Physics 100: The First-Year Seminar in Physics

Dark Matter in the Universe to Accelerator-Based Materials Analysis

The course is divided into five two-week parts, with five different professors presenting background material in their fields of expertise. We hope to make some connections between the material across these different topics and the professors will be coordinating the grading and logistics of the course. Here's an outline of the topics covered in the course:

1. **Accelerator-Based Materials Analysis::** PIXE, or Proton Induced X-ray Emission spectroscopy, is a powerful analytical tool used to determine the trace elemental composition of a solid sample. The PIXE technique provides a relatively inexpensive and non-destructive means of materials analysis that is used routinely in research and industry. A beam of 2.2 MeV protons will be created using a Pelletron particle accelerator and this beam will interact with the atoms that make-up the unknown sample. X rays characteristic of the elements in that sample will be produced from the interactions between the protons and the inner shell electrons in the atoms. A characteristic x-ray energy spectrum will be recorded and analyzed to identify the elemental composition of the sample. (Scott LaBrake)

2. **Computational Physics:** Computational physics consists of a set of tools (algorithms) that allow us to use computers to solve difficult physics problems, typically those that are impossible to solve with pen and paper. In the next two weeks, I hope to introduce you to a couple of these algorithms, in order to give you a taste for the power of this approach. In the process, I will be providing an (extremely brief) introduction to computer programming, which is a necessary skill for implementing our algorithms, and to Mathematica, which is the programming language we will use. (Nelia Mann)

3. **Physics of the Earth's Interior:** Earth is, and has always been, an extraordinarily dynamic planet. Earthquakes alone release more than 10^{17}J of energy each year, which is approximately equivalent to 100 million tons of TNT explosives. The science of earthquakes and the resulting waves that travel through the materials that make up Earth is called seismology. In this module we will discuss how earthquakes occur, and the tools seismologists use to detect and evaluate them. We will analyze real data from recent earthquakes to determine their location. While sometimes very destructive to human life and civilization, earthquakes are also an essential tool used to understand our planet. Seismic waves traveling through Earth are used to "image" the deep interior structure of the Earth that is inaccessible to traditional sampling. In this module, you will develop a realistic model of the interior of the Earth based on seismologic evidence, and our knowledge of seismic wave behavior through candidate Earth materials. (Heather Watson)

4. **How Do We Know Quantum Physics Is Real?** Quantum physics, developed in the first half of the 1900's, describes a world that operates by very different rules than ordinary, everyday reality. This strangeness helps it capture the imagination of many non-physicists, but can also seem too weird to actually be true. In this module, we'll look at how and why quantum physics developed, and some of the experimental techniques physicists use

to clearly and unambiguously demonstrate that the strange predictions of quantum physics accurately describe the world in which we live. (Chad Orzel)

5. **Dark Matter and the Distribution of Galaxies in the Universe:** Astronomers have concluded that most of the matter in the Universe does not emit light. We will discuss the observations leading to this conclusion and how the discovery of dark matter has helped us to understand the structure and evolution of the Universe. For example, numerical simulations of the distribution of dark matter explain why galaxies are distributed in filamentary patterns with high density regions containing lots of galaxies separated from other high density regions by nearly empty ones, the voids. We will help search for galaxies in one of the most prominent supercluster and void environments in the local Universe by carrying out a remote (internet) observing run at the Arecibo Radio Telescope in Puerto Rico. (Becky Koopmann)

Reading material will be supplied for each modular topic as will homework assignments. The nature of the homework may vary with the module, but there will be some graded work for each two-week portion of the course. *Students are encouraged to work on the assignments together with others in the course.* It is expected, however, that *the work you hand in to be graded will be written up independently by you* after discussions with other students. **Please indicate on the homework who you worked with in preparing the assignment.**

Each module will also have an associated quiz, lab, or project.

Your grade in each module will be based on your performance on the quiz/project and/or homework, and your final grade for the course will be the average of your grades in the five modules.

Union College recognizes the need to create an environment of mutual trust as part of its educational mission. Responsible participation in an academic community requires respect for and acknowledgment of the thoughts and work of others, whether expressed in the present or in some distant time and place.

Matriculation at the College is taken to signify implicit agreement with the Academic Honor Code, available at honorcode.union.edu. It is each student's responsibility to ensure that submitted work is his or her own and does not involve any form of academic misconduct. Students are expected to ask their course instructors for clarification regarding, but not limited to, collaboration, citations, and plagiarism. Ignorance is not an excuse for breaching academic integrity.

Students are also required to affix the full Honor Code Affirmation, or the following shortened version, on each item of coursework submitted for grading: "I affirm that I have carried out my academic endeavors with full academic honesty." [Signed, Jane Doe]