Physics-III: Modern Essentials (33-211)

"Not only God knows, I know, and by the end of the semester, you will know."

-Sidney Coleman

Course Description:
This course is about the revolutions in physics (Relativity and Quantum Mechanics) that took place in the early 20th century. Relativity and Quantum Mechanics changed our understanding of reality and what we take physics to be. They were important both philosophically and practically in shaping the modern world. Philosophically, they up-ended our common-sense notion of the way the world works. Practically, they underlie our understanding of everything from the basic stability of matter to the operation of modern electronics. These theories are the foundation for modern physics; the Standard Model of particle physics – our current best understanding of nature on the smallest scales – is by and large a direct consequence of the combination of the principles Relativity and Quantum Mechanics. These revolutions continue to take center stage in the drama that underlies current research in physics and cosmology.

The first part of the course will focus on the motivation for – and implications of – Einstein's theory of relativity. Relativity is the correct way to think about space and time. The necessary mathematics is simple, but the concepts challenge our everyday intuition.

The second part of the course introduces Quantum Mechanics, the basic theory used to describe the microscopic world. We will briefly discuss its historical development and how – by completely changing our view of reality – we were finally able to account for basic features of our everyday lives. Here again, the concepts are challenging, but the mathematical formalism is straightforward.

The class will improve your skill in thinking through and solving physics problems and apparent philosophical paradoxes. One of the main goals of the course is to develop reliable intuition for relativistic and quantum physics.

Professor:
John Alison
Office: 7420 Wean
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Lectures:
MWF 9:00-9:50 am in Doherty Hall 1211
H 10:00-10:50 am in Wean Hall 7316

Office Hours:
T: 3:30 - 4:30
H: 2:30 - 3:30

References:
This course use the textbook "Modern Physics, 5th edition", by Paul A. Tipler and Ralph A. Llewellyn, as well as some extra lecture material and supplementary notes. This book has been chosen because it covers the required material at an appropriate level and is available electronically online. Message me if you cannot find a copy with a simple web search.

Course Website: https://canvas.cmu.edu/courses/32799

Grader:
Patrick Shaw
Email: pshaw2@andrew.cmu.edu

Grading: There will be three one-hour exams during the semester and a three-hour comprehensive final exam. The hour exams will be given during regular class times in the usual lecture room. They will be closed-book exams with no electronic devices permitted. If you cannot take an exam for any reason, tell the instructor beforehand, after-the-fact make-up exams cannot be given.

The amounts to which the homework, mid-terms and final exam contributes to your grade are:

Mid-term Exams	45%
Final Exam	45%
Assignments	10%

Letter grades will be computed from your overall numerical score at mid-semester and again at the end of the semester. You are not in competition with your fellow students, but only with yourself and with the material. In borderline cases, based on the instructors' perception of your work, we will consider diligent lecture attendance, class participation, and consistency of performance throughout the semester.

Assignment Philosophy: There will be weekly homework assignments, consisting of readings and written problems. Doing the assignments, especially problem solving, is the single most important tool for learning the course material. The assignments are intended to:

- Fill in claims/sketches of arguments made in class.
- Reiterate concepts discussed in class.
- Build your problem solving skills
- Introduce/exercise "straight-forward" concepts from your reading.
- Set the stage for future topics.
- "Fun facts": ideas/calculations that are interesting (or historically important) that you can now understand.

Homework dealing with the ongoing week's concepts will be due on Fridays, uploaded to Canvas. Written solutions will later be provided on the course website. A random subset of the problems will be graded in detail, and all problems will be checked to see if you made a serious effort to solve them. 20% credit per day will be deducted for late work, and zero credit will be given after the solutions are posted.

Pro-Tip: review your returned work and the posted solutions each week, even the problems that were not graded in detail. Test problems will be similar to the homework problems.

Assignment Collaboration Policy: Speak to each other! You often learn just as effectively through discussion with your peers as you do from lecture. However, all homework you submit should be written individually and independently by you. All the work you submit should be your own work and reflect your understanding.

Preliminary Schedule: The following is a rough outline of topics we will discuss each week.

Week 1	Big picture / Foundations of Relativity	Jan -/18/19/20
Week 2	The interval / Lorentz Transformations	Jan 23/25/26/27
Week 3	Spacetime diagrams / Paradoxes / Doppler Effect	Jan 30/ Feb 1/2/3
Week 4	Velocity Parameter / Relativistic Momentum / **Exam 1**	Feb 6/8/9/**10**
Week 5	Relativistic Energy / Invariant Mass	Feb 13/15/16/17
Week 6	Applications / General Relativity	Feb 20/22/23/24
Week 7	Early Atomic Theory / Black Body Radiation / **Exam 2**	Feb 27/March 1/2/ **3**
Week off	Spring Break	-/-/-/-
Week 8	Radioactivity / photo-electric effect / X-rays / Photons	March 13/15/16/17
Week 9	Models of Atoms (Rutherford/Bohr) / X-rays (revisited)	March 20/22/23/24
Week 10	Models of Atoms	March 27/29/30/31
Week 11	Wave nature of particles	April 3/5/6/7
Week 12	Uncertainty Principle / **Exam 3**	April 10/**12**/-/-
Week 13	Schrodinger Equation	April 17/19/20/21
Week 14	Atoms done right	April 24/26/27/28