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WINNERS OF THE *CiSE* SOFTWARE CONTEST

By Denis Donnelly

IT IS WITH GREAT PLEASURE THAT WE ANNOUNCE THE WINNERS OF THIS YEAR'S SOFTWARE CONTEST. WINNING ENTRIES INCLUDE A HIGHLY FLEXIBLE PACKAGE TO STUDY ORBITAL MOTION, A POWERFUL GENERAL-PURPOSE SIMULATION for physics, and a Web-based package on molecular dynamics. Honorable mentions go to a virtual spectroscope software package, a simulation of the solar system, and a program to explore chaotic scattering.

This year is a transitional year for the software contest. The organization for this 10th contest was the same as it had been for the past nine years when the contest was sponsored by *Computers in Physics*, but the scope was broader: software developers from all the sciences and engineering disciplines were eligible to enter. Exactly how the contest will be structured in the future is still open to discussion. A steering committee is considering how the contest should evolve and develop, given the broader scope of *CiSE*.

In the next Education column (Jan./Feb. 2000 issue), several members of the computing community will discuss a number of possibilities. In addition, there will be a brief summary of the suggestions made by this year's contest judges Harvey Gould of Clark University, John Risley of North Carolina State University, Don Shirer of Yale University, and myself. We welcome reader's comments. (Please contact either of the *CiSE* Education editors.)

Prize winners

Contest winners receive a cash prize of $500 and an award certificate. This year's awards will be presented at the annual winter meeting (January 2000) of the American Association of Physics Teachers in Kissimmee, Florida.

Planets and Satellites. Planets and Satellites, by Eugene Butikov of St. Petersburg State University, Russia, is an extensive educational software package to help students visualize and understand the laws of orbital motion as they apply to both natural planetary systems and artificial satellites. Separate sections discuss Kepler's laws, velocity space, satellite and missile orbits, orbital precession (see Figure 1), orbital maneuvers (both manual and preprogrammed), and two- and many-body problems.

Each section has many preselected examples (we counted at least 155) ranging from simple elliptical orbits to the effect of "intruder stars" on entire planetary systems. The examples make good use of color and shading to illustrate the orbits and dynamical vectors, and the user can vary the parameters and create and store custom examples.

A well-designed interface makes the program easy to use for casual browsers. There is also extensive online help, with many suggestions and problems posed for those wishing further individual study. This program, used with its accompanying manual and tutorial, should be useful not only for students in elementary astronomy and classical mechanics courses but also for those pursuing a more advanced study of orbital dynamics. Instructors can also use it to provide animated illustrations for their lectures.

Two limitations of this program are the inability to alter the force law, which remains inverse square, and the inability to alter the view, which remains perpendicular to the plane of motion. On the other hand, examples of orbital parameters can be viewed from center-of-mass, heliocentric, and geocentric frames of reference. All motion is computed numerically with little apparent delay, and the results seem quite stable.

xyZET. xyZET, by Michael Ludke and Hermann Haertel of the Institute for Science Education in Kiel, Germany, is a general-purpose simulation

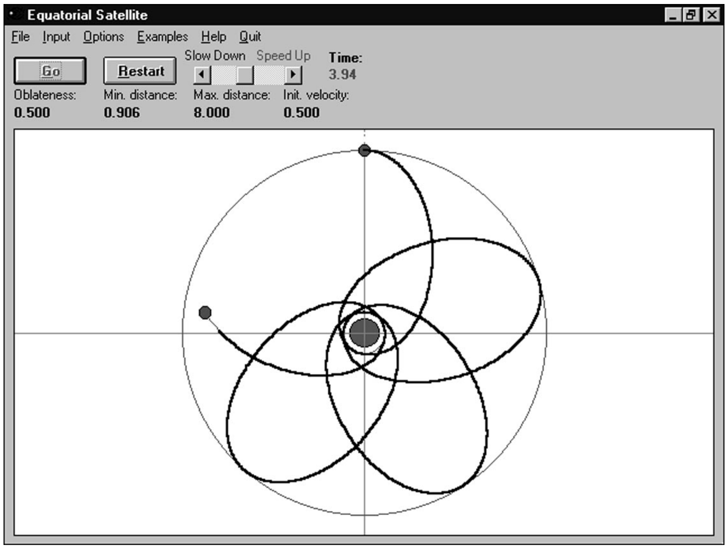

Figure 1. Precession (slow rotation of the major axis) of an equatorial satellite's orbit around an oblate planet.

program for physics, with numerous preprogrammed experimental situations. These scenarios can be viewed in three dimensions from any user-selected perspective. Forces include contact, spring, friction, gravity, Coulomb, and Lorenz. Extended objects are realistically constructed as point masses connected by springs. For sufficiently high speeds, you can simulate the relativistic change in mass. In addition, you can illustrate electric-field lines of accelerated charges obeying retarded potentials. For example, Figure 2 shows the equipotential surface associated with a distribution of charged particles.

Instructors can customize the program by limiting the number of control buttons, providing explanations or assignments, and combining Web pages with the simulations. Existing simulations include pendula (simple through chaotic), falling objects, Gauss's law, and oscillating charges. The objects simulated can be rotated in real time while the animation is playing. In addition, there are a half dozen display panels that let the user access the main controls, the manner in which a particle is displayed, a description of the simulation, and an energy-momentum monitor with graphing options. The 3D capabilities make this program unique. The controls are easy to use and obvious to a new user. The program encourages user experimentation; for instance, you can quickly change the kind of force that is acting on the particle in real time and thus immediately compare the effect of a magnetic field to that of an electric field.

xyZET was originally written for Unix. This means that a user must have X-Windows installed on a PC to make it work. Perhaps because of this Unix genesis, the program does not work as quickly as you would expect, and it also requires a large screen for all the display panels. However, the program's strength—enabling users to visualize complex and difficult physics processes—helps students acquire a

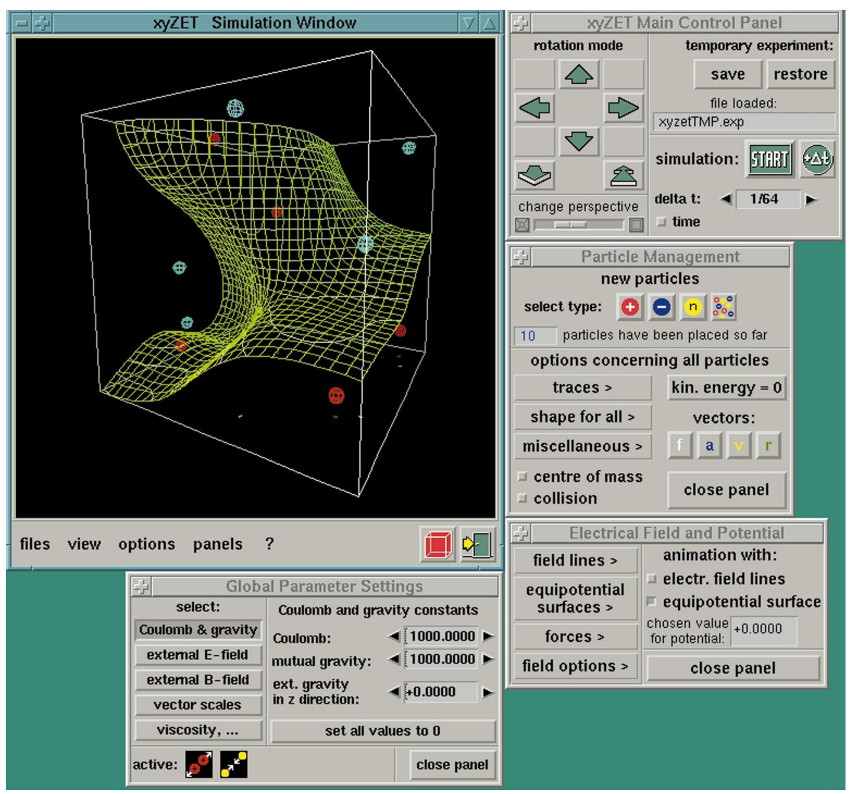

Figure 2. xyZET. The equipotential surface associated with a distribution of five positively charged and five negatively charged particles.

conceptual understanding of these topics and makes the disadvantages of X-Windows a small price to pay.

Student prizewinner: Molecular Dynamics Physlet. The Molecular Dynamics Physlet (a form of applet), written by Jim Nolen, an undergraduate at Davidson College, models the dynamics of hard disks to simulate the properties of dilute gases in two dimensions, where particles bounce elastically off each other and off the walls. (The more common boundary condition in research applications is periodic boundary conditions.) The simulation illustrates the equipartition theorem, the rapid convergence to the Maxwellian velocity distribution from a nonequilibrium situation, and the effects of slow and rapid compression of the system using a piston. Figure 3 illustrates the program's simulation of Brownian motion.

The real strength of Molecular Dynamics Physlet is that instructors can use Javascript to modify the applet —changing the initial conditions, plotting physical quantities of their choice, and using the applet in different contexts. Such changes can be made without seeing the source code. The author has documented the classes and variables used by the applets and explained how to modify the accompanying Javascript. For example, it would not be difficult to modify the software to find the nature of the solid phase or to estimate the density of the fluid-to-solid transition. Another interesting modification would be to initially fill only half of the box and then watch the system become more uniform in time.

Physlets, developed by Wolfgang Christian of Davidson College, are like other Java applets, except that several applets are typically used on a page, and the output of one applet is used as the input for another so as to facilitate making graphs and doing animations. Javascript is used to specify which variables are passed and the values of the parameters. Physlets require a Java 1.1 capable browser with JavaScript-to-Java scripting capability, but are otherwise platform independent. Unfortunately, they do not run correctly on Macintosh computers because at the time of this writing, Internet Explorer 4.5 does not support Javascript-to-Java communication and Netscape 4.x does not fully implement Java 1.1. Shame on Apple for allowing this situation to exist as long as it has. Physlets run surprisingly quickly on Windows-based computers and also run under Linux and Unix.

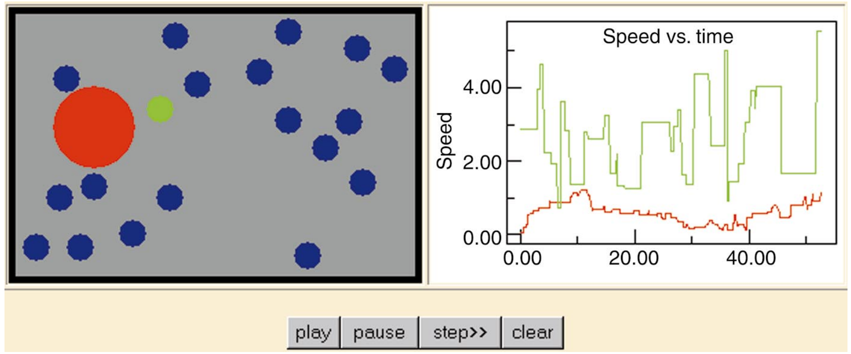

Figure 3. Brownian motion simulation using the Molecular Dynamics Physlet. The program passes data from the red and green particles to the Data Graph physlet using inter-applet communication.

Honorable mentions

Honorable mentions receive an award certificate.

Virtual Spectroscope. Virtual Spectroscope is another in a series of carefully conceived, well executed, pedagogically useful packages for beginning students from the Science Education department of the Harvard-Smithsonian Center for Astrophysics. This package, created by Paul Antonucci, Freeman Deutsch, Philip M. Sadler, and M.G. Wood, offers teachers and students a graphical and interactive way to study spectra and spectral-intensity graphs.

The program displays both a visual representation of some spectrum, similar to the output from a spectrograph with the spectrum dispersed spatially, and directly above a graphical representation of the same spectrum (intensity versus wavelength or energy). These two displays help students visualize absorption and emission lines and become familiar with both the spectra of various sources and the spectral sensitivity of detectors.

Students can create or redraw a spectral-intensity graph, or "spectral curve," using the mouse. The corresponding spectroscope view appears or changes instantly to mirror the changed wavelength or energy intensities. This immediate feedback helps students make the connection between the spectrum and its graphical representation.

There are a modest number of response curves included: those for human red, blue, and green receptors, a bee's green, blue, and ultraviolet receptors, and a silicon photo diode. Given any spectrum, the user can observe the selected response curve and the spectrum before and after filtration by the response curve.

It is difficult for software to present colors that will appear the same on all systems; whether that is the source of some modest difficulty here is uncertain. On the two computer systems on which the judges examined this software, there appeared to be some difficulty near the red end of the spectrum. For example, the He-Ne laser line has a

How to obtain the software

Molecular Dynamics Physlets: Wolfgang Christian, wochristian@davidson.edu; http://webphysics.davidson.edu/Applets/Applets.html. The software is free.

Pinball Billiards: Iacovos Kyprianou, kypriano@buffalo.edu; http://www.buffalo.edu/~kypriano.

Planets and Satellites: Physics Academic Software, Box 8202, North Carolina State University, Raleigh, NC 27695-8202; email pas@ncsu.edu; http://pcep.physics.ncsu.edu/pas. A single-user copy is $100, a high school site license is $250, and a 10-copy lab pack costs $400. The creator Eugene Butikov can be reached at butikov@spb.runnet.ru.

Solar System Sim 2.0: Dean Dauger, Dept. of Physics, UCLA, Los Angeles, CA 90095; dauger@physics.ucla.edu; http://www.physics.ucla.edu/~dauger/SSS. The shareware cost is $20.

Virtual Spectroscope has not yet been released in its entirety. A Windows version is in final development. The full program, titled MiniSpectroscopy, might be available in early 2000; a simplified version is at http://mo-www.harvard.edu/Java/MiniSpectroscopy. Contact Freeman Deutsch at fdeutsch@cha.harvard.edu for further information.

xyZET: Michael Ludke and Hermann Haertel, Institute for Science Education (IPN – Institut fur die Padagogik der Naturwissenschaften), Olshausenstr. 62, D-24098 Kiel, Germany; luedke@ipn.uni-kiel.de; http://www.ipn.uni-kiel.de/english/projekte/a7/a7.1/xyzet/mainpage_e.html. The demo version is free; a single license costs 100 deutsche marks, a class license is DM 300, and a school license is DM 500.

decidedly orange cast. And when looking at the after-response curve associated with the human red receptor, we observed precious little red for any spectral input. A modest amount of tweaking should eliminate this difficulty.

Student honorable mention: Solar System Sim. Solar System Sim by Dean Dauger of the University of California at Los Angeles is a visualization program for the Macintosh that simulates and displays *N*-body problems in three dimensions. It is a useful tool for visualizing planetary and satellite orbits. Each interaction includes a "space craft" whose maneuvers can be adjusted interactively or with a set of programmed thrusts, allowing the design of transfer orbits and gravitational

Year 2000 contest

By 31 January 2000, the *CiSE* Web site (http://computer.org/cise) will have contest information available, including the application form and guidelines. All updates about the contest will be posted there.

assists. One of the included examples is the Voyager grand tour of the outer planets using the "slingshot" effect to redirect its orbit.

This entry exhibits many clever programming features such as interactive zoom and tilt of the 3D viewing plane, the use of an arbitrary power law between bodies, planetary images based on astronomical photos, and the provision of a stellar background based on actual starmaps. Users with 3D glasses can see the orbits in an optional red/cyan 3D view. Users can also select and compare several different methods of numerical integration. Although it does not include many pedagogical features, and occasionally the user can become confused by the myriad adjustments to its display, this program would make a useful adjunct to the Planets and Satellites program discussed earlier for those wishing to extend their study of orbital motion out of the 2D plane.

Student honorable mention: Pinball Billiards. Pinball Billiards, by Iacovos Kyprianou, a University of Cyprus physics student at the time of the contest, is a Mathematica-based package that helps users learn about the chaotic and statistical properties of scattering due to clusters or lattices of elastic or inelastic disks. Chaotic scattering results when a small difference in the impact parameter leads to big differences in the trajectories and the final scattering angles. Chaotic scattering can be observed with as few as three disks.

Once the user specifies the disks' number and placement, the package computes and plots the orbits of the scattered particles, the mean Lyupanov exponents, and the various fractal properties associated with chaotic scattering. Most of the package is written in C so that many disks can be considered if desired.

The package and the associated manual are reasonably well documented, and the background theory is given in some detail. However, the work should have been spell-checked. We recommend the package to instructors and advanced undergraduates and graduate students interested in learning more about classical scattering and chaos. The package runs on Windows 95, 98, and NT.

Acknowledgments

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