

more experiments with lots of accurate data do not necessarily mean progress in physics. They could, instead, perpetuate old theories, just refining their free parameters and adding new generations of something now and then. This danger is even greater today, when the data are screened by computers; these are looking for what we want to find and tend to mask the rest. Ptolemy's theory would be disproved by observing the crescent of Venus; would, however, the imaginary Alexandrian observer include in his computer program a code that could recognize such a crescent?

In the continuing debate about SSC funding we hear arguments about what physics can contribute to society, with obvious references to Faraday's research. There is another question, whose answer is with much less obvious: What will the SSC contribute to physics?

References

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2/89

The Computer as Tutor

I read with great interest Leo Kadanoff's remarks on "Interactive Computation for Undergraduates" in the December 1988 issue (page 9). The opening paragraph about the computer revolution's resulting "in some revision in the style and content of physics instruction" particularly caught my attention. So did the references to Halliday and Resnick and to Goldstein.

I studied physics in the 1960s, and graduated in 1970 with a PhD in theoretical nuclear physics. As the economic climate at that time was not good for physicists, I made a career switch and went into the computer field. I spent six years in the Federal government and then moved into private industry. Since 1976, I have been with an aerospace corporation, doing systems analysis. My specialty is software quality assurance.

I have lost contact with academia. However, Kadanoff's remarks spurred me to recall my past as a physics student. I too got my introduction to physics with Halliday and Resnick and learned my classical mechanics from Goldstein. About

this I have no regrets because I think they are fine texts. But Kadanoff's references to these texts together with his comments about the computer revolution raised the following questions in my mind:

▷ Is physics still being taught the way it was in the 1960s? In particular, are concepts such as the harmonic oscillator and the square-well potential emphasized?

▷ Have computer programs like MathView Professional, Eureka, PowerMath, Milo and Mathematica (I am heavily into Macintosh software) reshaped physics instruction? In particular, now that mathematics no longer stands in the way of solving "realistic" physics problems, are students shown how to deal with oscillators other than harmonic and potentials other than square wells?

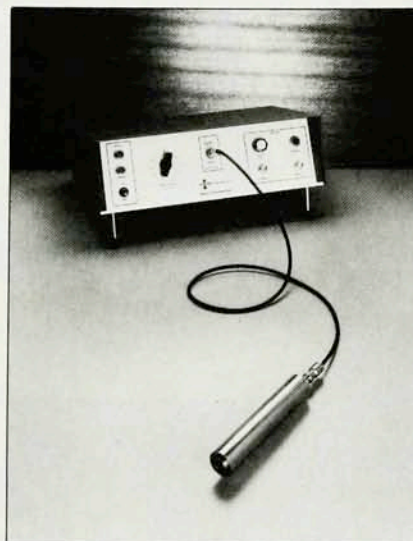
▷ The technology embodied in personal computers (not to mention powerful pocket calculators, like the HP-28S with its 32K of memory and symbolic math capability) is, of course, a two-edged sword. Their ready availability increases the potential for misapplication of mathematics to physics. What is being done to train physicists (and engineers) in the proper use of these tools? How are students being sensitized to distinguish nonsense from physically meaningful results when they look at the output from these tools?

Over the past few years, I have noticed the growing impact that computers have had within my company. Things that used to take weeks now take hours. Now that many of us are becoming more acclimated to this technology, we increasingly integrate it into our planning. The effect on productivity is often quite significant. But not all engineers are in step with what this technology can offer. Some still prefer to do things the old way—and some do it the old way quite well. My question is, Does the old way still dominate physics education? If so, why? If not, how is personal computer technology being used to improve the breadth and depth of physics education?

You may be asking yourself why an ex-physicist is so concerned about the way physics is being taught in colleges and universities. My answer is the following: I left physics in 1970 with mixed emotions. There were few job opportunities where I could directly apply physics. (Even academic positions were in short supply.) Since that time, I believe, physics has failed to attract sufficient numbers of students to meet the demands of industry. Certainly within my own com-

continued on page 127

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continued from page 15

pany physicists are rare individuals. My contacts with other companies lead me to similar conclusions. Physicists have one dominant trait that offers them rich opportunities in industry—their ability to solve problems. This trait makes them highly adaptable. Industry greatly covets individuals who can attack a problem and get answers that can be demonstrated to make sense. With the availability of personal computer technology, I believe that physics can once again enjoy a day in the sun. If academia integrates this technology into the physics curriculum, it can make physics appealing to more students and, at the same time, train them to pursue careers outside of academia (if that is their bent).

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1/89

The article "Using Computers in Teaching Physics," by Jack M. Wilson and Edward F. Redish (January 1989, page 34) mentions briefly a project known as PLATO, but leaves the possible impression that this project was developed solely by Control Data Corporation in the 1970s and has since faded from use. The PLATO system is actually a development of the University of Illinois at Urbana-Champaign and has been in constant and expanding use since its 1959 inception. Today it is one of the largest university-based computer-aided instruction systems in the world.

The first phase of the PLATO system consisted of one student terminal connected to the ILLIAC 1 computer. This was followed by three other versions, each supporting more terminals. The system was developed with the intention of providing interactive, self-paced instruction to a large body of students. As the project grew, support was provided by the National Science Foundation, the State of Illinois, Control Data Corporation and many private and public agencies. Control Data Corporation purchased the rights to the name PLATO and the license to market the system in 1976. By that time there were approximately 1000 terminals across the Urbana campus, at other universities and colleges, at several levels of public schools, and in businesses and medical institutions. Almost 3 000 000 student contact hours of system use had already been delivered. An extensive volume of PLATO courseware is now available in physics, mathematics, engineering and other disciplines, some of which has been extended to other CAI systems,

and there are dozens of PLATO systems around the world.

Research has continued on this project at Urbana. The original system has grown to about 2000 terminals and has delivered almost 20 million contact hours of instruction. A new PLATO-like network is experiencing rapid growth due to recent developments that have dramatically lowered the cost of the communications network and the central computer, as well as made provision for a wide variety of student terminals.

PLATO terminals were installed in the university's physics department in 1971. These and more recent additions have been in constant use since in a wide range of courses, but primarily those at the introductory level. As one example, students in the first semester of the calculus-level introductory course can elect a lecture-laboratory-PLATO version or a "standard" lecture-laboratory-recitation format. The PLATO version has been taken by about 800 students each year for the past 14 years. A review of the early experience with PLATO in physics was published¹ in 1983.

PLATO components have subsequently been added to other physics courses. This system continues to be an effective way to deliver computer-aided instruction, especially in courses with large enrollments. PLATO has also proven to be a useful tool for handling administrative aspects of large courses, including the assignment of students to class sections and the determination, storage and dissemination to students of grade and rank-in-class information. In past years, before personal computers became available, PLATO permitted the use of numerical techniques to solve problems in advanced courses (such as quantum mechanics).

The experience with PLATO at Urbana in physics and chemistry provides a rich and valuable base for any study of the limitations, advantages and role of computer-aided instruction in university-level science courses. We were therefore surprised to discover that that experience had been both misstated and greatly understated by Wilson and Redish.

Reference

1. L. M. Jones, D. Kane, B. A. Sherwood, R. A. Avner, *Am. J. Phys.* **51**, 533 (1983).

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4/89

In the article "Using Computers in Teaching Physics" by Jack M. Wilson and Edward F. Redish, there was an

omission—an oversight, I'm sure—in the section on simulations. There was no mention of the recent two-volume work *An Introduction to Computer Simulation Methods: Applications to Physical Systems*, by Harvey Gould and Jan Tobochnik (Addison-Wesley, Reading, Mass., 1988). These volumes can be considered a major contribution to physics pedagogy. Anyone interested in encouraging students to explore physical concepts with the assistance of a computer should consult these works.

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2/89

WILSON AND REDISH REPLY: We were not trying to either misstate or understate the role of the University of Illinois in the PLATO project. We were simply constrained by article length and only planned to mention PLATO in passing.

Similar constraints led to the deletion of our reference to Gould and Tobochnik's excellent two-volume work. The original article as submitted was nearly twice as long and had over twice the number of references. Our apologies to others who may have felt that we slighted their work. The editors' work resulted in an article that was much less complete but (we must admit) much more readable than the original.

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10/89

Feynman: Wobbles, Bottles and Ripples

Being more adventurous but less careful than B. Fong Chao (February 1989, page 15), I have tried to reconstruct Richard Feynman's explanation for the motion of a wobbling spinning plate. Why, in "simple" terms, does a wobbling plate wobble twice as fast as it spins? One seeks an explanation like Feynman's textbook explanation for the torque on a forced-precession gyroscope in terms of the Coriolis acceleration of its particle masses. The wobbling plate is in free precession and, it turns out, is in some sense easier to understand. So here, for general entertainment, is an explanation with some equations to help with visualization.

Consider a particle in a circular orbit about the origin that is slightly tilted off a reference plane. Consider another particle of equal mass also in