Axioms, Goals, etc

Physics II: Modern Physics

Spring 2024. College of the Atlantic

Axioms: In mathematics and physics, axioms are propositions that are assumed to be true. The mathematician Federico Ardila-Mantilla has written four axioms that guide the work he does in education and outreach. Federico's axioms resonate strongly with me. They are:

1. Mathematical [and physics] potential is distributed equally among different groups, irrespective of geographic, demographic, and economic boundaries.
2. Everyone can have joyful, meaningful, and empowering mathematical [and physics] experiences.
3. Mathematics [and physics are] a powerful, malleable tools that can be shaped and used differently by various communities to serve their needs.
4. Every student deserves to be treated with dignity and respect.

Community Agreement: Taking the above axioms as a starting point, let's think about what type of community we want to create this term. Here is a community agreement based on one written by Federico Ardila-Mantilla.

> This course aims to offer a joyful, meaningful, and empowering experience to every participant; we will build that rich experience together by devoting our strongest available effort to the class. You will be challenged and supported. Please be prepared to take an active, critical, patient, creative, and generous role in your own learning and that of your classmates.

Course Goals:

1. Stay physically and mentally healthy and maintain intellectual and personal connection during a potentially difficult time.
2. Experience the challenge, joy, and beauty of theoretical physics.
3. Gain a firm, grounded, enduring understanding of the basic elements and structure of special relativity and quantum mechanics.
4. Engage with the philosophical and ontological questions surrounding relativity and quantum mechanics. I hope you'll leave this course thinking somewhat differently about space/time, reality, determinism, and causality.
5. I want to help you improve your basic facility with algebra and functions, your problem solving skills, your ability to create and interpret different types of graphs, and your overall mathematical confidence.
6. Have fun while growing and learning.

Official Course Description

What are relativity and quantum mechanics, and why were they viewed as revolutionary when they were formulated in the early 1900s? How and why do relativity and quantum mechanics compel us to discard commonsense ideas about the nature of the physical world that are part of classical mechanics? Why is there not agreement on how to interpret quantum mechanics, and why does quantum mechanics even need interpretation? This version of Physics II covers Einstein's theory of special relativity and selected topics in quantum mechanics, and is designed to introduce students to some of the formalism and central results of relativity and quantum mechanics, so that they can formulate scientifically grounded answers to the above questions. Throughout the course we will start with first principles and carefully build toward key results, allowing students to see how relativity and quantum mechanics—two of the pillars of modern physics—were constructed and how they cohere as mathematically consistent and experimentally verified theories. The first half of the course will cover relativity topics including the principle of relativity, spacetime intervals and proper time, coordinate transformations, time dilation and Lorentz contraction, and relativistic energy and momentum. The second half of the course will turn toward the foundations of quantum mechanics, including: spin-1/2 particles, wave-particle duality, and Bell's inequalities and the Einstein-Podolsky-Rosen paradox. If time permits, we may cover additional topics such as blackbody radiation, the photoelectric effect, Bohr's model of the hydrogen atom, and quantum cryptography. To gain a sense of the scientific, social, and material context in which the theories of relativity and quantum mechanics were developed, we will read a number of papers and book chapters by historians and philosophers of science. This course is designed to appeal to a wide range of students: both those whose interests lie outside of science as well as those who are drawn toward the sciences or mathematics. Students who take this course should be comfortable working with mathematical abstraction. Evaluation is based on weekly problem sets, participation in weekly discussion sections, and several short reflection assignments.

This course meets *both* the **QR** and the **ES** requirements.