birth, he was hailed as standing on a par with Aristotle and Avicenna. Now widely revered in the U.S.S.R. as "a Soviet cultural icon," many of whose books have been published posthumously, Vernadsky is regarded there as the predecessor of Lovelock and Margulis, whose well-known Gaia hypothesis of 1972 has found wide acceptance by Western environmentalists.

Yet this "great Russian patriot, one of the major Soviet scientists of the twentieth century" still remains largely unknown in the West. One can only hope that the recent publication of the late Kendall E. Bailes's (1940–1988) book will promote an awareness and appreciation of Vernadsky's achievements by persons whose linguistic ability is limited to English.

Universally considered one of the founders of geochemistry, Vernadsky proposed a geochemical classification of the elements and produced seminal studies of the biosphere (all the earth's living plants and animals and their physical environment), including the effect of the biosphere on chemical phenomena occurring on the earth's surface. As a political liberal and philosophical eclectic, he was concerned with the fate of science and learning in Russia throughout his long and distinguished career under both the czarist empire and the Soviet regime. During the Stalinist era, he remained an independent thinker and a scientist of great personal integrity; his scientific *Weltanschauung*, which regarded all knowledge as partial, tentative, and incomplete, provided a sharp contrast to Stalinist dogmatism. Soviet officials regarded him as a valuable scientist with untrustworthy political views. His stature and the loyalty of the students of what became known as the Vernadsky school, were largely responsible for preventing Stalinist repression in the earth sciences.

In addition to providing an insightful, richly researched portrait of Vernadsky's life and times, Bailes successfully shows "through an analysis of the career and work of... Vernadsky and his scientific school, the social matrix in which such ideas originated and why they have become popular among a later generation of Soviet natural scientists and other intellectuals." His study concludes with a masterly assessment of Vernadsky's intellectual legacy and a discussion of the recent popular revival of his thought in the U.S.S.R. I warmly recommend this meticulously documented but eminently readable book to chemists, geologists, mineralogists, crystallographers, and environmentalists as well as to historians of these disciplines and of science in general.—*George B. Kauffman, Chemistry, California State University, Fresno*

Computer Software

Desktop Tabletop Physics

Interactive Physics. Version 1.2. Knowledge Revolution, 497 Vermont Street, San Francisco, CA 94107; 415-553-8153. $249. Quantity discounts available for school use. Requires an Apple Macintosh computer with at least one megabyte of memory.

You hang a weight from a piece of string, then tie a second weight to the first one, and attach a third to the second. When you give this compound pendulum a nudge, the three weights take off on a chaotic trajectory, swinging, bumping, bouncing and lurching like an unpredictable amusement-park ride. In an effort to analyze the motion, you set up a pair of strip-chart recorders to keep track of the x and y positions of the third weight. You add more instruments to monitor the corresponding components of velocity. In the spirit of experiment you try turning up the air resistance in the laboratory, doubling its normal value. Then you switch off the gravity.

All of this happens on a computer screen, of course; it is not real physics but a simulation. Strangely, it is all the more interesting for that reason: The well-done fake is more appealing than the real thing. Just as a painting may well arouse greater admiration than a real landscape, the artfully simulated trajectories of *Interactive Physics* seem more impressive than those that nature so effortlessly computes.

The realism of the simulations is achieved by simple means. Images on the screen will certainly not be taken for photorealism: The objects are unembellished circles, lines and polygons, without texture or shadows. Seeing them at rest, they look quite crude. But when the images move, the program comes to life. We instantly recognize the behavior of objects taken from our own world—objects with mass and elasticity, objects that bounce and spin and roll just the way familiar things do. A baseball struck by a bat in *Interactive Physics* would fly to just the place where Joe DiMaggio would wait to catch it.

The realm of the program is tabletop physics. The apparatus available for doing experiments includes ropes, springs, dashpots, and masses of various sizes and shapes. You construct a simulation simply by drawing the initial state on the screen, using tools that work much like those of a graphics program. Draw a triangle to represent an inclined plane; draw a circle and place it on the plane; select the "Run" command, and the wheel begins to roll downhill. You can specify various properties of individual objects, such as the rate constant of a spring, the elasticity of a rope, the coefficient of friction between two surfaces, or the initial velocity of a mass. You can also alter global properties, such as air resistance and the value of g, the acceleration due to gravity.

Additional resources within the program allow for measurement and data collection. Selecting a menu item is all that is needed to create a meter or a strip-chart recorder to monitor the motion of a selected object; instruments are available for measuring various aspects of position, velocity, acceleration, energy, momentum and forces. Another command annotates the display with vectors representing velocity, acceleration or force. Having all this information instantly available is a great luxury. On a real physics lab bench, measuring the position or velocity of a moving object requires considerable effort; quantities such as energy and momentum almost always have to be calculated rather than measured directly. With *Interactive Physics*, every object is connected to its own data-acquisition system. Moreover, the data can be exported to another program for further analysis or graphing.

The program's toolbox of ropes and springs and masses is enough to cover a large part of elementary mechanics: the analysis of static forces and equilibrium, rectilinear motion, rotational motion, ballistics, inertia and acceleration, the conservation of energy and momentum. The package comes with a curriculum guide that suggests 16 lesson plans and has cross-references to two dozen introductory physics texts. Experimental setups for all of the lessons are provided on disk, along with 50 additional simple experiments and several more-elaborate demonstrations.

The computer simulations of *Interactive Physics* are meant to supplement the laboratory component of a first-year physics course. If the program is to be used in this way, the question of realism takes on a new importance. It is not enough for the simulated experiments to "look right"; they must also give answers that are quantitatively correct. I decided to try an independent check of the program's accuracy. I set up two simple pendulums, one made of simulated rope and a simulated sphere, the other assembled from real thread, a thumbtack and a worn-out squash ball. Both pendulums were one meter long. I measured their period during small-amplitude oscillations. *Interactive Physics* produced the textbook answer to three significant digits. Reality was only slightly inferior to simulation: An average period calculated over 100 cycles came within 3 percent of the "correct" answer.

In one respect, the emphasis on realism in *Interactive Physics* has been taken a little too far for my taste. When I discovered that g is an adjustable parameter, my first impulse was to set it to zero and play with weightlessness. Next I set g to the highest possible value, to see what happens when things get really heavy. Unfortunately, the maximum value allowed by the program is only 25 meters per second squared, which is less than three times the value at the surface of the earth, and roughly equal to the value on Jupiter. Why can't we measure the period of a pendulum on the sun, where g is greater than 100, or even on a neutron star, where g might reach 10^{11} or more?

Doubtless there are good reasons for this limitation and for the several others like it built into the program. If they were lifted, new algorithms might be needed, and the speed of the simulations could suffer. Numerical accuracy might be put in jeopardy. In extreme cases, physical laws would be stretched beyond their proper domain. (A neutron star, for example, is not a suitable object for experiments in tabletop physics; it demands a description based on general relativity rather than Newtonian gravitation.) In spite of all that, I still feel disappointed that my impulse to play with hypothetical worlds was frustrated. After all, one of the principal advantages of simulation is that it lets one escape the tyranny of the real world and its petty constraints (such as a fixed value of g).

A license to ignore the real world is also one of simulation's conspicuous *dis*advantages. Performing a real physics experiment teaches not only physics but also the techniques and the perils of working with real pendulums and real stopwatches. It teaches you to deal with real experimental data, in which F never quite equals ma. Viewed in this context, no simulation will ever attain full realism. And yet a good simulation is more than just an animated equation. It ought to reflect a deeper understanding of how the world works and how its parts fit together. The best simulations ought to produce a few surprises, just as the best experiments do.

One of the prepared simulations supplied with *Interactive Physics* is a simple harmonic oscillator, made of a square block attached to a spring and sliding on a horizontal rectangular slab. Initially, the components are frictionless, so that the oscillations of the spring and block continue undamped forever. An obvious modification is to add some friction between the block and the slab. On my first try, I was somewhat reckless in making this adjustment, and I thereby made the surfaces very sticky indeed. Under these conditions, a simulation that merely solved the equations for a harmonic oscillator would continue to yield ordinary harmonic motion, albeit heavily damped. *Interactive Physics* showed a much more interesting outcome: The block refused to slide on the sticky surface; a corner of the square dug into the substrate; finally the spring tension lifted the block and overturned it, making the square wheel roll. For a moment or two, I was more than willing to suspend my disbelief and see the real world on the screen.—*Brian Hayes*