John Perry

is about

Computer programming

Summary

# MAT 305: Mathematical Computing Introduction to Mathematical Computing

John Perry

University of Southern Mississippi

Fall 2011

Outline

1 What this class is about

2 Computer programming

### Outline

1 What this class is about

2 Computer programming

### Description

- Online: Introduction to a computer algebra system using calculus-based projects. Students will solve mathematical problems in the MAPLE environment which require an understanding of calculus concepts.
- Syllabus: Introduction to a computer algebra system using calculus-based projects. Students will solve mathematical problems in the Sage environment which require an understanding of calculus concepts.

### Problem solving or programming?

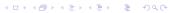
- This class is about problem-solving, like mathematics
- Some problems best attacked with a computer
  - Repetitive/tedious
  - Long
- Computers require instructions, called **programs**
- We study *some* programming, but class not about programming

### Sage?

- Software for Algebra and Geometry Exploration
- Computer Algebra System "started" by William Stein



- Access to other CASs
  - Calculus & symbolic computation: Maxima, SymPy,
  - Linear Algebra: M4RI, Linbox, PARI, ...
  - Commutative Algebra: SINGULAR, Macaulay, ...
  - Group theory: GAP, ...
  - etc.



# Why Sage?

- "Free" software
  - "Free as in beer": no cost to you
    - Downloading free
    - Installing free
    - Copying free
    - Bug fixes free
    - Future versions free
  - "Free as in speech":
    - Open-source software
    - No hidden algorithms
    - Can study implementation
    - Can correct, improve, contribute to Sage

# Analogy

#### Free mathematics

### Theorem

There are infinitely many primes.

### Proof.

- Consider finite list of primes,  $q_1, q_2, ..., q_n$ .
- Let  $p = q_1 q_2 \cdots q_n + 1$ .
- By Division Theorem, p not divisible by any of the  $q_i$  (remainder 1, not 0).
- Hence p divisible by a prime  $q_{n+1}$  not listed!
- .: no finite list, lists all primes.



John Perry

What this class is about

Computer programming

Summar

### Analogy

#### Hidden mathematics

#### Theorem

There are infinitely many primes.

### Proof.

"I have discovered a truly marvelous proof of this, which this margin is too narrow to contain."

†Real quote, different theorem. (to be fair: in private notes, not letter, article)

### Analogy

### Proprietary mathematics

Theorem

There are infinitely many primes.

Proof.

Trade Secret.



### But I prefer Maple!

- Fine, buy your own copy
  - Student discount available
  - I will tell you the Maple equivalents for everything we do in Sage
  - You can submit homework as Maple worksheet

#### • Be warned:

- Future versions not free
- Bug fixes not free
- I used to use Maple and switched to Sage
- Recent versions disappointed me
- After you graduate, pay full price
- Not always backwards compatible (neither is Sage, but Sage is free)



Outline

What this class is about

2 Computer programming

John Perry

What this classis about

Computer programming

Summary

## Why program?

- Programming bridges gap between humans, computers
  - Computers don't understand human languages
    - Humans intuitive, poetic; computers literal, mechanical
    - Computers only understand on or off
  - (Most) humans don't understand a computer's native language
    - Mathematics literal and precise, but (most) humans don't understand it, either!
    - Even the humans that do, prefer not to talk to the computer in that language
- Control over computer
- Deeper understanding of computer technology



# Kinds of computer languages

- Compiled
  - C/C++
  - FORTRAN
  - Go
- Interpreted or scripting
  - BASIC
  - Python
  - Perl
- Mixed ("bytecode")
  - C# (.NET)
  - Java

### Paradigms of computer languages

• Imperative: BASIC, FORTRAN

Modular: Modula-2

• Object-oriented: Smalltalk

• Functional: Haskell, ML

• Modern (C++, Python) languages blend

### Python

- "Sage" primarily Python
- Python also interface between Sage and user
- Not all *components* of Sage in Python:

• Maxima: LISP

• Singular: C/C++

• Python also interface between Sage and user

### Advantages of Python

- Modern
  - Facilities for object-oriented, functional programming
- Wide distribution, usage
  - Many employers use it
- Flexible
  - Many good packages enhance it
- Compile for efficiency: Pyrex or Cython

# Python $\neq$ Sage

- Some Python commands don't work in Sage's worksheet mode
  - input()
- Sage commands do not work in plain Python

programmin

Summary

Outline

What this class is about

2 Computer programming

- This class about problem solving
- Uses programming via Sage
- No "secret methods" in Sage: can
  - inspect inner workings
  - modify it, fix it, break it...
- Interface is sound programming language in wide use