

William Stein

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Sage

Sage: create a viable free open source
alternative to Magma, Maple, Matlab, and
Mathematica

Sage: completely free and open source

Why?

- **Funding** from NSF, Microsoft, Google and donors
- **Volunteer contributions** from nearly 500 people over the last decade.

What?

- **Standalone** software solution: a web-based notebook, command-line, and Python library
- Comprised of about **100 (mathematical) software libraries**
- On top of that, the **Sage library** combines them and contains unique algorithms

The Sage/Python ecosystem

Status: awesome!

- Does much of what Magma, Maple, Matlab, and Mathematica does, but differently and better.
- Way ahead of Maple and Mathematica in combinatorics and number theory.
- Use any Python library inside of Sage – probably the most active programming language community on earth.
- Superb alternative to Matlab due to the massive **scientific Python** ecosystem.

The Sage/Python ecosystem

Status: fail

Failed so far at its mission statement to be a viable alternative to Ma*. For example:

I am very proud of my code for darmonpoints which does lots of things and is implemented in Sage. However, since it has Magma dependencies (mainly because of the lack of support of quaternion algebras in Sage) I have no plans to include it in Sage any time soon." - Marc Masdeau, Jan 10, 2015.

NEW and Improving: Documentation

Many Tutorials

- The official Sage PREP tutorials, ...

Very good introductory books about/using Sage

- Gregory Bard's new Sage for Undergraduates that AMS is publishing any day now, and the electronic book is **free**.

SageMathCloud

SageMathCloud (SMC)



SageMathCloud (SMC) – what it solves

SMC contribution:

You and all of your students and collaborators can now use Sage/IPython/LaTeX/R etc. together **without installing anything**

Acknowledgement

- **NSF/Google**-funded project over the last two years

What is SMC?

It's a large distributed system with **80 running VM's**

What you can do with SMC

- **Mathematics software:** Use Sage, R, Octave, Python, Cython, GAP, Pari, Macaulay2, Singular, and more
- **Teach:** Organize teaching a course
- **Interactive editing:** Collaboratively edit LaTeX documents, IPython notebooks, Textfiles and Sage worksheets
- **Programming:** Write, compile, and run code in C/C++, Java, Haskell, and most languages
- **Organize:** Manage TODO lists with hashtags
- **Backed up:** Every few minutes a consistent snapshot of all your files is sent to different data centers
- **Shell access:** Full Linux accounts copied with color terminals

SMC Users

Number of users

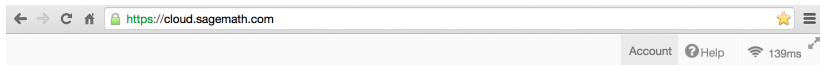
- **10K active weekly users**
- Over **500 simultaneous users** some days in December

Commercialization

- Use of SMC website for courses will likely eventually involve paying a fee to support the site. **Sage will always be free.**
- **Will be affordable:** due to **efficiently leveraging** open source.

Tour

Make an SMC account



Welcome to SageMathCloud™!

- **Mathematics software:** Use Sage, R, Octave, Python, Cython, GAP, Pari, Macaulay2, Singular, and more
- **Interactive editing:** Collaboratively edit LaTeX documents, IPython notebooks and Sage worksheets
- **Programming:** Write, compile, and run code in most languages
- **Organize:** Manage todo list with hashtags
- **Teach:** Organize teaching a course
- **Backed up:** All of your files are automatically snapshotted every few minutes
- **Shell access:** Full Linux accounts with color terminals

SageMathCloud is a free service hosted at University of Washington that is supported by the National Science Foundation (awards [1161226](#), [1147802](#), [1020378](#) and [1015114](#)) and [Google's Education Grant program](#).

Create an account (or [sign in](#))

First name

Last name

Email

Password

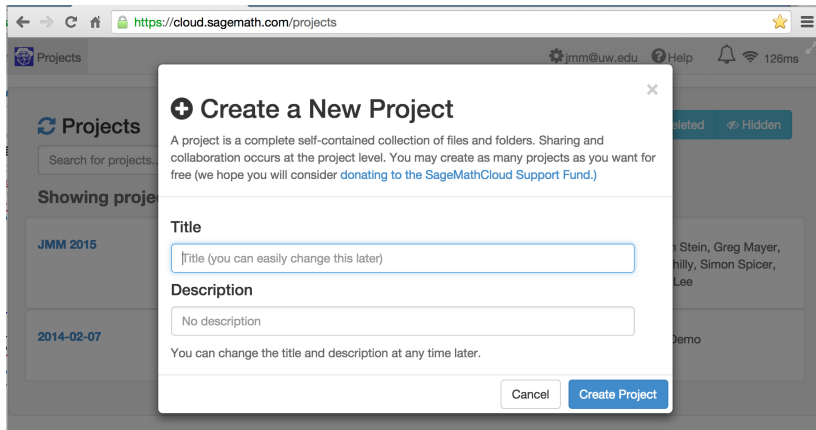
Retype password

Agree to the [SageMathCloud Terms](#)

Create account for free

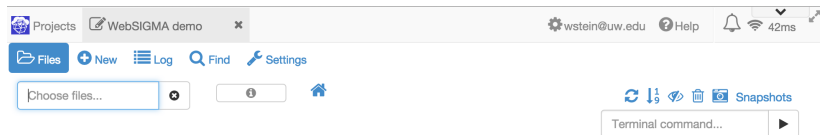


Create a project



The screenshot shows a web browser window at <https://cloud.sagemath.com/projects>. A modal dialog box titled "Create a New Project" is open. The dialog contains the following text: "A project is a complete self-contained collection of files and folders. Sharing and collaboration occurs at the project level. You may create as many projects as you want for free (we hope you will consider [donating to the SageMathCloud Support Fund.](#))". Below this text are two input fields: "Title" with the placeholder text "[Title (you can easily change this later)]" and "Description" with the placeholder text "No description". At the bottom of the dialog are two buttons: "Cancel" and "Create Project". The background shows a list of projects, including "JMM 2015" and "2014-02-07".

Open your new project



+ Create or Import a File, Worksheet, Terminal or Directory...

Add files

The screenshot shows a web browser window with the SageMathCloud interface. The browser's address bar shows 'Projects' and 'WebSIGMA demo'. The page title is 'Create New in home directory of project'. Below the title, there is a section for creating a new file or directory. A text input field contains the name '2015-01-12-085124'. Below the input field, there is a section for selecting the type of file or directory. The options are: Sage Worksheet, IPython Notebook, File, Folder, From Internet (most sites blocked), LaTeX Document, Terminal, Task List, and Course. Below the selection options, there is a section for uploading files from the computer, which is currently empty and displays the text 'Drop files to upload'.

Projects WebSIGMA demo x

wstein@uw.edu Help 40ms

Files New Log Find Settings

Create New in home directory of project

+ Create a new file or directory

Name your file or paste in a web link

Select the type

Sage Worksheet IPython Notebook File Folder From Internet (most sites blocked)

LaTeX Document ... Terminal Task List

Course

Upload files from your computer

Drop files to upload

Sage Worksheet

The screenshot displays a SageMathCloud worksheet with the following components:

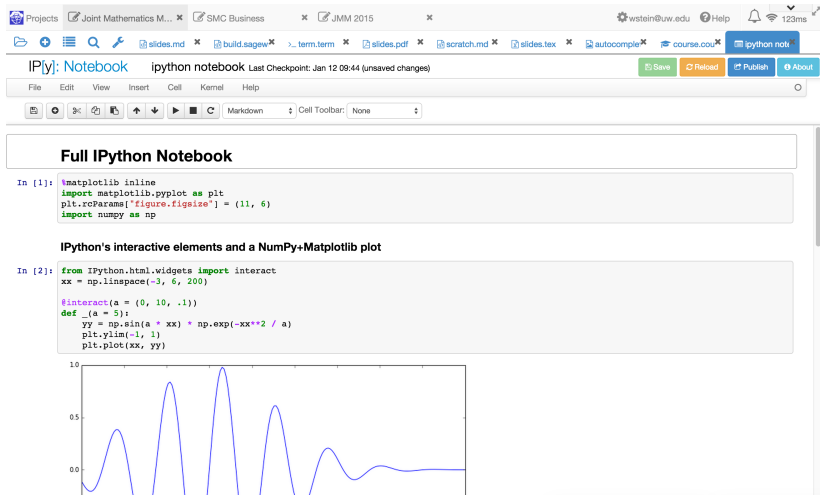
- Top Bar:** Shows the user 'wstein@uw.edu' and a '127ms' timer. The interface includes tabs for 'Run', 'Stop', 'Restart', and 'Tab', along with various tool icons.
- Line Plot:** A line graph titled 'Statistics with R' showing the USD/RUB exchange rate from February to December. The y-axis ranges from 30 to 65. Two lines are plotted: a blue line representing the actual exchange rate and a black line representing a smoothed trend. The exchange rate shows a steady increase from approximately 33 in February to over 60 in December.
- 3D Plot:** A 3D surface plot of a function, likely a sine wave, with axes labeled X, Y, and Z. The Z-axis ranges from -10 to 10. The surface is colored with a gradient from blue to red.
- Code Editor:** Contains R code for reading a CSV file and Sage code for plotting a 3D surface. The R code is:

```
155  
159  
160 read.csv(file="usd-rub.csv", head=TRUE, sep=",")  
162
```

The Sage code is:

```
128  
131 Or with Sage  
132 vvar x, y, z  
133 plot3d(sin(x)+x*cos(y), (x,-5,5), (y,0,10), mesh=1, spin=5)  
134  
135  
136
```

IPython Notebook



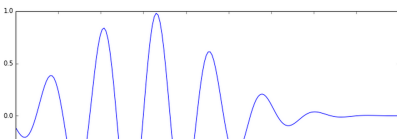
The screenshot shows a web browser window with multiple tabs. The active tab is titled "ipython notebook" and shows the notebook interface. The notebook has a title "Full IPython Notebook" and contains two code cells. The first cell, labeled "In [1]:", contains code to import matplotlib and numpy. The second cell, labeled "In [2]:", contains code to create a plot of a function. The plot shows a blue line with several peaks and troughs, with the x-axis ranging from -3 to 6 and the y-axis from 0.0 to 1.0.

```
In [1]: %matplotlib inline
import matplotlib.pyplot as plt
plt.rcParams["figure.figsize"] = (11, 6)
import numpy as np
```

IPython's interactive elements and a NumPy+Matplotlib plot

```
In [2]: from IPython.html.widgets import interact
xx = np.linspace(-3, 6, 200)

@interact(a = (0, 10, .1))
def _(a = 5):
    yy = np.sin(a * xx) * np.exp(-xx**2 / a)
    plt.ylim(-1, 1)
    plt.plot(xx, yy)
```



The plot displays a function $y = \sin(ax) \cdot \exp(-x^2/a)$ for $a = 5$. The x-axis ranges from -3 to 6, and the y-axis ranges from -1 to 1. The function has several peaks and troughs, with the highest peak reaching 1.0 at $x \approx 2.5$.

Publish your IPython Notebook

Projects Joint Mathematics M... x SMC Business x IMM 2015 x wstein@uw.edu Help 125ms

IP[y]: Notebook ipython notebook

File Edit View Insert Cell Kernel

Full IPython Notebook

```
In [1]: %matplotlib inline
import matplotlib.pyplot as plt
plt.rcParams["figure.figsize"] =
import numpy as np
```

IPython's interactive elements

```
In [2]: from IPython.html.widgets import interact
xx = np.linspace(-3, 6, 200)

@interact(a = (0, 10, .1))
def _(a = 5):
    yy = np.sin(a * xx) * np.exp(-xx**2 / a)
    plt.ylim(-1, 1)
    plt.plot(xx, yy)
```

1.0
0.5
0.0

Publishing IPython Notebook

Publishing... done
100%

Share the following link:

<https://cloud.sagemath.com/projects/091a4332-78db-432d-8c70-18a0218a7dfd/file>

(Anybody may read this public notebook; only collaborators may change it.)

Close

Save Reload Publish About

Latex Document

The screenshot displays the SageMathCloud interface. On the left is a code editor with the following LaTeX code:

```

24 you don't need to compute the number
25 yourself, or even cut and paste
26 it from somewhere.
27 \section{Block of instructions}
28
29 \begin{sageblock}
30 x, y = var('x, y')
31 i = 3
32 f1(x) = (2 * x) / (i + x + x^2)
33 \end{sageblock}
34
35 A function  $f_1$  inline:  $\sage{f1}$  or in
36 an equation environment:
37  $\sage{f1}$ 
38
39 and its integral:
40
41  $\int \sage{f1(x)} \, dx$ 
42  $\sage{f1.integrate(x).expand()(x)}$ 
43
44 \pagebreak
45 \section{Embedded plotting}
    
```

Below the code editor, the LaTeX preamble is visible:

```

1 \documentclass{DIV=13}{scrartcl}
2 \usepackage{utf8}[inputenc]
3 \usepackage{cmbright}
4 \usepackage{inconsolata} % better monospaced font!
5 \usepackage{T1}[fontenc]
6 \usepackage{amsmath}
7 \usepackage{sagetex}
8
9 \title{Using Sage and \LaTeX{} Together}
10 \author{Sage Booth}
11 \date{\sage{factor(2015)} A.D.}
    
```

The preview window on the right shows the rendered document:

Using Sage and \LaTeX Together

Sage Booth

5 · 13 · 31 A.D.

For example, there are 7403838878452687162912842119176262318542314409 integer partitions of 2016. You don't need to compute the number yourself, or even cut and paste it from somewhere.

Block of instructions

$x, y = \text{var}('x, y')$
 $i = 3$
 $f_1(x) = (2 * x) / (i + x + x^2)$

A function f_1 inline: $x \mapsto \frac{2x}{x^2+x+3}$ or in an equation environment:

$$x \mapsto \frac{2x}{x^2+x+3}$$

and its integral:

$$\int \frac{2x}{x^2+x+3} dx = -\frac{2}{11} \sqrt{11} \arctan\left(\frac{1}{11} \sqrt{11}(2x+1)\right) + \log(x^2+x+3)$$

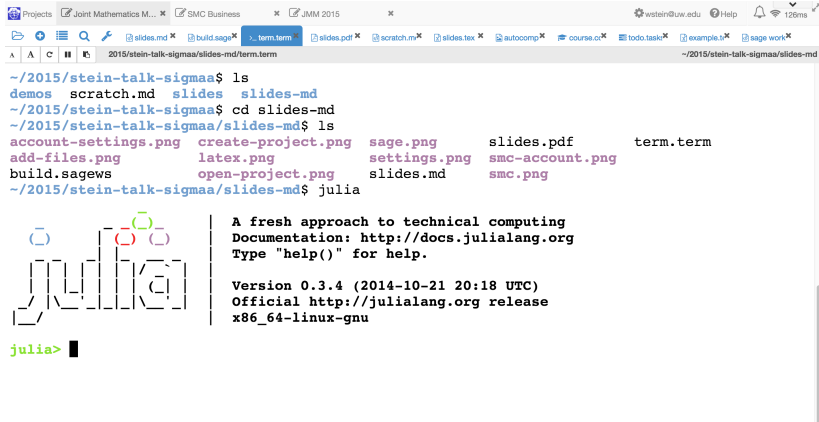
On the right side of the preview window, there is a chat area with the following text:

William Stein (less than a minute ago):
 Hi there!
 Consider

$$\frac{2x}{i + x + x^2}$$

At the bottom of the chat area, it says: Chat using HTML, Markdown and LaTeX...

Terminal



```
~/2015/stein-talk-sigmaa$ ls
demos  scratch.md  slides  slides-md
~/2015/stein-talk-sigmaa$ cd slides-md
~/2015/stein-talk-sigmaa/slides-md$ ls
account-settings.png  create-project.png  sage.png          slides.pdf          term.term
add-files.png         latex.png            settings.png       smc-account.png
build.sagews          open-project.png    slides.md         smc.png
```

A fresh approach to technical computing
Documentation: <http://docs.julialang.org>
Type "help()" for help.

Version 0.3.4 (2014-10-21 20:18 UTC)
Official <http://julialang.org> release
x86_64-linux-gnu

```
julia> █
```

Task List

Projects Joint Mathematics M... SMC Business JMM 2015 wstein@uw.edu Help 125ms

#booth #organize #posters

Find task... Done Deleted Showing 4 tasks.

New Custom Order Due Changed

#booth Booth is number 532. none less than a minute ago

pay for additional items, e.g., electricity (no option yet)

- (bought) table
- (bought) electricity
- (bought) \$150 internet

I will be buying 3 high-quality REI-style camping chairs, which we'll bring, since the rental chairs are nearly \$80/each, for the worst!

- ⓧ (0:22) (1:00?) pay for electricity, table, etc. — <https://mail.google.com/mail/u/0/#inbox/14815ffe3237e4cf>
 - Ordered electricity from edlen (Order Number 10389): <http://edlen.com/>
 - Ordered a 8'x42" draped table.

HSY: just a quick idea, what about a small **portable projector** (beamer)? I have never been to that exhibition, but as long as there is a blank wall behind you this should work.

RAB: Ping John Travis. He brings a projector and a portable rear projection screen to the WeBWorK booth. Works great.

#posters Park posters at booth about 9 hours ago less than a minute ago

Close

#posters Park posters at booth

R Beizer: Tom Judson and Kent Morrison will have posters from NSF and Open resources sessions that may be appropriate to spend

Course

The screenshot shows a web browser window with several tabs open, including 'Projects', 'Joint Mathematics M...', 'SMC Business', 'JMM 2015', and 'course.'. The 'course.' tab is active and displays a navigation menu with 'Students (2)', 'Assignments (1)', 'Settings', and 'Help'. Below the menu is a search bar for assignments and a folder selection dropdown. A folder named '2015/stein-talk-sigmaa' is selected, and three action buttons are visible: 'Assign all...', 'Collect all...', and 'Return graded...'. The interface is clean and modern, with a light blue and white color scheme.

Markdown files

The screenshot shows a SageMathCloud interface. The top navigation bar includes 'Projects', 'Joint Mathematics M...', 'SMC Business', and 'JMM 2015'. The user is 'wstein@uw.edu' and the time is '124ms'. The editor has several tabs open: 'slides.md', 'build.sagevs', 'term.term', 'slides.pdf', 'scratch.md', 'slides.tex', 'autocomplete.pr', and 'course.course'. The toolbar contains various editing tools like bold, italic, underline, link, image, and list. The main editor area shows a Markdown document with the following content:

```
1 % William Stein
2 % January 12, 2015
3 %
4
5 # Sage: create a viable free open
6 source alternative to Magma, Maple,
7 Matlab, and Mathematica
8
9 ## Sage: completely free and
10 completely open source
11
12 ### Why?
13 - Millions of dollars of
14 funding from NSF, Microsoft, Google
15 and donors
16
17 - Volunteer contributions from
18 nearly 500 people over the last
19 decade.
20
21 ## The Sage/Python ecosystem
22
23 ### Status: good
24
25 - Does much of what Magma, Maple,
26 Matlab, and Mathematica does, but
27 differently and better.
28
29 - Way ahead of Maple and Mathematica
30 in combinatorics and number theory.
```

The preview pane on the right shows the rendered output of the Markdown document. It features a blue header with a white geometric logo and the word 'sage' in white lowercase letters. The main content is rendered in a clean, sans-serif font, matching the original text in the editor. A 'Preview' button is visible in the top right corner of the preview pane.

Notification feed

x wstein@uw.edu ? Help 127ms

scratch.m x

Search notifications... Mark Read

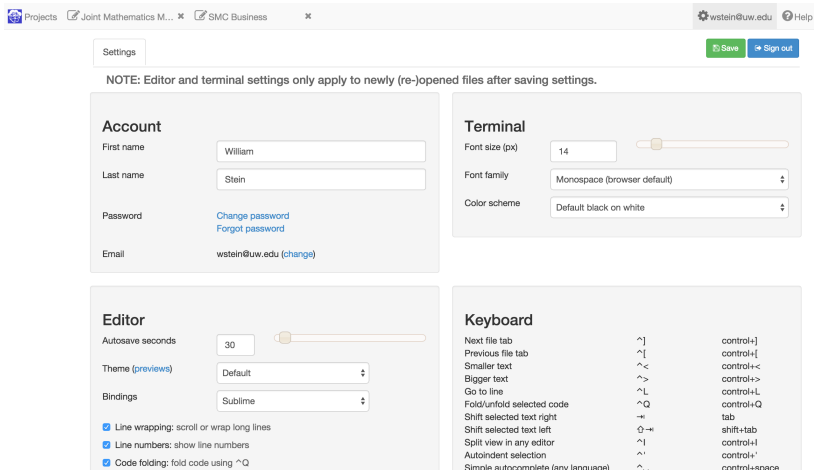
- Harald Schilly, You, David Perkinson and 4 other people** used the **Joint Mathematics Meetings Ex...** project less than a minute ago
- JMM Math** edited **2015-01-12-101431.course** in **JMM 2015** about a minute ago
- JMM Math, You, Harald Schilly and 2 other people** used the **JMM 2015** project about a minute ago
- Harald Schilly** edited **...n-talk-sigmaa/slides-md/build** in **Joint Mathematics Meetings Ex...** about a minute ago
- You** edited **...-talk-sigmaa/slides-md/slides.md** in **Joint Mathematics Meetings Ex...** 5 minutes ago
- JMM Math and Harald Schilly** *commented on* and edited **3d-**

Project settings

The screenshot shows the SageMathCloud interface for project settings. At the top, there's a navigation bar with 'Projects', 'WebSIGMA demo', and user information 'wstein@uw.edu'. Below the navigation bar, the title 'Project Settings and Controls' is displayed. The main content area is divided into several sections:

- Title:** 'WebSIGMA demo'. **Description:** 'No description'.
- Collaborators:** A search box for adding collaborators. One collaborator, 'William Stein (owner)', is listed in a green box.
- Quota:** Shows resource usage: Disk usage: 19 MB of 5000 MB, /scratch disk usage: 0 MB of 15000 MB, CPU cores: 1 (shared), RAM: 8 GB (shared).
- Project Server:** Includes fields for Project ID (a531feb7-7a25-49c2-98bc-ab0b71acc428) and Location (...). A 'Project Server' status is shown as 'Running' with a 'Restart Project Server' button. Below this is an SSH command: `ssh a531feb7a2549c298bcab0b71acc428@127.0.0.1`.
- Sage Worksheet Server:** Includes a 'Restart Sage Worksheet Server' button and text explaining that existing sessions are unaffected and the new version of Sage will be used.

Also, account settings



The screenshot shows the SageMathCloud account settings interface. At the top, there are browser tabs for 'Projects', 'Joint Mathematics M...', and 'SMC Business'. The user is logged in as 'wstein@uw.edu' and can click 'Sign out'. A 'Settings' button is visible, along with 'Save' and 'Sign out' buttons. A note states: 'NOTE: Editor and terminal settings only apply to newly (re-)opened files after saving settings.'

Account

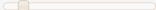
First name:

Last name:

Password: [Change password](#)
[Forgot password](#)

Email: [wstein@uw.edu \(change\)](#)

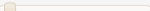
Terminal

Font size (px): 

Font family:

Color scheme:

Editor

Autosave seconds: 

Theme (previews):

Bindings:

- Line wrapping: scroll or wrap long lines
- Line numbers: show line numbers
- Code folding: fold code using ^Q

Keyboard

Next file tab	^]	control+]]
Previous file tab	^[control+[[
Smaller text	^<	control+< <
Bigger text	^>	control+> >
Go to line	^L	control+L L
Fold/unfold selected code	^Q	control+Q Q
Shift selected text right	⇨	tab
Shift selected text left	⇧⇨	shift+tab
Split view in any editor	^I	control+I I
Autoindent selection	^_	control+' '
Simple autocomplete (arv lanuaae)	^..	control+space