Review of Mathcad 2001

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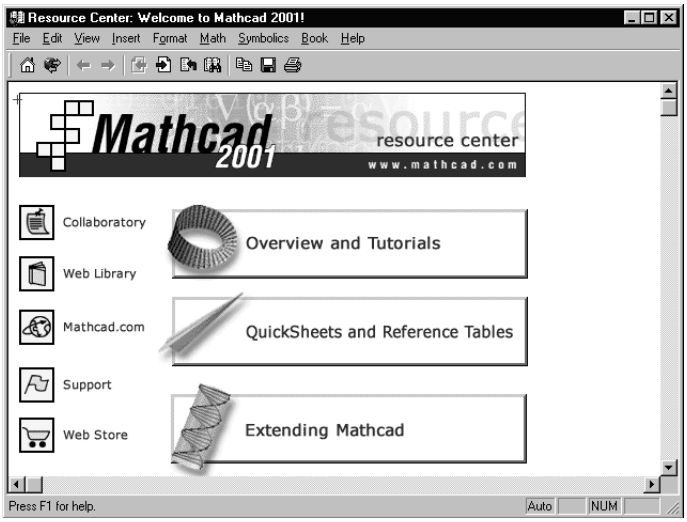
Mathcad is a Windows program designed to work with formulae, text and graphics. Earlier releases have been described in detail by the reviewer (Mathcad 6 - *Maths&Stats* Nov 96) and by Duncan Robertson (Mathcad 7 – *Maths&Stats* Aug 98 and Mathcad 8 – *Maths&Stats* Aug 99). In this review the main features of Mathcad are therefore only briefly discussed before the changes and enhancements between Mathcad 8 and Mathcad 2001 are described. Currently Mathcad 2001 is available in two forms – Mathcad 2001 Professional (education price £199 – upgrade from any non-student edition £115) and Mathcad 2001 Premium (education price £399 – upgrade from any non-student edition £199). The difference between the professional edition and the premium edition is that included with the premium edition are several additional programs such as Axum 6, Smartsketch 3.1 and the Mathcad Solving & Optimisation Pack. The latest student edition is Mathcad 8. Student editions contain restrictions on arrays to a maximum of 1000 elements and do not have all the programming capabilities.

When Mathcad 2001 is opened the Resource Centre is immediately available which contains extensive help and access to other web-based facilities.



Mathcad capabilities

Mathcad uses normal mathematical notation to enable variables, functions and expressions to be defined. Mathcad is able to perform symbolic and numerical operations. Examples are:

$$\lim_{x \to 0} \frac{\sin(x)}{x} = 1 \qquad \int \sqrt{1 - x^2}\, dx = \frac{1}{2} \cdot x \cdot \left(1 - x^2\right)^{\frac{1}{2}} + \frac{1}{2} \cdot \operatorname{asin}(x)$$

The accuracy of numerical calculations can easily be investigated. For example, using the default tolerance of 0.001 produces

$$\int_0^{\infty} x^{10} \cdot e^{-x}\, dx = 3.6288000071 \times 10^6$$

compared with the true value 10! = 3268800. Using a higher tolerance of 0.0001 the exact value is returned from the integral. Mathcad uses several

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different algorithms for the numerical evaluation of integrals. There is an automatic selection of appropriate algorithm but users may opt for other methods. This is useful when investigating the convergence of integrals containing singularities or infinite limits.

Symbolic calculations are easily performed in Mathcad. However, many integrals and derivatives yield common functions such as the sine integral, Si(x), and elliptic integrals, LegendreE(x,k) which are not amongst the 250 standard functions included within standard Mathcad. These functions have to be separately loaded from the Resource Centre. The reviewer feels that these functions should be standard and made similar comments when reviewing Mathcad 6.

The remainder of the review will concentrate on the enhancements made between Mathcad 2001 and Mathcad 8, the last reviewed program.

One of the weaknesses of releases of Mathcad prior to Mathcad 2000 was an inability to correctly display partial differentiation operators. The new releases enable the standard operators to be used thereby clarifying expressions. For example

$$\frac{d}{dx}\frac{\sin(x)}{\cos(y)}$$

can now be displayed as

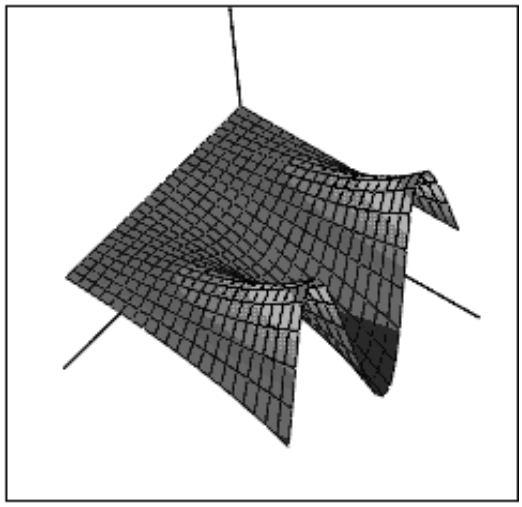
$$\frac{\partial}{\partial x}\frac{\sin(x)}{\cos(y)}$$

Minor, though welcome improvements, are the ability to express numeric output in fraction and engineering formats and a traceback facility to enable the origin of errors in complex formulae to be determined. Improvements have been made to the accuracy of numerical calculations and to speeding up operations. Releases 7 and 8 were justly criticised for being slow, much slower than release 6. The new calculation engine can for example rotate a three dimensional graphic in real time.

Major improvements have been introduced in the handling of text. Regions of a Mathcad document can now be high-lighted and bordered in colour to give emphases to parts of the document. The reviewer would welcome the ability in text to produce fully left and right justified text as used in this article as well as text aligned to left and right margins. Release 8 introduced the ability for documents to be saved as HTML. Release 2001 has added the extra facilities of saving in HTML with MathML (Mathematics Mark Up Language). These files can also be read and inserted in Mathcad documents. Graphic images are saved as JPEG files and can be easily inserted into other programs. The example below shows a simple 3-D graphic image saved in HTML and re-entered into Mathcad.

$$i := 0..25$$

$$f_{i,j} := \sin\left(\frac{i}{2.5}\right)\cdot\left(e^{\frac{j}{10}} - 1\right)$$



One of the features which has made Mathcad popular with users is the ability to add Electronic Books, for example in Civil and Mechanical Engineering, where standard textbook formulae have already been coded. These books enable formulae to be copied and inserted directly into a Mathcad document. To enable the resulting documents to be more easily readable it is possible to hide portions of calculations. The new release has improved and simplified the methods of writing Electronic Books so that using these books and the use of HTML described above it is possible to produce web-based instructional material.

Mathcad links to other programs

A major improvement since version 8 has been the simplification of links between Mathcad and other programs such as the Microsoft Office suite. In previous releases the reviewer found it very tedious to make OLE links. The example given below shows two vectors defined in Mathcad passed into Excel to calculate the value of a sub-set of a bill of quantities and the result returned to Mathcad. The user manual gives clear instructions on how the links are set up. It took the reviewer only a few minutes to produce the spreadsheet.

In fact, more time was spent in transferring the results into Word as the Excel component kept overwriting its assignment vector.

$$quantity := \begin{pmatrix} 130 \\ 550 \\ 220 \\ 15 \end{pmatrix} \qquad unit\_price := \begin{pmatrix} 5.21 \\ 3.22 \\ 1.04 \\ 13.22 \end{pmatrix}$$

$$\begin{pmatrix} item\_value \\ total\_value \end{pmatrix} :=$$

ref No.	quantity	unit	unit_price	item_price
532	130	m^3	5.21	677.30
533	550	m	3.22	1771.00
534	220	m^3	1.04	228.80
535	15	m^2	13.22	198.30
				2875.40

(quantity unit_price)

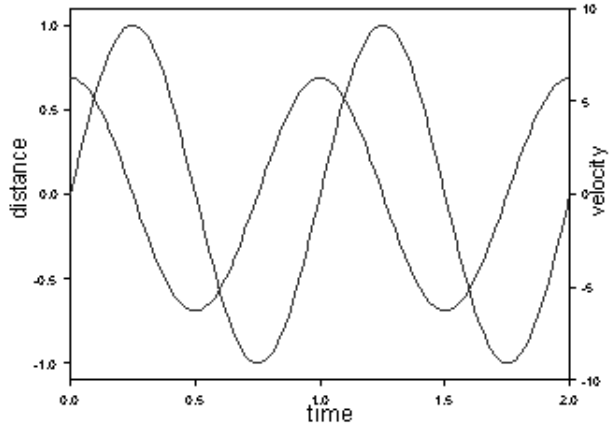
$$item\_value = \begin{pmatrix} 677.30 \\ 1771.00 \\ 228.80 \\ 198.30 \end{pmatrix} \qquad total\_value = 2875.40$$

Help is readily available in Mathcad using the Resource Centre. For experienced users this help enables an understanding of the new or lesser used facilities to be obtained. The reviewer feels that the extensive tutorial facility built into the Resource Centre requires an understanding of the elements of Mathcad before it can be effectively used. The reviewer regularly teaches Mathcad to students and has found that they need at least one hour's tuition in the basics of Mathcad before they can navigate efficiently through the tutorial system.

Mathcad 2001 includes either Axum LE with the Professional Edition or Axum 6 with the Premium Edition. This program is an extensive graphics program enabling fully annotated plots to be produced. The LE version is restricted to 2D whereas the full version, Axum 6, handles 3D plots, trellis plots and a full range of non-linear curve fitting algorithms. As an example of the simplicity and extra graphical features consider the standard problem of plotting distances and velocities of a particle on the same graph. In Mathcad the example was created by first creating arrays of distances, velocities and time. Following the sequence *Insert - Component -Axum Graph – Line with Scatter, Multiple XY, 3 input variables* produced a blank graph with three placeholders. *t, s* and *v* were then input to produce the graph with default axes and labels. The axis labels and tick marks were edited to produce the following example.

$$i := 0 .. 100$$

$$t_i := \frac{i}{50} \qquad s_i := \sin\left(2 \cdot \pi \cdot t_i\right) \qquad v_i := 2 \cdot \pi \cdot \cos\left(2 \cdot \pi \cdot t_i\right)$$



(t s v)

Although the reviewer tried for several hours he was unable to produce the example listed in the Mathcad manual which has extensive annotation and axis labelling inserted. Sophisticated graphics, which Axum is capable of producing, seem only to be available easily when working in Axum without links and copying data files. A 2D drawing package, Smartsketch LE, is also included with the distribution set of the Professional Edition. This, when linked with Mathcad using the component facility, enables parametric two dimensional, Autocad-like engineering drawings and other graphics, to be produced. The reviewer instantly used its flowchart sub-component when writing a paper.

The first two editions of Mathcad introduced a program with excellent WYSIWYG (what you see is what you get) numerical facilities for combined calculus and text processing. The numerical capabilities of Mathcad have been enhanced throughout the various editions culminating in recent editions with 13 differential equation and partial differential equation solvers and with several root finding and optimising functions. Included with the Premium Edition is an advanced Solver and Optimisation Pack which is claimed to be able to solve systems containing hundreds of variables. The reviewer has not tested this facility. The reference library introduced in Release 8 enables users to find out about the algorithms being applied and also to manually select the appropriate algorithm. The symbolic capabilities of Mathcad were introduced in Release 3

by the incorporation of a subset of the Maple engine. Throughout the following editions symbolic facilities have been improved so that the engine is now robust and reasonably extensive. The reviewer would like to see, however, the symbolic solution of classes of first and second order differential equations which are available in other systems such as Maple and MATLAB.

Mathcad user groups

The Mathcad online discussion list, hosted by Adept, is active and issues relating to Mathcad and its uses are raised. For example, in March 2001 there was discussion about the numerical evaluation of sin(x)/x when x tends to 0. Using the symbolic processor the limit is returned as 1 but sin(0)/0 produces 0. The discussion has centered on whether, or not, Mathcad should return NAN (not a number) or ERROR – division by zero, in this case. The coding of the numerical algorithm has, in order to speed up calculations, used the rule that if the value of a numerator is 0 the result is 0 regardless of the value of the denominator. The reviewer has learnt many tricks and facets of Mathcad from the discussion list. In addition to the discussion list there are several web-based facilities run by Mathsoft and found in the Resource Centre. Firstly, there is a library of Mathcad worksheets and Electronic Books and secondly the Collaboratory. The Collaboratory consists of forums where users can post messages download files created by other Mathcad users. It is possible to search the Collaboratory for key phrases.

Conclusions

The reviewer feels that although he has criticised the package in several places it must be emphasised that he, and his research students, use the package on a day-to-day basis as it enables complex structural engineering calculations with good graphics to be performed. The reviewer particularly appreciates the use of standard mathematical operations. The additional web authoring facilities, in particular, will be used by the reviewer in the conversion of his existing lecture notes to a web-based form of delivery. Finally, with this version of Mathcad, several useful extra programs are included as standard.