What is Sage?
and
What Should I Use It For?

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slides available at

`http://www.calvin.edu/~rpruim/talks/`

What is Sage?

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> *Sage is a free open-source mathematics software system licensed under the GPL. It combines the power of many existing open-source packages into a common Python-based interface.*

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Other features:

- Web browser interface
- Stand-alone programming (interpreted or compiled)
- Integrates with LaTeX

Sage vs. the Big Boys

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Q. Should Sage replace Mathematica (or Maple, or . . .)?

A. That depends on what is important to you.

Some Strengths of Sage

We'll look at a few examples that demonstrate some of Sage's strengths:

- Universality
- Ubiquity
- Conformity
- Community

Universality

From `sagemath.org`:

> *Mission: Creating a viable free open source alternative to Magma, Maple, Mathematica and Matlab.*

The Goal: To be your one-stop mathematical computing environment

- First application area was elliptic curves (GP/pari)
- Maxima and numpy/scipy form core elements of the engine
- Can interface with several other programs (Maple, Mathematica, Matlab, etc.) if they are installed
- Provides interface to R (incomplete?)

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> *Sage was fine, but it seems like every semester we learn software that we never use again.*
>
> *— an engineering student in Math 232*

Ubiquity

Because sage is

- free, and
- available via a web browser,

there is almost no start-up cost in using Sage.

In particular, students can use Sage any time on any machine with a web browser and internet connection.

- We can set up a new account in a few seconds and then get to work.
  - available at `http://sagemath.org`
  - or (temporarily, at least) at `http://dahl.calvin.edu:8000`

The Importance of Ubiquity

<rant>

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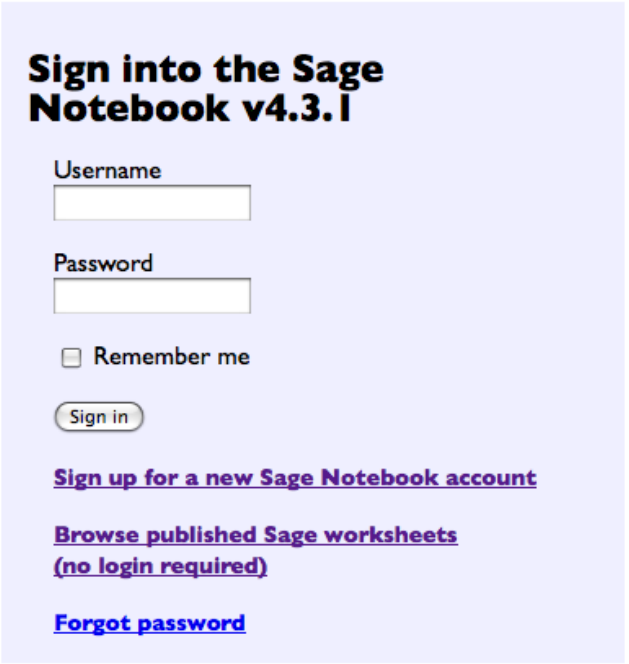
Exhibit A: Students in my Intro Stats course

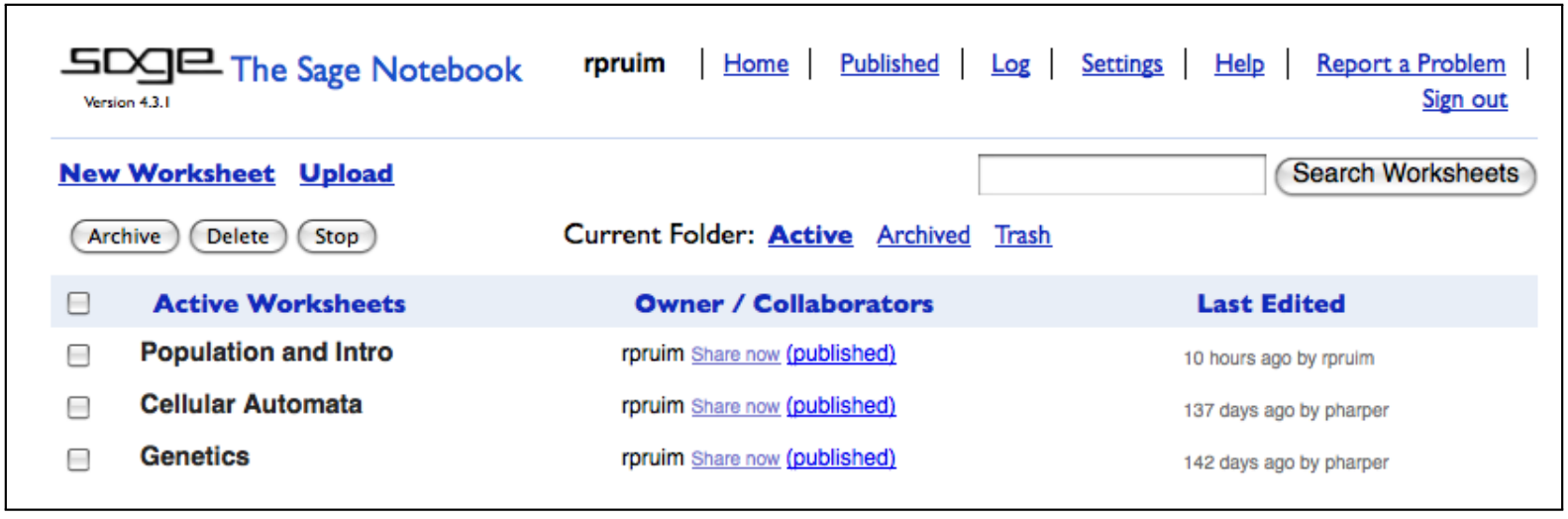
Setting Up An Account

1. Go to `http://sagemath.org` or `http://dahl.calvin.edu:8000`
2. Select "Sign up for a new Sage Notebook account"
3. Follow the instructions.
4. Login.



Sage Worksheets in your Browser

This simplest way to start is via the online worksheet interface.



If installed on your local machine, Sage can also be used

- in a browser, but using a local sage engine
- in its own (text-based) interpreter
- within stand-alone programs
  - easy access to compiled C via Cython (for speed)

Conformity

Sage pulls together open source utilities from a number of different origins and brings them together into one (mostly) coherent system.

Sage is built on the python programming language.

- Sage skills transfer to Python
- Python skills transfer to Sage

Python

- light syntax (easy to get started)
- comprehensive, high level (won't outgrow it)
- good for scripting, prototyping (getopt, system, strings)
- interpreted (but Cython, too) (command-at-a-time)
- libraries for the sciences (short "time to science")

Python and Sage

Python (and hence Sage) are object-oriented

- but lots of procedural sugar-coating

Objects available in Sage

- Python base objects: `int`, `float`, `bool`, `str`, etc.
- Python containers: `list`, `tuple`, `set`, `dict`, etc.
- Sage mathematical objects (lots): `Integer`, `Rational`, `RealLiteral`, symbolic expressions (variables, "functions", `pi`, `...`), vectors and vector spaces, polynomial rings, etc, etc, etc.
- `numpy` and `scipy` objects: special array and matrix classes tuned for numerics, probability distributions, etc, etc, etc.

And, of course, you can build your own objects, too.

Community

Like most open source projects, Sage is community-supported.

- Sage notebooks can be published, making them available to anyone.
- Published notebooks can be searched.
- If you have a great idea for Sage, you can submit it. If it passes quality control, the core development team will add it to the next release of Sage.
  - Calvin student Ethan VanAndel just found out that some utilities he developed will be included in the next release.
- Excellent LaTeX support.

Sage and LaTeX

The latest version of Sage includes the `sagetex.sty` style for LaTeX.

output

The sum of $1 + 2 + \sqrt{3} = \sqrt{3} + 3 = 4.7321$.

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LaTeX code

```
The sum of $1+2+\sqrt{3}
= \sage{1+2+sqrt(3)}
= \sage{round(1+2+sqrt(3),4)}$
```

Workflow

LaTeX, Sage, LaTeX

- works with `pdflatex`, custom rules exist for `latexmk`

Sage and LaTeX

Of course, Sage has many fancier things, too.

output

There are

$$625542347387943217255115334717978795312568 2826$$

integer partitions of 2010.

LaTeX code

```
There are \[\sage{number_of_partitions(2010)}\]

integer partitions of 2010.
```

Sage and LaTeX

Let $f(x) = e^x \sin(2x)$, then the second derivative of f is

$$\frac{d^2}{dx^2} e^x \sin(2x) = -3\, e^x \sin(2x) + 4\, e^x \cos(2x).$$

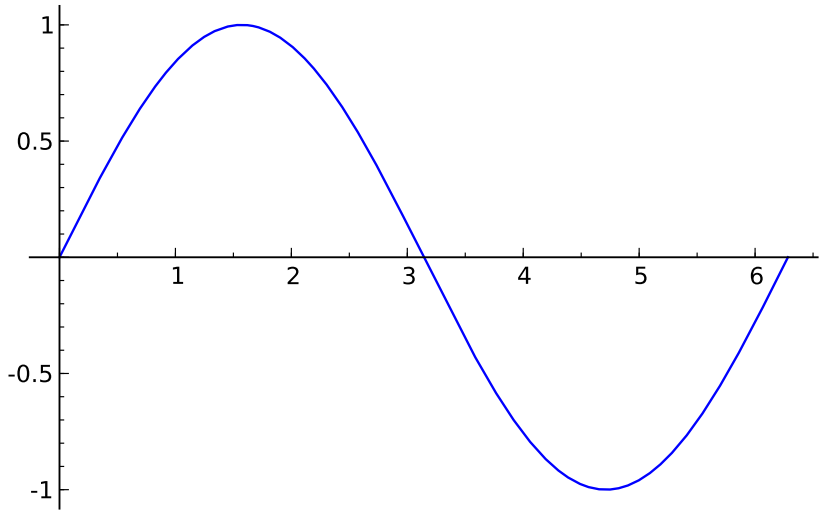
Code

```
\begin{sagesilent}
f(x) = exp(x) * sin(2*x) \end{sagesilent},

Let $f(x) = \sage{f(x)}$, then
the second derivative of $f$ is
\[
  \frac{d^{2}}{d x^{2}} \sage{f(x)} =
    \sage{diff(f, x, 2)(x)}.
\]
```

Sage and LaTeX (plots)

Plotting works, too.



code

```
\sageplot{plot(sin(x), x, 0, 2*pi)}
```

Potential Drawbacks

- New kid on the block
- Jack-of-all-trades . . . Master of none?
- Web-interface isn't as slick as a custom interface
- JMol probably not ideal choice for general purpose graphics platform

Links

http://www.calvin.edu/~rpruim/talks/

http://dahl.calvin.edu:8000

http://sagemath.org/

http://localhost:8000/

http://www.python.org/

http://www.sagenb.org/home/rpruim/51/

http://www.sagenb.org/home/rpruim/51/

http://dahl.calvin.edu:8000/home/rpruim/13/