Partnership for Integrating Computing into Undergraduate Physics

PICUP

Our Vision

Computation is an integral part of the education of every physics student.

Our Mission

To create a vibrant community of educators, a forum for open discussion, a collection of educational resources, and a set of strategies and tactics that support the development and improvement of all aspects of computational physics education.

Executive Summary

Our mission is to increase the utilization of computing to improve the undergraduate physics curriculum. From programs used to acquire and analyze data and simulations used to illustrate concepts in the classroom to applications that solve complicated physics problems on supercomputers, computing is an essential tool for the physicist of the twenty-first century. It is also a tool for the many other scientists and engineers who receive their education in physics. Thus computing must play a vital role in enhancing physics education.

We realize that it will take time and a focused effort to create an environment that is supportive of a strong computational presence in classrooms and labs. But we are confident that by creating and sustaining a community that works together and shares ideas and experiences, we will achieve this goal. As a first step we are organizing a "visioning workshop" within which to survey the current situation, generate ideas and discussion, and deliberate issues that surround the development and implementation of curricular revisions in different institutional settings.

The creation of a thoughtfully planned computational physics agenda will enable us to pursue these developments, but can also drive a coherent set of national programs to improve and transform physics education and provide students the skills they need to solve the problems they will encounter in today's world. Computer simulations and visualizations often illustrate concepts far more clearly than drawings on blackboards or in textbooks. Interactive computer programs that allow student involvement enhance student understanding. Whether using existing programs or writing code from scratch, the art of scientific computing is commonplace in today's workplace. Thus, graduates who have the skills to create and use scientific code are more marketable. Students develop a more complete understanding of physical systems by studying computational physics because the *algorithms* used in programs and the traditional *equations* of physics are the products of fundamentally different and complimentary modes of thought. Equations are statements of relationships, while algorithms are the embodiments of processes.

Student understanding benefits from employing a variety of models to represent a single physical system and comparing their relative merits. This variety of alternative models is frequently not apparent within the simplified analytic descriptions that are traditionally presented to the physics student. Numerical methods will make it possible to study systems that are not amenable to analytical solution, including complicated systems exhibiting emergent and chaotic behavior. Knowledge of the unique challenges of scientific computing (such as step and grid size, round-off error, stability, and program validation and verification) equips the student to develop solutions to a much broader range of systems.

Finally, the physics curriculum must include instruction in the art of using computers and microcontrollers to acquire and analyze observational and experimental data. These are essential skills for those who decide to pursue a career in experimental physics, and at least as important to those who instead pursue other scientific and engineering careers. Data analysis and mining techniques are also essential tools for extracting useful information from the large amounts of data generated by massive computer simulations related to complex systems.

In order to bring these benefits to the student we will provide the physics educator with assistance. We will develop a variety of approaches to integrating computation into the student's educational experience. We will develop strategies and tactics to overcome institutional and cultural barriers. We will identify sources of funding. We will consider changes to the traditional curriculum. We will identify or create software and teaching materials. This is only a partial list of our endeavors. By working together we will provide solutions for challenges and create a future in which computer technology plays an essential role in all aspects of physics education.