

Advancing the Cause of Computation in Computational Physics

The Department of Shameless Commerce Comes to *CiSE*

By Steve Gottlieb and Rubin Landau

The mission statement of this magazine notes that “useful advances in computational techniques that could benefit many researchers are rarely shared, [and so] *CiSE* presents scientific and computational contributions in a clear and accessible format.” Indeed, a recurring theme of this column has been the importance of teaching these advances to students so that they can make more significant contributions in their work—and find in the future.

There are numerous approaches to incorporating computational science advances in education, and one of us (Landau) has contributed to this effort by writing textbooks on computational physics. Many physics departments now teach a course in CP, usually in the upper division. Some also teach a lower-division scientific computing class. And, of course, computers are often used to help teach physics classes, but value is usually placed on the physics and not the computation. Although there is yet no standard CP curriculum, there are now several excellent texts available for CP classes. However, few textbooks cover the standard topics in a physics curriculum while also integrating modern computational techniques.

Why integrate more computation into the curriculum? First, it will help us teach physics better. For example, visualizations via instance graphing, surface plots, animations, sonifications, and 3D figures help students better understand physical phenomena. Second, using computation more closely imitates professional practice in physics, as well as other sciences and engineering disciplines. Accordingly, teaching physics integrated with computing better prepares students for their future work and employment. Indeed, the National Science Board estimates that only 22 percent of physics undergraduates and 52 percent of the graduate students actually end up working in physics. In any case, both theoretical and experimental physicists need more computing knowledge than those of a generation or two back, and it will benefit our students to teach them proper computation at an earlier stage in their educations, much as we do now with mathematics.

How might we better integrate computation in the physics curriculum? When we were students, the availability of computing resources was an issue. Today, however, student often carry laptops that are more powerful than the supercomputers of our student days, and they can get free or inexpensive software that far exceed what we could get—even at national laboratories—in the “good old days.” Given this, many instructors are now incorporating significant computation into their courses; indeed, this year’s Undergraduate Computational Engineering and Sciences (UCES) prize finalists were most impressive in this regard (see www.krellinst.org/uces_award).

Unfortunately, at least one major barrier remains: there are still few textbooks on specific subjects like classical dynamics and E&M that integrate computing into their approach. (And this is where the “Shameless Commerce” in our subtitle comes in....) Because we both believe in this type of systematic change in university curriculum, we’ve agreed to become editors for a series of advanced textbooks published by Taylor & Francis Group that address the interface of physical and computational sciences. This is an especially interesting development for Landau, who had to initiate legal consult to get permission from his former commercial publisher to write new books for Princeton University Press, a nonprofit corporation interested in advancing computational science. PUP can sell a higher-quality version of our text at about one-third the price of the commercial publisher, something we also support to advance CSE.

Although our proposed series will be generally classified as CP, the texts are targeted to specific disciplines without a CP text, including condensed matter, materials science, particle/astrophysics, math methods of CP, quantum mechanics, plasma physics, fluid dynamics, statistical physics, optics, biophysics, E&M, gravity, cosmology, and HPC in physics.

We’re eager to find authors for textbooks of this sort at both the undergraduate and graduate levels. Please contact either of us if you are interested in becoming an author or can identify a colleague who has done an excellent job in integrating computing into a standard course.

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//Rubin & Steve: We need a 15-20 word abstract and keywords for the digital library here. Following is a suggestion but it might be too general, so please rewrite as needed and also add keywords as indicated.//

Incorporating computational science into physics education is crucial for the future of both students and the field itself.

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