Using Sage in Lower Level Math Courses

J. Bradford Burkman Louisiana School for Math, Science, and the Arts

What is Sage?

- Alternative to Maple, Mathematica, and Matlab
- FREE and Open Source ... and FREE!
- Industrial-Strength Math Software that students can use throughout their STEM careers
- Python based
- Uses Web Browser as GUI
- Available for Download or to use Online
- Lots of Support from Developers and Users

Ways to Teach Math with Sage

- Lecture: Displaying 3D graphs
- Student Work:
  - Teacher publishes "worksheets" online
    - Write directions and examples in LaTeX
    - Write sample code in Sage Python
  - Students modify/adapt/create code
  - Students "share" their worksheets with the teacher.
  - Work in Sage can complement work by hand.

Benefits to Students

- First exposure to precise syntax
- Powerful tool they can use throughout their STEM careers
- Exposure to large array of computational tools
- No installation or license to use on their personal computers

Useful Sage Functions

- Solving equations, numerically or symbolically
- gcd/lcm
- Prime factorization of integers
- Factorization of polynomials
- Simplification of expressions
- Partial Fraction Decomposition
- `((f(x+h)-f(x))/h).rational_simplify()`
- Differentiating and Integrating
- Statistics in R
- Handles large calculations, as for RSA
- Writes your LaTeX for you, by [optionally] giving solutions in formatted code to cut and paste.

Also Ask Me About Using ...

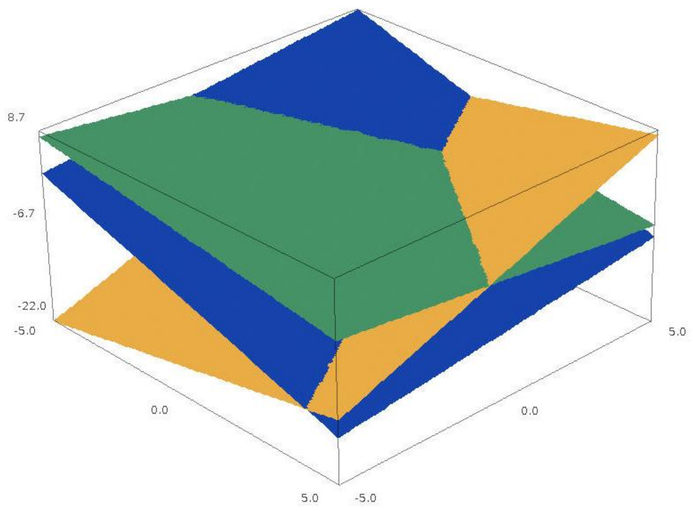
- GeoGebra
- LaTeX and Ti*k*Z
- MathType
- LittleFe Mini Supercomputer

Sage Examples
3×3 Systems

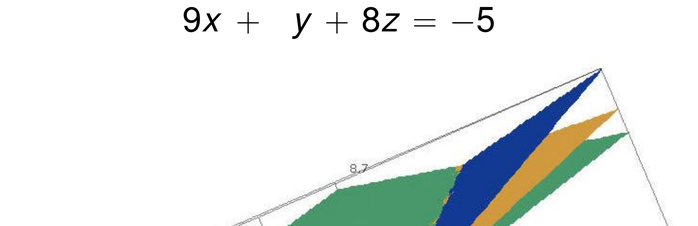
Visualizing 3×3 Systems

Visualize the system to conjecture whether it has a unique solution. If so, solve. If not, explain algebraically why the system has no solution.

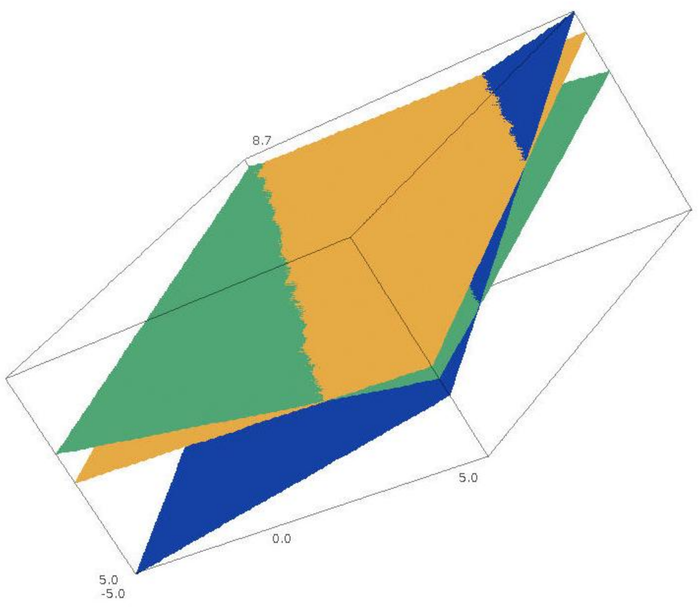
1.
$$\begin{aligned} 5x - 2y + 3z &= -9 \\ 4x + 3y + 5z &= 4 \\ x + 2y - z &= 7 \end{aligned}$$



2.
$$\begin{aligned} 5x - 2y + 3z &= -9 \\ 4x + 3y + 5z &= 4 \\ 9x + y + 8z &= -5 \end{aligned}$$



3.
$$\begin{aligned} 5x - 2y + 3z &= -9 \\ 4x + 3y + 5z &= 4 \\ 9x + y + 8z &= 11 \end{aligned}$$



Sage Methods for Solving Systems

- `solve([f(x,y,z)==0,g(x,y,z)==0, h(x,y,z)==0],x,y,z)`
- `A.echelon_form()`
- `A.inverse()*B`
- `A.solve_right(B)`

Sage Examples
Introduction to Programming

Bracket and Halving: Approximate $\sqrt{2}$

```
f(x)=x^2-2                      3/2
a=1; b=2; c=0;                  5/4
while b-a>0.01:                 11/8
    c=(a+b)/2                   23/16
    if f(a)*f(c)>0:             45/32
        a=c                     91/64
    else:                       181/128
        b=c
    print c
```

Newton's Method: Approximate $\sqrt{2}$

```
f(x)=x^2-2
g(x)=derivative(f(x),x)
a=1
while abs(f(a))>0.00001:
    n=n+1
    h(x)=g(a)*(x-a)+f(a)
    a=find_root(h(x),1,2)
    print a, f(a)
```

```
1.5                 0.25
1.41666666667       0.00694444444444446418
1.41421568627       6.007304882427178e-06
```

Acknowledgements

- This material is based upon work supported by the National Science Foundation under the NSF EPSCoR Cooperative Agreement No. EPS-1003897 with additional support from the Louisiana Board of Regents.
- Shodor, the National Computational Science Institute
- Louisiana Alliance for Simulation-Guided Materials Applications
- Center for Computation and Technology, Louisiana State University

Contact Me

Brad Burkman
Instructor in Mathematics
Louisiana School for Math, Science, and the Arts
www.lsmsa.edu
bburkman@lsmsa.edu
318 - 527 - 9209 (Cell)