

MathJax: SEAMLESS MATHEMATICS ON THE WEB

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Introduction

MathJax is an easy-to-use system for including mathematical expressions in web pages, developed under the sponsorship of the American Mathematical Society, the Society for Industrial and Applied Mathematics, and Design Science, Inc., with more recent support from other organizations such as the Mathematical Association of America. Since MathJax utilizes JavaScript for the display of mathematics, it will work with all major browsers—including mobile devices—without installation of any add-ons or plugins. And since it utilizes fonts supplied on demand by cloud-based servers, no locally installed fonts are needed.

Unlike previous methods of displaying mathematical expressions on the web, most of which relied on the use of fixed-size images, the MathJax system provides for fully scalable mathematics, with none of the alignment problems common to web pages relying on images. A web page author simply includes TeX, LaTeX or MathML markup for an expression into the HTML for the page, and MathJax does the rest, displaying and scaling the mathematics on the client side, through the browser's built-in JavaScript capability.

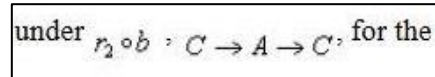
What? You don't know TeX or MathML? No problem! The TeX or MathML markup for an expression can be generated easily by MathType (a product of Design Science, Inc.), and then pasted into the HTML for your web page. (Well, OK—you do also have to include a simple `<script>` call to download the JavaScript code from the MathJax cloud, which is then loaded automatically into the client browser at run time.)

Best of all, since MathJax is an open-source project distributed under the Apache License, it is totally free to both the author and the viewer of a web page.

The Past

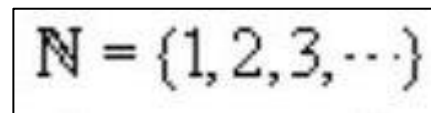
In the distant past, the standard way to include mathematical symbolism in a web page involved creation of a symbolic expression using software like TeX or MathType,

creating a .gif or .jpg image from the expression, saving the image in an appropriate folder on your web server, and then including the image in your web page using HTML (or a web page editor that would write the HTML for you). Besides being labor-intensive, this approach had many drawbacks. Perhaps the most pervasive problem with this approach is the fact that vertical alignment of images was not standardized in web browsers, and so different browsers would display the mathematics and text differently. Moreover, resizing of a web page by zooming cannot change the fixed resolution of an image, and so mathematical expressions could look quite pixelated under magnification. (See Figures 1 and 2.)



under $f_2 \circ b : C \rightarrow A \rightarrow C$, for the

Figure 1: Vertical alignment problem



$\mathbb{N} = \{1, 2, 3, \dots\}$

Figure 2: Pixelation

In the late 1990's, MathML (Mathematical Markup Language) was proposed as a solution to the problem of mathematical symbolism on the web. As an application of XML, MathML could be embedded into XHTML web pages and displayed using an XHTML compatible browser. However, most browser development did not keep pace with the desires of the mathematical community. Until very recently, only Firefox provided native support for MathML, with other browsers either requiring additional components or not supporting MathML at all. As a result, outside of specialized publishing applications, MathML never really “took off” as a means of displaying mathematical content in web pages.

Between 2004 and 2010, a new mathematical display system, based on JavaScript, was developed by Union College professor Davide Cervone. This system, known as jsMath, was designed to provide a cross-platform system that utilized the ubiquitous, client-based JavaScript, along with font collections, to display mathematical symbolism encoded in HTML pages using the TeX markup language. While this was a huge step toward freeing the web from the use of images as the main means of mathematical symbolism, it also required the hosting web server to install the jsMath software and font sets.

The Present: MathJax

MathJax [4], also developed under the leadership of Davide Cervone, is the natural successor to jsMath. MathJax allows a web page author to include TeX or MathML code for mathematical expressions in any HTML page. The author includes a simple `<script>`

call to the MathJax server cloud in each web page, and the MathJax system then utilizes the client browser’s native JavaScript to interpret the mathematical expressions. Fonts are downloaded automatically from the MathJax cloud on demand, and the result is beautifully rendered, fully scalable mathematics—with no vertical alignment problems, no pixelation, and no need to install anything on your server—in virtually any browser anyone would use!

The American Mathematical Society uses MathJax as the default system for displaying abstracts in MathSciNet. Because of this, the reader can be totally unaware of what transpires behind the scenes, and can simply focus on the mathematics. Figure 3 shows a MathSciNet review of a paper, displayed via MathJax.

AMERICAN MATHEMATICAL SOCIETY
MathSciNet
 Mathematical Reviews
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Publications results for "Author=(d'ambrosia)" MathJax is on

MR1402552 (98a:16027) Reviewed

Anderson, Frank W.(1-OR); D'Ambrosia, Barbara K.(1-JOCA)

Square-free algebras and their automorphism groups. (English summary)

Comm. Algebra 24 (1996), no. 10, 3163–3191.
 16P10 (16S35 16W20)

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A finite-dimensional algebra A over a field K is square-free if $\dim_K(eAf) \leq 1$ for all primitive idempotents e and f in A . Choosing a complete set of primitive orthogonal idempotents $e_i, i = 1, \dots, n$, of A , one obtains a semigroup S with zero denoted by θ by letting $S = \{e_i A e_j \mid e_i A e_j \neq 0\} \cup \{\theta\}$ and where the multiplication is given by the formula

$$e_i A e_j \cdot e_l A e_k = \begin{cases} e_i A e_j A e_k & \text{if this is nonzero and} \\ \theta & \text{otherwise.} \end{cases}$$

Now choosing a K -basis $e_{ij} \in e_i A e_j$ for all i and j with $e_i A e_j \neq 0$ and $e_{ij} = e_j$ one gets that the structure constants λ_{ijk} given by the multiplication $e_{ij} \cdot e_{jk} = \lambda_{ijk} e_{ik}$ correspond to a two-dimensional cocycle ξ on S with coefficients in K^* ; now A is isomorphic to the semigroup algebra of S over K twisted by ξ . After these preliminaries the authors prove that the group of outer automorphisms $\text{Out } A = \text{Aut } A / \text{Inn } A$ of A fits into a short exact sequence

$$1 \rightarrow H^1(S, K^*) \rightarrow \text{Out } A \rightarrow \text{Stab}_\xi(\text{Aut}_0 S) \rightarrow 1,$$

where $H^1(S, K^*)$ is the first cohomology group of S with coefficients in K^* , $\text{Aut}_0(S)$ is the group of "normal" automorphisms of the semigroup S and $\text{Stab}_\xi(\text{Aut}_0 S)$ is the stabilizer in $\text{Aut}_0 S$ of ξ under the action of $\text{Aut}_0(S)$ on $H^2(S, K^*)$. This sequence splits in case $\xi = 1$.

Figure 3: A MathSciNet review, with mathematics rendered via MathJax

How to use MathJax

Not only does MathJax produce beautiful mathematical expressions in web pages, it is also incredibly easy to use. Although, as an option, you can install MathJax on your own web server, the easiest thing to do is to include the following call to MathJax in the `<head>` block of your HTML code:

```
<script type="text/javascript"
  src="http://cdn.mathjax.org/mathjax/latest/MathJax.js?config=TeX-AMS-
  MML_HTMLorMML">
</script>
```

Then, wherever you wish to include a mathematical expression in the text of your web page, simply type the TeX (or MathML) code for the expression—with the following exceptions. Because TeX markup is so much simpler than MathML, we will confine our attention to the use of TeX in the remainder of this paper.

Exceptions to TeX markup:

1. Use either `$$. . . $$` or `\[. . . \]` as delimiters for displayed math.
2. Use `\(. . . \)` as delimiters for in-line math.
3. If you use a “less than” sign, be sure to put spaces around it, to avoid possible confusion with an HTML tag.

Figure 4 shows TeX markup for some mathematics, as it would be entered into an HTML

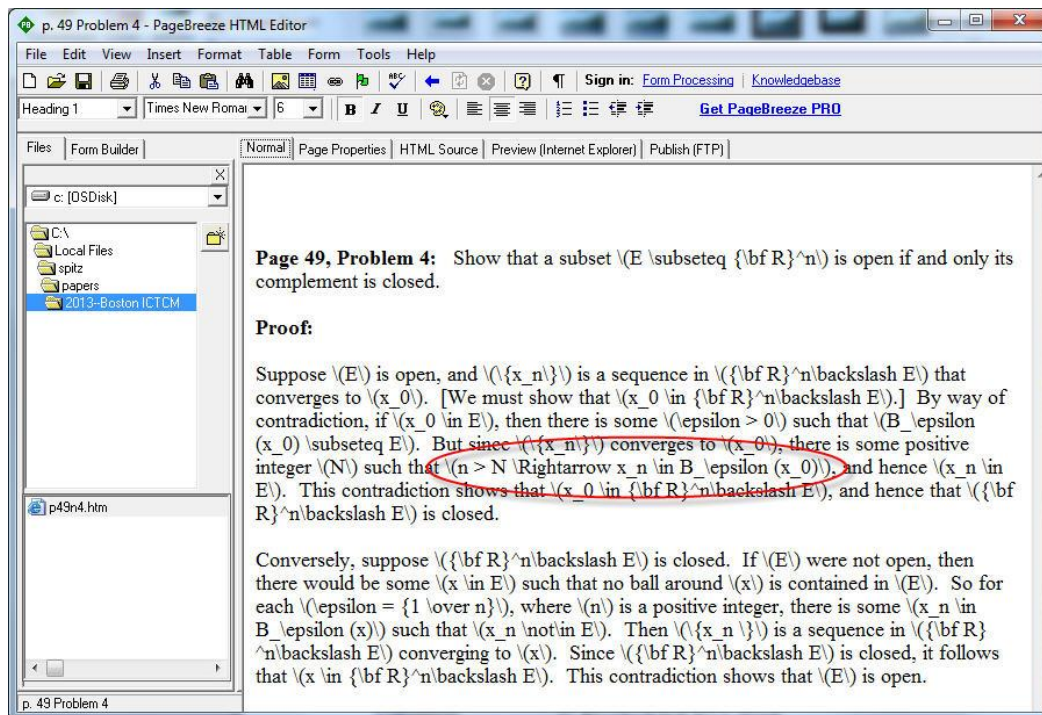


Figure 4: TeX markup in an HTML editor

editor. Figure 5 shows the resulting web page, viewed in a browser. The circled portions in the two figures correspond.

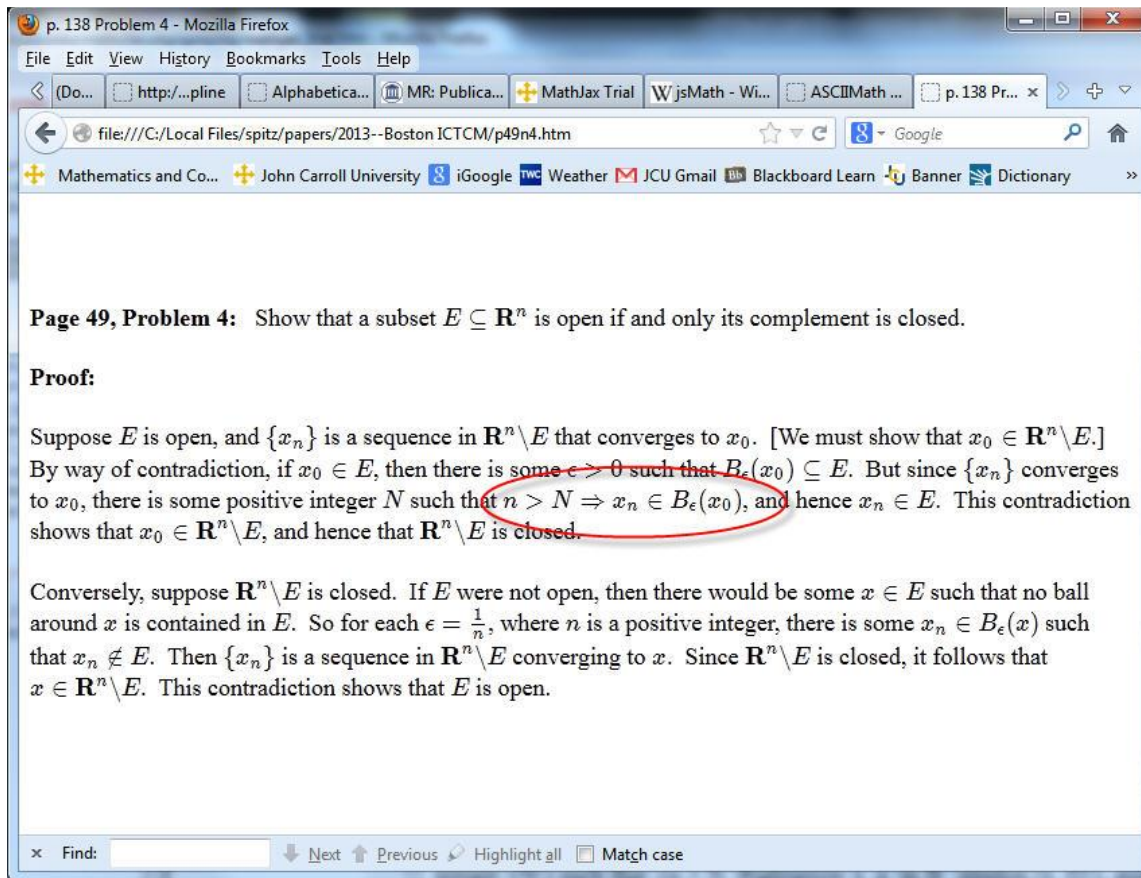


Figure 5: Web page with mathematics rendered by MathJax

Figure 6 shows the required call to the MathJax content delivery network, inserted into the `<head>` block of the same web page. You will need to access the HTML directly, using your web page editor, in order to make this insertion.

A useful feature of MathJax is its ability to provide a “magnifying glass” for the reader of a web page to enlarge the details of mathematical expressions. After the magnifier is enabled (one time only), it will appear whenever you hover on an equation for 500 ms. (See Figure 7.) MathJax settings—including enablement of the magnifier and specification of the degree of magnification—are accessed by right-clicking an equation (or using control-click in MacOS). You can also view what the equation looks like in TeX or in MathML—as well as copy the markup code for pasting into another application. If you choose to install MathJax on your own server (which we do not), then you can control the extent to which the reader of your pages can access these special

features. For instance, access to the magnifier and other features is turned off by the MathSciNet server.

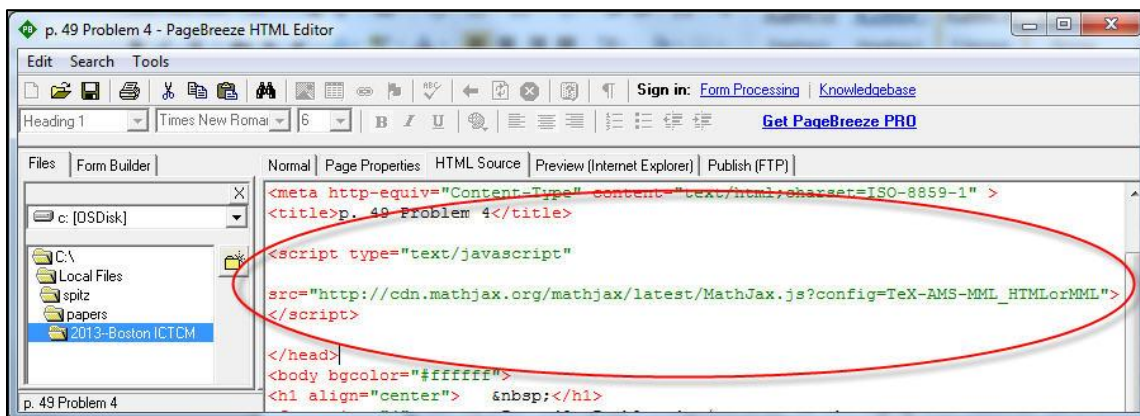


Figure 6: Call to load MathJax into the web page

Page 49, Problem 4: Show that a subset $E \subseteq \mathbf{R}^n$ is open if and only its complement is closed.

Proof:

Suppose E is open, and $\{x_n\}$ is a sequence in $\mathbf{R}^n \setminus E$ that converges to x_0 . [We must show that $x_0 \in \mathbf{R}^n \setminus E$.]
 By way of contradiction, if $x_0 \in E$, then since $\{x_n\}$ converges to x_0 , there is some positive integer $n > N \Rightarrow x_n \in B_\epsilon(x_0) \cap E$. This contradiction shows that $x_0 \in \mathbf{R}^n \setminus E$, and hence $\mathbf{R}^n \setminus E$ is closed.

Conversely, suppose $\mathbf{R}^n \setminus E$ is closed. If E were not open, then there would be some $x \in E$ such that no ball around x is contained in E . So for each $\epsilon = \frac{1}{n}$, where n is a positive integer, there is some $x_n \in B_\epsilon(x)$ such that $x_n \notin E$. Then $\{x_n\}$ is a sequence in $\mathbf{R}^n \setminus E$ converging to x . Since $\mathbf{R}^n \setminus E$ is closed, it follows that $x \in \mathbf{R}^n \setminus E$. This contradiction shows that E is open.

Figure 7: Magnified expression in a web page

If you don't know TeX or MathML

Don't worry! Although many simple mathematical expressions can be coded in TeX fairly easily, you do not need to know TeX or MathML in order to start posting beautiful mathematics on the web. MathType (a product of Design Science, Inc. [2], that is designed to produce mathematical expressions for inclusion in documents created in Word or other software) provides an easy-to-use point-and-click interface for creating mathematical expressions. After creating an expression with MathType, and before closing the MathType editor, select "Cut and Copy Preferences" from the "Preferences"

menu. Then choose whether you wish to have MathType generate TeX or MathML code. (We like to use Plain TeX. See Figure 8.) When you copy the expression you have created, what will be copied to the clipboard is the markup code for your expression. Then simply insert that code into your web page, using the appropriate delimiters discussed above.

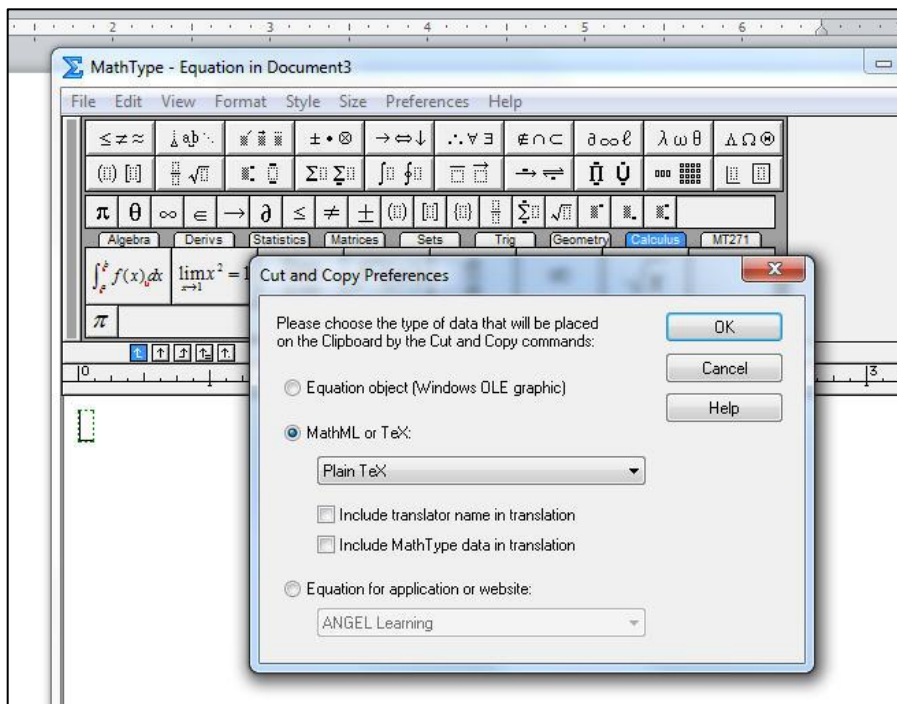


Figure 8: Setting the “copy” preference in MathType

For those who prefer to operate on “full autopilot,” the latest release of MathType, version 6.9 for Windows, includes a rewritten version of Design Science’s MathPage technology that takes full advantage of MathJax. After installing MathType 6.9, simply create a Word document containing whatever MathType expressions you wish, and then, from the MathType ribbon in Word, select “Publish to MathPage.” In the “Equations” section, select “HTML + MathJax.” (See Figure 9.) MathPage will do the rest of the work for you, creating both an HTML page and a folder with a small number of additional files. Copy both the folder and the HTML page to your web server, and your web page will be ready for viewing, complete with beautifully typeset mathematics and full MathJax functionality.

Conclusion

While MathJax does a superb job of rendering mathematical expressions in web pages, it is important to remember that it is *not* a page-formatting system. The *positioning* of text

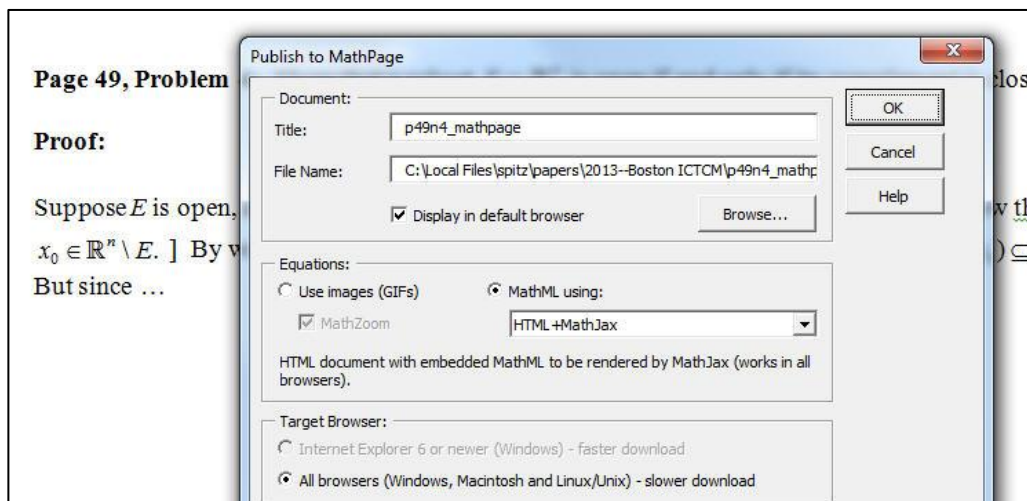


Figure 9: The “Publish to MathPage” dialog box

(and mathematical expressions) in a web page is still handled by the reader’s browser, while MathJax handles the rendering of the mathematics. So, for instance, if you wish to post a faithful reproduction of a document on the web, it is better to do that with a pdf copy produced by page-formatting software such as TeX or Word. Moreover, MathJax may not implement absolutely every mathematical expression macro provided by every TeX, LaTeX or AMS-TeX implementation, although it does indeed handle an impressive array of mathematics. References [3] and [5] contain lists of TeX commands that are currently handled by MathJax.

Although there may be some room for future improvements, there is no question that MathJax is what we (the authors) have been waiting for, for the last fifteen years!

References

- [1] Cervone, Davide, “Math Jax: A Platform for Mathematics on the Web.” *Notices of the American Mathematical Society* **59** (2012): 312–316.
- [2] Design Science, Inc. homepage. <<http://www.dessci.com>>.
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- [5] MathJax supported LaTeX commands. <<http://docs.mathjax.org/en/latest/tex.html#supported-latex-commands>>.