an unexcused absence for the class.

**Expected Hours:** This course expects you to spend at least 12 hours per week in and out of class.

**Policy on Late Work:** For problem sets, I will grade an assignment with a 10% lateness deduction if turned in by 5:00PM on the due date. Following that, assignments will receive a further 10% lateness deduction for each successive *school day* late (with days considered to end at 5:00 PM).

**Make-up Tests:** Make-up tests may be given only under unusual circumstances. If you miss a test, and have an official college excuse for that absence, then I will generally be willing to arrange for a make-up test, but I reserve the right to have your overall test average substitute for the missed test.

**Academic Integrity:** The College academic integrity policies are vigorously enforced. Although you are encouraged to work in groups on problem sets, at a general conceptual level, all specific problem-solving work turned in for a grade must be your own. Please familiarize yourself with the College's academic integrity policies.

**Accessible Education Services:** *Accessible Education Services (AES)* is located in the Goode-Pasfield Center for Learning and Teaching in Fintel Library. AES provides reasonable accommodations to students with documented disabilities. To register for services, students must self-identify to AES, complete the registration process, and provide current documentation of a disability along with recommendations from the qualified specialist. Please contact Laura Leonard, Assistant Director of Academic Services for Accessible Education, at 540-375-2247 or by e-mail at aes@roanoke.edu to schedule an appointment. If you have registered with AES in the past and would like to receive academic accommodations for this semester, please contact Laura Leonard at your earliest convenience to schedule an appointment.

**Subject Tutoring:** Located on the lower level of Fintel Library (Room 5), tutoring is open 4 pm – 9 pm, Sunday – Thursday. We are a Level II Internationally Certified Training Center through the College Reading and Learning Association (CRLA). We have an excellent physics tutor this semester named Rachel Lindsay, whom some of you may know already. Tutoring sessions are available in 15, 30, or 45-minute appointments. Feel free to drop by for a quick question or make an appointment at www.roanoke.edu/tutoring for a longer one-on-one appointment. For questions or concerns, please contact 540-375-2590 or subject_tutoring@roanoke.edu.

| # | Date | Topic | Reading | Due | Laboratory |
|---|---|---|---|---|---|
| | | **UNIT 1: Unexpected experiments** | | | |
| 1 | Jan. 13 | Introduction to the course | -- | | Lab schedule posted |
| 2 | 15 | Classical physics | 1.1-1.3 | | in an update soon |
| 3 | 17 | Atomic theory, & unresolved questions | 1.4-1.6 | | |
| 4 | 20 | The Electron and Its Charge | 3.1-3.2 | | |
| 5 | 22 | Line spectra | 3.3-3.4 | | |
| 6 | 24 | Blackbody radiation | 3.5 | | |
| 7 | 27 | Photoelectric effect | 3.6 | PS 1 | |
| 8 | 29 | Compton effect | 3.8 | | |
| 9 | 31 | Rutherford scattering | 4.1-4.3 | | |
| 10 | Feb. 3 | The Bohr model | 4.4-4.5 | PS 2 | |
| 11 | 5 | Review/catchup | | | |
| 12 | 7 | **TEST 1** | | | |
| | | **UNIT 2: Quantum theory** | | | |
| 13 | 10 | No class (Dr. Robb out of town) | | | |
| 14 | 12 | De Broglie waves and scattering | 5.1-5.3 | | |
| 15 | 14 | The Uncertainty Principle | 5.4-5.6 | | |
| 16 | 17 | Probability and wavefunctions | 5.7-5.8 | | |
| 17 | 19 | The Schrodinger equation | 6.1 | | |
| 18 | 21 | Expectation values | 6.2 | | |
| 19 | 24 | Infinite square wells | 6.3, 6.5 | | |
| 20 | 26 | Barriers and tunneling | 6.7 | PS 3 | |
| 21 | 28 | Alpha decay and scanning microscopes | 6.7 | | |
| | | **Spring Break** | | | |
| 22 | Mar. 9 | The hydrogen atom | 7.1-7.2 | | |
| 23 | 11 | Quantum numbers | 7.3 | | |
| 24 | 13 | Magnetic effects and intrinsic spin | 7.4,7.5 | PS 4 | |
| 25 | 16 | Review/catchup | | | |
| 26 | 18 | **TEST 2** | | | |
| | | **UNIT 3: Special relativity** | | | |
| 27 | 20 | The ether and Michelson-Morley | 2.1-2.2 | | |
| 28 | 23 | Einstein postulates; Lorentz transformation | 2.3,2.4 | | |
| 29 | 25 | Time dilation and length contraction | 2.5,2.6 | | |
| 30 | 27 | Experimental verifications | 2.7 | | |
| 31 | 30 | The twin paradox and spacetime | 2.8,2.9 | PS 5 | |
| 32 | Apr. 1 | Relativistic momentum and energy | 2.11,2.12 | | |
| 33 | 3 | Relativistic collisions | 2.11,2.12 | | |
| 34 | 6 | Review/catchup | | PS 6 | |
| 35 | 8 | **TEST 3** | | | |
| 36 | 10 | **Good Friday** | | | |
| | | **UNIT 4: FURTHER TOPICS** | -- | | |
| 37 | 13 | Research on final topic in groups | -- | | |
| 38 | 15 | Research on final topic in groups | -- | | |
| 39 | 17 | Research on final topic in groups | | | |
| 40 | 20 | Preparation of final presentations | | | |
| | | **FINAL EXAM: Monday, April 27, 2:00-5:00** | -- | | |