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# MuPad Pro

Here's a functional, economical, symbolic math package for all but the highest-end tasks.

## Barry Simon

MuPAD Pro is a full-featured \$500 symbolic mathematics package developed at the University of Praderborn and SciFace software in Germany. It is distributed in the United States by MacKichan Software. MuPAD provides symbolic manipulation, computer algebra and calculus, exact rational and arbitrary precision real arithmetic, two- and three-dimensional graphics, a proprietary language for writing programs that extend the system, and a variety of special functions.

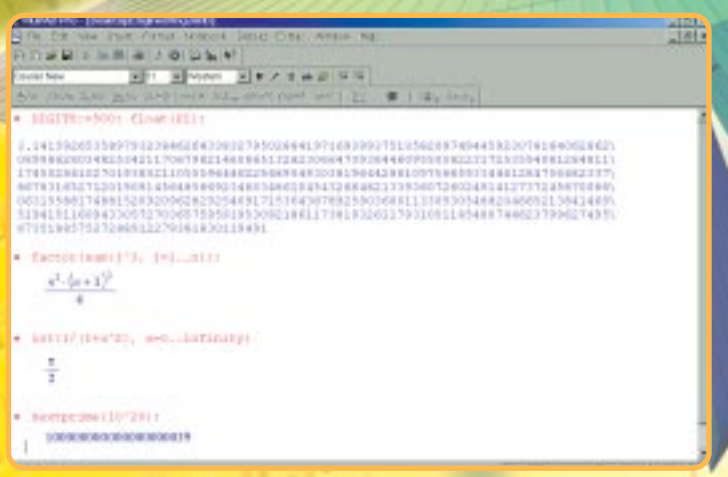
This will sound a lot like the capabilities of Mathematica (\$1,495) and Maple (\$1,700) with which MuPAD directly competes. While there are a few areas of particular strength for MuPAD, in most areas its capabilities are bested by its pricier brethren. Indeed, MuPAD reminds me of these other products about five years ago—it is in some ways stronger than they were then but its limitations are of a similar sort to those that they have since addressed.

## PRODUCT CAPABILITIES

In 1996, I developed a symbolic math test suite for *Desktop Engineering* (see *September 1996, p. 39*) based in part on test suites of Wester and of Postel-Zimmerman. The suite consists of roughly 30 problems in 10 categories. At the time, Macsyma, Maple, and Mathematica failed one to three of the problems (in that they were either unable to do certain calcula-

tions or timed out on the lengthy problem that required an answer within 10 minutes) but later versions of Mathematica and Maple got perfect scores. The current MuPAD failed to do six of these problems with only partially correct answers on two others. (See sidebar, "How we Tested," to see the first two tests, then visit our website, [www.deskeng.com](http://www.deskeng.com), and click on this article to see the complete suite of tests.)

MuPAD Pro has all the basic symbolics down cold. It can compute pi to 500 places, compute the sum of powers and integrals symbolically, and find primes.





Half of the problems that MuPAD was unable to do involve limitations on its simplification algorithm—issues we also saw when we tried some complicated integrals where, for example, the program gave the answer for a definite integral of a real valued function (namely  $\log(\text{abs}(b-x))$ ) as a sum of various complex numbers whose imaginary parts canceled. The answer was correct but in a form that would require additional work to use.

Another place where MuPAD's simplification routines fell down was in calculating the integral that represents the gravitational potential of a sphere, a tricky problem that is famous as a test of symbolic manipulation and which, for example, Mathematica only computed with the simple closed form at the release of Mathematica 3.0 two years ago. MuPAD's answer is so complicated that it would not be useful except for numeric substitution.

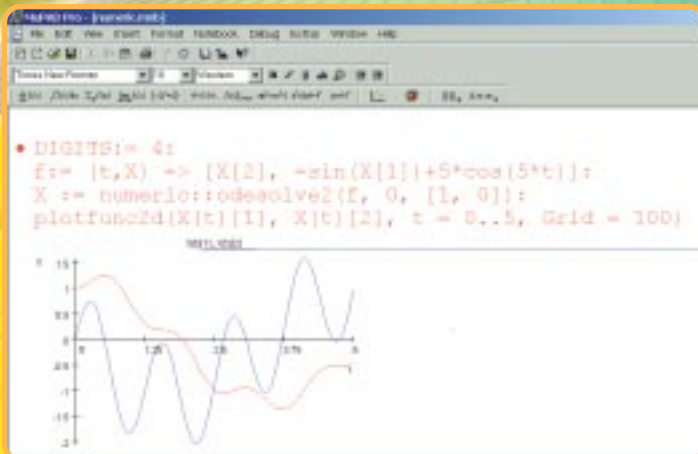
A final test suite issue concerns the lack of certain specialized functions—while MuPAD can compute infinite integrals of Bessel functions, it cannot compute integrals whose answers involve dilogarithms. It should be emphasized that the test suite is designed to push the edges of a symbolic program's capabilities and that MuPAD does fine on the basic symbolic tasks.

**STRONG POINTS**

There are some areas where MuPAD shines. Its Solve function always returns all the solutions of a problem as a set that you can manipulate to find specific solutions. It has a well-implemented "assume" facility where you can tell the program that some parameter is real or positive or otherwise limited and it normally automatically returns special values explicitly (although when I asked it to integrate  $x^n$ , it didn't tell me about the special case when  $n = -1$ ).

MuPAD allows you to manipulate graphs as objects with a variety of commands. It does not have the 3D lighting capabilities or animation abilities of Mathematica or Maple but this is expected to be added to the next version due out in the first half of 2002.

With MuPAD Pro, one can solve and plot solutions of differential equations.



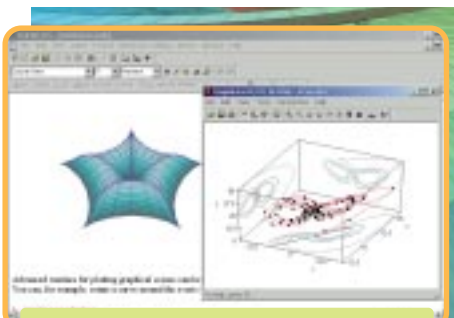
Also planned is OpenGL rendering technology. In the current version, I was especially impressed by how easy it is to display the Lorentz attractor.

While its core is symbolic, MuPAD has some special numeric routines. It can

handle sparse matrix problems and it has a variety of numeric differential equation solvers to supplement its strong array of symbolic differential equation techniques.

The vendor has plans to incorporate SciLab ([www-rocq.inria.fr/scilab/](http://www-rocq.inria.fr/scilab/)) into the next version of MuPAD. Scilab is a numeric package intended to offer much of the functionality of MATLAB.

Another strong point of MuPAD is its programming environment. It includes a debugger far superior to the one found in any other symbolic mathematics package albeit not with all the bells and whistles that you'll find in Visual Basic or C++.

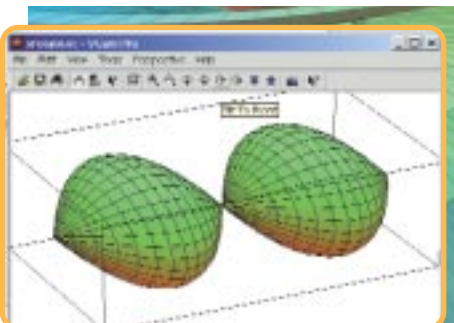


MuPAD can draw stunning 3D graphs and plot the output of nonlinear differential equations like the Lorentz system.

**INTERFACE ISSUES**

Like other programs of this genre, MuPAD is mainly driven with a command line interface. It has some of the interface devices that have enhanced the competition in recent years but often in scaled-down versions. Whereas Maple and Mathematica have multiple palettes of symbols that can enter formula using blackboard notation (for example, integral signs), MuPAD has a single limited button bar and even though there is an integral sign on the button, all it does is enter a template that says "int(%?, %?)". That means there are no prompts for dealing with complex syntax but this is somewhat ameliorated by a superb help system.

There are other places where the interface could be a lot smoother. When you have a syntax error, the program reports the column number of the er-



The graphic viewer has control to change perspective.

## HOW WE TESTED

To test MuPAD, we provided the vendor with a suite of test problems that we've used in previous tests of symbolic math programs. Some of the problems are taken from existing problem suites of Wester and of Postel-Zimmerman (see <http://math.unm.edu/~wester/cas/Paper.ps> for references).

### 1. Numeric Calculations (MuPAD got these both correct)

(a) *Nearly singular matrices: Invert a  $40 \times 40$  matrix whose  $i, j$  element (with elements starting at 1,1) is  $1/(41-i+j)$  using exact rational arithmetic. You need not display it. Confirm that it is an inverse by multiplying this inverse times the matrix and display the first row of this product.*

This matrix is nearly singular. Double precision programs have problems on the analog of this  $N \times N$  matrix starting at about  $N=12$ .

(b) *Numeric calculation: Using any special functions you have to speed up numeric calculations, compute to the 12 decimal places the sum*

$$\sum_{j=1}^{100,000} \frac{4}{1 + \left(\frac{j}{100,000}\right)^2} \frac{1}{100,000}$$

This is a Riemann sum (with 100,000 terms) approximating an integral whose value is  $\pi$ . It is intended to see how the programs do at raw numeric computation.

### 2. Simplifications (MuPAD had problems with two of these five problems: parts c and e)

(a) *Simplify  $\sqrt{6+2\sqrt{5}}$ . The answer is  $1+\sqrt{5}$ .*

(b) *Simplify  $\sqrt{5+12i}$ . Give the answer in both rectangular and polar form. The answer is  $3+2i$ .*

(c) *Clear radicals from the denominator of  $1/\cot(\pi/24)$ . The answer is  $\sqrt{6} - \sqrt{3} + \sqrt{2} - 2$ . MuPAD didn't even simplify  $\cot(\pi/2)$  let alone simplify its inverse.*

(d) *(Wester 27) Write  $\cos(3c)/\cos(c)$  in terms of  $\cos(c)$  and  $\sin(c)$ . The answer is:  $4 \cos^2(c) - 3$ .*

(e) *(Wester 31) Simplify  $\sinh(\log(\tan((c/2)+\pi/4))) - \tan(c)$ . The answer is 0.*

MuPAD didn't try to simplify the sinh.

**To see the complete suite of symbolic math tests developed by Barry Simon, visit [www.deskeng.com](http://www.deskeng.com) and click on this article.**

ror, which can be difficult to deal with if there are dozens of letters on a command line. The program should place an arrow below the offending point. And, there are dozens of special functions in packages, but you have to load them by hand rather than the automatic loading that the competition eventually adopted.

### THE BOTTOM LINE

I still am somewhat in awe of a program that can do things like compute the sum of the first  $N$  cubes. Numerics on a computer is understandable since we think of arithmetic as totally algorithmic. But symbolic manipulation seems much closer to intelligent thought. At some level I understand that the wizard is really just a man behind the curtain and that these programs do their magic by putting together a huge number of algorithms but I still find them amazing tools.

MuPAD is a powerful product that has 90% of the basic capability of Maple or Mathematica at one-third the price. If you use this kind of program on a daily basis, you are probably already using Mathematica or Maple and there is no reason to switch. If you want a program like this around for occasional use, this is an excellent choice—unlike MathCAD's symbolics or Calculation Center, it provides a full-fledged symbolic environment and for all but the highest-end tasks, it does the job.

### Contributing Editor Barry Simon

is a professor of mathematics and theoretical physics and chair of the mathematics department at the California Institute of Technology. He is the author of numerous books, including **The Mother of All Windows 98 Books** (Addison-Wesley). You can contact him through e-mail at [bsimon@bigfoot.com](mailto:bsimon@bigfoot.com).

### COMPANY INFORMATION

**MuPAD Pro 2.0**  
**MacKichan Software**  
Bainbridge Island, WA  
206-780-2799  
[www.mackichan.com](http://www.mackichan.com)

**Price:** Contact MacKichan Software for pricing.

**Requirements:** Windows 95/98, 2000/NT, or Me/XP; 16MB RAM (32 recommended), and 30MB disk space.



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