Web*Mathematica* Introduction

***webMathematica* is a new technology that allows the generation of dynamic web content with *Mathematica*. It integrates *Mathematica* with a web server.** *webMathematica* harnesses the full range of *Mathematica* technology to build sophisticated web applications, providing immediate access to the world's leading technical computing software from any web browser.

Those accessing *webMathematica* sites do not have to know how to use *Mathematica.* In fact, they do not need to know they are using *Mathematica*.

webMathematica is the clear choice for adding interactive calculations to the web. This unique technology enables the user to create web sites that allow users to compute and visualize results directly from a web browser. Based on the world's leading technical computing software and Java Servlets, a proven server technology, *webMathematica* is fully compatible with Mathematica and state-of-the-art dynamic web systems.

In this chapter we will demonstrate an operation of *webMathematica* and the development of a *webMathematica* site. This introduction considers the reasons for using *Mathematica* in a web site, examines a few areas in which you might use *webMathematica*, briefly discusses the underlying *Mathematica Server Pages* technology, and outlines the requirements for running *webMathematica*.

WebMathematica technology is scalable, reliable, and easy to use. It allow the deployment of the building of calculators, algorithms, and problem-solvers over the web or intranets, custom web sites that provide specialized calculations to customers, delivery ofinteractive courseware over the web and publishing of interactive textbooks and book supplements on the web.

Why Use Mathematica in Your Web Site?

There are various important features that *Mathematica* can offer to a web site, including **computation, an interactive programming language, connectivity, the *Mathematica* front end, and enhanced support for MathML**.

Computation

Mathematica contains a large collection of functions for computing in many areas, such as numerics, symbolics, and graphics. ***webMathematica* makes all of this functionality available over the web.**

Many web technologies, so powerful in many areas, are not well suited to scientific computation; it is simply not their main focus. *Mathematica*, on the other hand, is very suitable for scientific computation, and can provide this on the web.

Interactive Programming Language

Mathematica contains a high-level, interactive, functional programming language. It lends itself to rapid prototyping but can scale up to large intensive computations. These are also advantages for web content generation, since large sites can be developed with less programmer effort.

Connectivity

Mathematica connects readily to external services, which may be provided by languages such as Java, C, Fortran, or Perl. These services can provide a data source for computations and also take the results from *Mathematica.* It is particularly easy to connect to Java via *J/Link*, a toolkit for integrating Java into *Mathematica*.

The Mathematica Front End and Alternatives

The *Mathematica* notebook user interface (front end) has long provided the premium mechanism for working with the *Mathematica* kernel. Now, *webMathematica* provides an alternative interface via the web. Even in a web environment, the front end is extremely useful. It is used to typeset mathematics and render two- and three-dimensional graphical objects into images. In addition, the front end can generate notebook documents on the server to send to the client.

Mathematical Typesetting and MathML

Mathematica is a premium system for interactive mathematical typesetting. It is also a powerful system for working with MathML, which is designed to allow the use and reuse of mathematical and scientific content on the web and by other applications. These features are a valuable component of *webMathematica*, which works well with the increasing number of tools that are available for MathML.

webMathematica adds interactive calculations and visualization to a website by integrating _Mathematica_ with the latest web server technology.

How is *webMathematica* different from *Mathematica*?

webMathematica and Mathematica have the same underlying engine, but they provide fundamentally different user interfaces and are aimed at different types of users.

webMathematica offers access to specific Mathematica applications through a web browser. The standard *Mathematica* interface provided requires little training to use effectively. In most cases, users neither have to be familiar with *Mathematica* nor need to know they are using *Mathematica*. In some sense, one can consider *Mathematica* a development environment for *webMathematica* sites. As an example, *Mathematica* is suitable for working on code that models some physical process-code that can then be

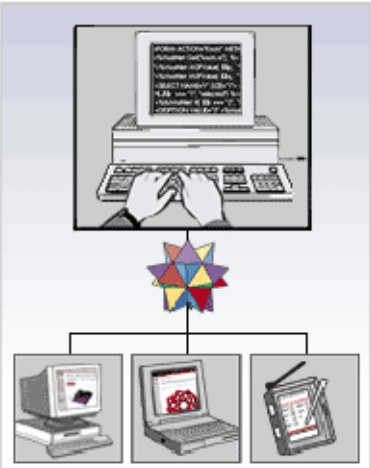
placed into a *webMathematica* site to enable people to run the model and use its results for their regular work.

webMathematica solves the problem of how to create and distribute solutions to technical computing problems quickly in today's networked environment. *webMathematica* user can develop new applications rapidly without requiring developers to learn new skills or to write a lot of Java code for mathematical algorithms, graphics, and input and output.

Developers do not have to worry about session management and error recovery. *webMathematica* takes care of all aspects of development, letting your R&D personnel concentrate on solutions, not the implementation details.

***webMathematica* lets you build, test, and deploy specialized web services for computation and visualization at a faster pace and a lower cost than ever before.**

The three most immediate technical advantages in using web*Mathematica* as a whole are:



Develop web services that can be accessed from any web-enabled device.

Computational Ability

webMathematica provides a large library of *Mathematica* commands for web development. This allows you to build technical—mathematical computing web services, including numerical, symbolic, and graphical applications that solve your daily mathematical computing problems quickly and easily. Also, *Mathematica* can import and export over 40 data, sound, and image formats, enabling users to process data online.

Server-Based Computation

There is no software to buy, install, or maintain in order to use *webMathematica* sites. **All that end users need is a web browser and, for some more-advanced features such as interactive 3D graphics, a Java runtime environment.**

Ease of Use

All user interface elements are standard web GUI

elements such as text fields, check boxes, and drop-down lists. This enables you to cut training time because your employees no longer have to learn different software applications. In many cases, no *Mathematica* experience is required.

webMathematica makes all of the functionality of *Mathematica* available for website development. This easy access to the latest high-level computational algorithms as well as to powerful data analysis, graphics, and typesetting functions means that you can concentrate on solving your problems, not on programming solutions yourself. Regardless of the size of the application you are creating, developing it in *webMathematica* will cut your development time and make your application more robust as well as easier to use and maintain.

Key advantages of *webMathematica* for teachers

Key advantages of *webMathematica* for teachers include:

Integration of Mathematica and HTML

webMathematica allows a site to deliver HTML pages that are enhanced by the addition of Mathematica commands. When a request is made for one of these pages, the Mathematica commands are evaluated and the computed result is inserted into the page, see Example 1 at the end of this chapter. This is done with JavaServer Pages (JSP), a standard Java technology, making use of custom tags. After the initial setup, all that you need to write *webMathematica* applications is a basic knowledge of HTML and *Mathematica*.

Standard Server Technology

webMathematica is based on two standard Java technologies: Java Servlet and JSP. Servlets are special Java programs that run in a Java-enabled web server, which is typically called a "servlet container" (or sometimes a "servlet engine"). There are many different types of servlet containers that will run on many different operating systems and architectures. They can also be integrated into other web servers, such as the Apache web server.

Connection Technology

Other software can readily be incorporated into *webMathematica* with MathLink technology. It is particularly easy to connect Java into Mathematica with J/Link, providing many exciting possibilities for *webMathematica* development. There is no problem with integrating Fortran or C libraries. Teacher can call functionality in the server to examine HTTP headers, create and inspect cookies, or use JDBC for database connectivity.

Mathematica Application Packages

webMathematica works seamlessly with the *Mathematica* application packages. They allow you to implement additional specialized functionality without months of development time. All standard *Mathematica* packages can be added to the

web*Mathematica* jsp pages. Also teacher's own packages can be simply implemented to the created courses.

Professionally Designed Web Page Templates

Included in *webMathematica* are professionally designed web page templates that can teachers modify for their needs, thus saving design time. All standard web technologies, CSS styles allow teacher to create more attractive and powerful sites.

Used Platform Independent Standards

webMathematica is built on platform-independent standards such as HTML, Java, and Java Servlet technology. For example, Java Servlet technology is supported, either natively or through plug-in servlet containers, by all modern web servers-including Apache, Microsoft IIS,-as well as by application servers such as IBM WebSphere.

webMathematica Technology »
webMathematica's kernel manager acquires a kernel for a request from a pool of preinitialized kernels.

Full Separation of Server Administration and Content Generation

The server setup and content generation are completely separate so that system administrators and webmasters can set up the system once and then others populate it. Content generators, be they teachers, writers, or instructors, do not have to understand or even have access to the underlying engine.

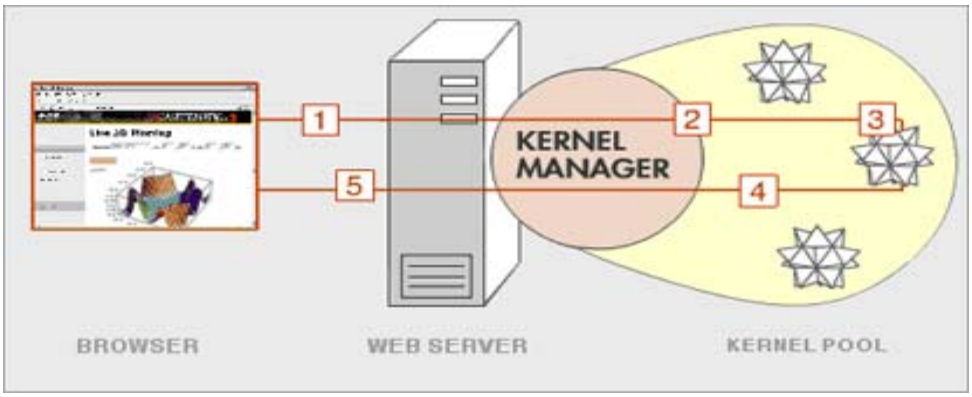
webMathematica Kernel Manager

An important part of *webMathematica* is the kernel manager, which calls *Mathematica* in a robust, efficient, and secure manner. The manager maintains pools of one or more *Mathematica* kernels; by maintaining more than one kernel, the manager can process more than one request at a time. Each pool takes care of launching and initializing its kernels. When a request is received for a computation, a kernel process is utilized to process the request and, upon completion, is returned to its pool. If any computation exceeds a preset amount of time, the kernel process is shut down and restarted. When the server is shut down, all of the kernel processes are also shut down. These features maximize the performance and stability of the server.

Key Technology of the *webMathematica* Pages

webMathematica integrates effortlessly with standard web technologies. You choose, install, and configure the web server, Java, and servlet container of your choice on the supported platform of your choice. You can then add the *webMathematica* application,

add *Mathematica*, and edit the *webMathematica* configuration files accordingly to fit your needs. This enables you to use proven web technology to manage your website.



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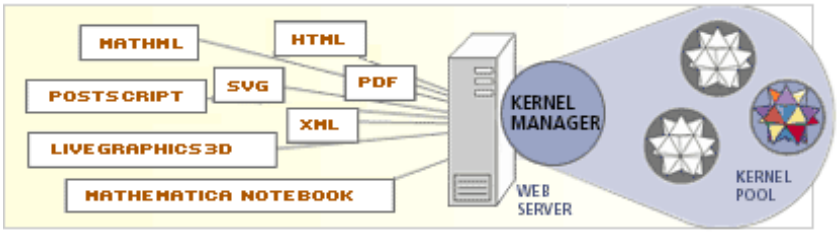
***webMathematica* allows a site to deliver HTML pages that are enhanced by the addition of *Mathematica* commands.** When a request is made for one of these pages, the *Mathematica* commands are evaluated and the computed result is inserted into the page. This is done with a standard Java technology, JSP, making use of custom tags.

webMathematica technology uses the request/response standard followed by web servers. Input can come from HTML forms, applets, JavaScript, and web-enabled applications. It is also possible to send data files to a *webMathematica* server for processing. Output can use many different formats such as HTML, images, *Mathematica* notebooks, MathML, SVG, XML, PostScript, and PDF.



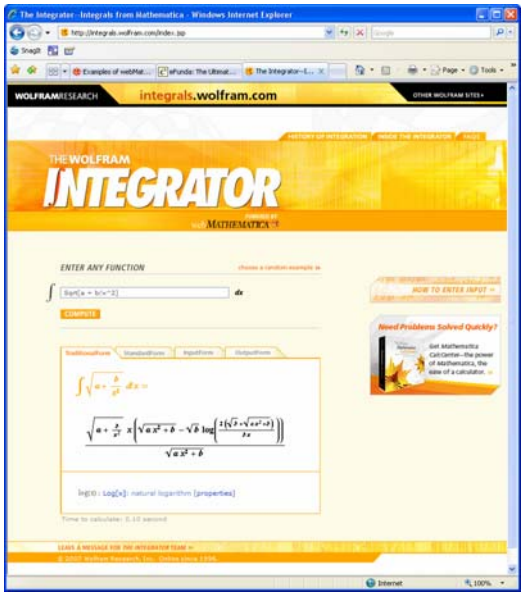
webMathematica can create output in many formats

Areas of Professional Use for web*Mathematica*

webMathematica enables users of *Mathematica* in commercial, research, and other institutions to provide their colleagues with online, interactive access to their *Mathematica* functions and packages. All of the computational power in *Mathematica* is available to build special calculators and problem solvers that are delivered over the web or your corporate intranet.

The development process is so simple that most *Mathematica* users can proceed through it without having to go through long development cycles or needing the services of dedicated developers. In many cases, all that is required to add the *Mathematica* commands and a couple of simple tags to a web page.

For Web Computations



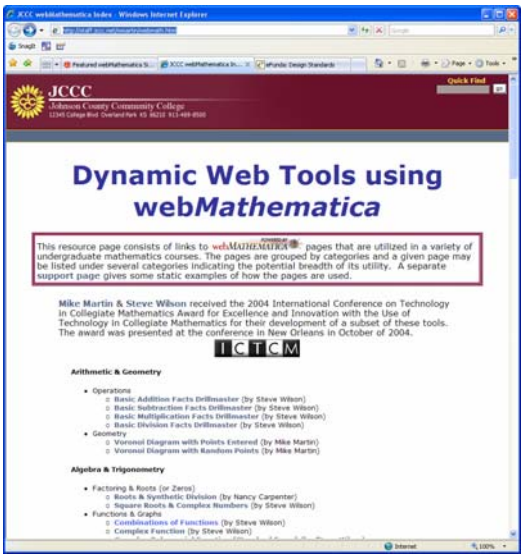
The Integrator is a Wolfram Research-developed website that solves integration problems. The heart of *The Integrator* is *Mathematica*'s built-in function Integrate--the same one used by accessing *Mathematica* directly.

Originally developed in 1997, the first *Integrator* used *MathLink* programs and a variety of Perl scripts to send commands back and forth from the web server to the *Mathematica* kernel and from the kernel to the front end. The programming was complex and time-consuming, even for experienced *Mathematica* developers and web programmers.

The current *Integrator* is a *webMathematica* implementation. Using the same web interface, the underlying system was completely reworked within a matter of hours.

http://integrals.wolfram.com/index.jsp

For Teachers / For Students



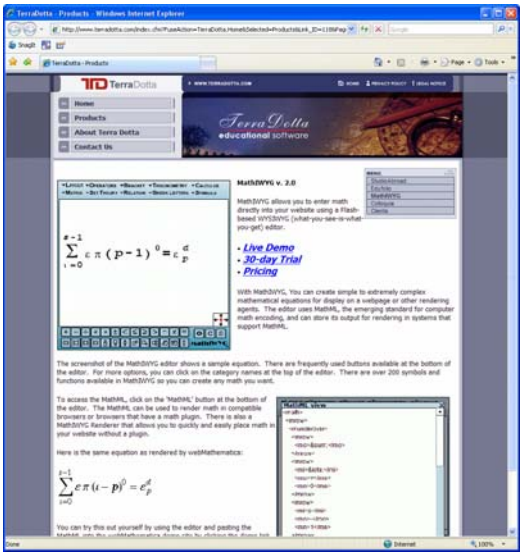
webMathematica is the ideal web environment for creating online courseware structured to meet the specific needs of any classroom setting. *webMathematica*'s graphics and functions - all built upon *Mathematica*'s intuitive programming framework - help students learn and retain more material in less time.

In many cases, you can take your pre-existing *Mathematica* educational applications and incorporate them as web-based education tools. Thus educators can quickly build special calculators and problem solvers and deliver them online.

With *webMathematica*, classroom demonstrations come alive with vivid graphics and interactive capabilities. Exciting 3D visualizations, formulas, and animations can help students quickly gain a deeper first-hand understanding mathematical concepts.

http://staff.jccc.net/mmartin/webmath.html

For Teachers



A simple example of how teachers have used *Mathematica* in education can be found in Terra Dotta's MathIWYG. Terra Dotta provides learning solutions for schools and universities. It has designed MathIWYG, a WYSIWYG math editor using *webMathematica*. MathIWYG is a commercial Flash application that can be embedded into any web page and requires no end-user download other than the Flash plugin.

With MathIWYG, you can create simple to extremely complex mathematical equations for display on a web page. The editor takes advantage of *webMathematica*'s capability for MathML, the standard for computer math encoding, and can store its output for rendering in systems that support MathML.

The screenshot of the MathIWYG editor shows a sample equation. There are over 200 symbols and functions available in MathIWYG, so you can create nearly any maths expression you want.

http://www.terradotta.com/

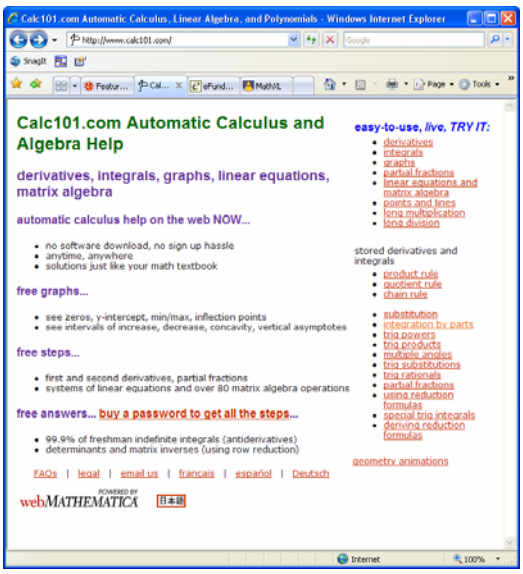
For Students (only for registered users)

Addison-Wesley, one of the world's most respected textbook publishers, sells online calculus tutorials and tests that use *webMathematica* technology. MathXL for Calculus is a web-based program designed to help assess students' calculus skills and to create a personalized study plan for each student based on individual test results.

To develop MathXL for Calculus, Addison-Wesley needed the display and evaluation capabilities of a symbolic computing system online, and *webMathematica* was the only tool that met those needs. "*webMathematica* made it possible for us to develop algorithmic calculus tutorials and tests in MathXL and to evaluate the students' answers. Using *webMathematica*, we can continue to add capabilities to MathXL to make sure it remains the best online mathematics testing and tutorial program out there," said Marlene Thom, senior producer at Addison-Wesley.

http://www.mathxl.com/

For On-line Calculations



Calc101.com, started in 1999, uses *webMathematica* to deliver online, on-the-fly, step-by-step solutions to high school and college level mathematics problems. It mixes free and pay-per-use calculators to lead precollege and college students through integration and differentiation. This site includes free integral calculations, but requires one to purchase a password to get these performed step by step. It also has a graph-plotting page that gives students a comprehensive understanding of how to plot functions, delivering over 80 graphs at once from a single input function.

http://www.calc101.com/