CS 106X, Lecture 30
Wrap-up / What's Next?

Plan For Today

- **Recap:** CS 106X
- Next Steps
- Parting Words
- Ask-Anything
- Course Evaluations

Plan For Today

- **Recap: CS 106X**
- Next Steps
- Parting Words
- Ask-Anything
- Course Evaluations

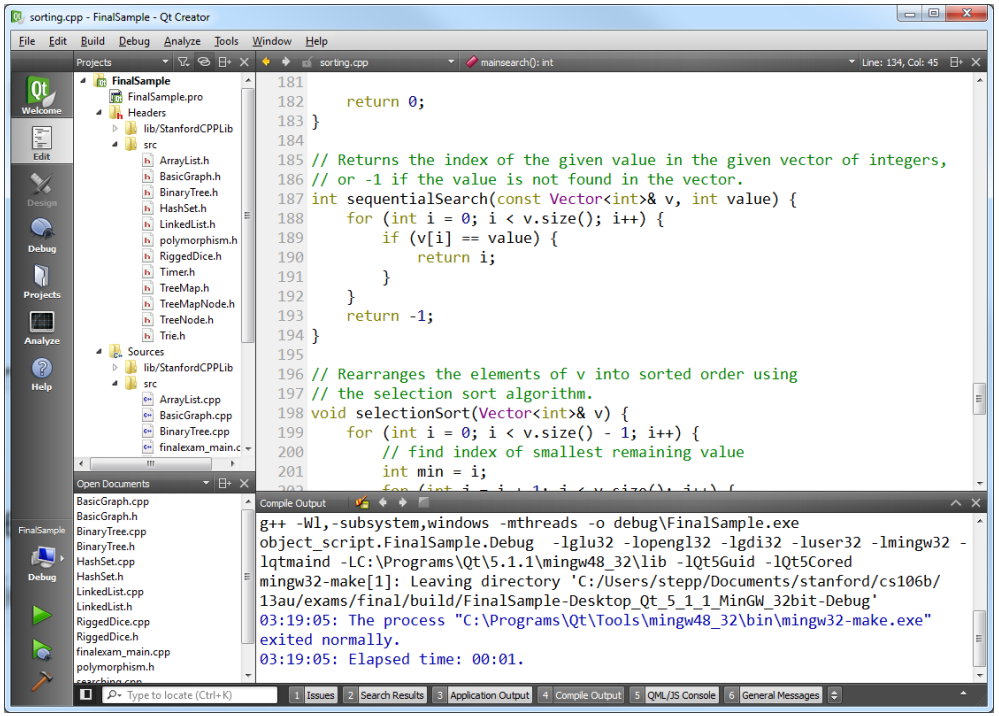
First Day

```
/*
 * hello.cpp
 * This program prints a welcome message
 * to the user.
 */
#include <iostream>
using namespace std;

int main() {
    cout << "Hello, world!" << endl;
    return 0;
}
```

We Learned About C++

- Basics of programming in the **C++** language
  - functions; value vs. reference parameters
  - pointers
  - strings
  - streams
  - operator overloading
  - Templates
  - classes
  - memory management
  - Stanford C++ libraries
  - Qt Creator IDE
  - Structs
  - How to turn QT Creator off and on again

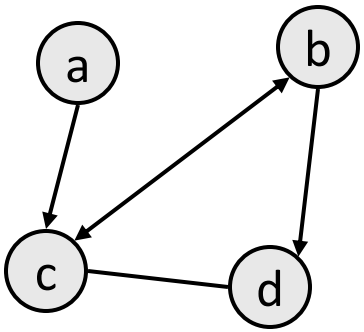


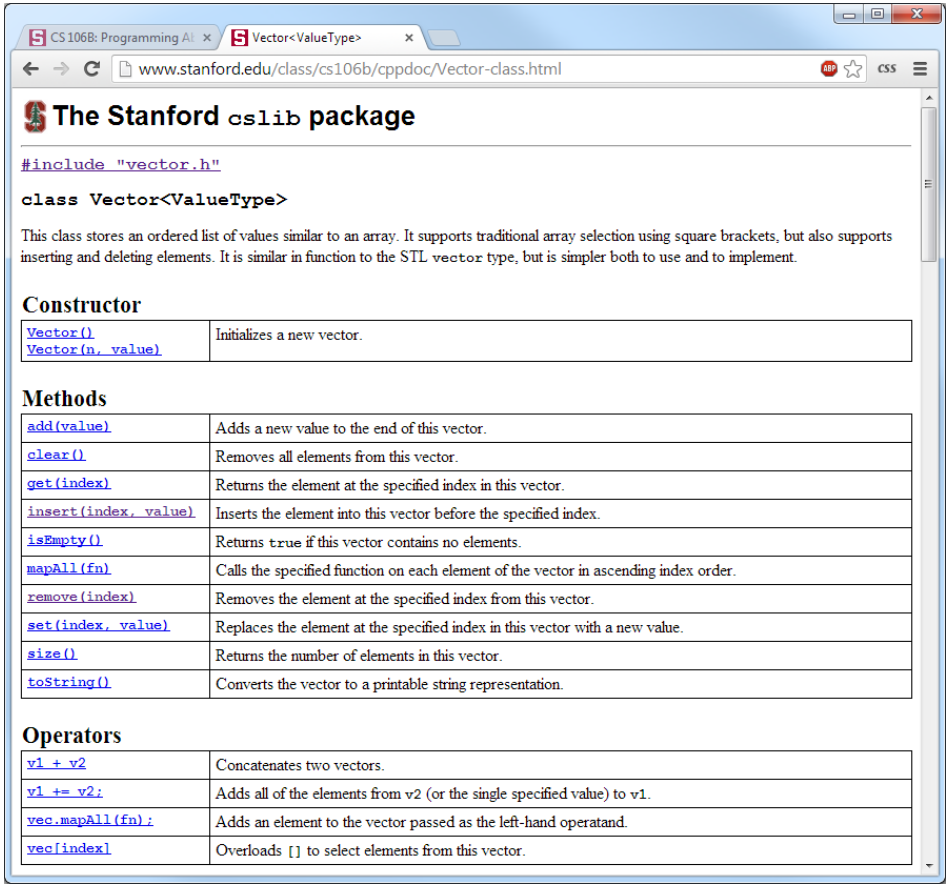
We Learned About Good Style

- Decomposition
- Commenting
- Descriptive Naming
- Abstraction
- Unit Testing
- Debugging

We Learned About Collections

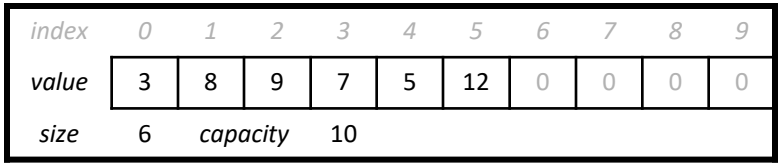
- How to use various **collections** to store and manipulate data
  - Vector, LinkedList
  - Grid
  - Stack, Queue
  - Set, HashSet, Lexicon
  - Map, HashMap
  - PriorityQueue
  - Graph

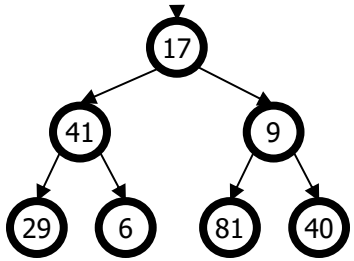


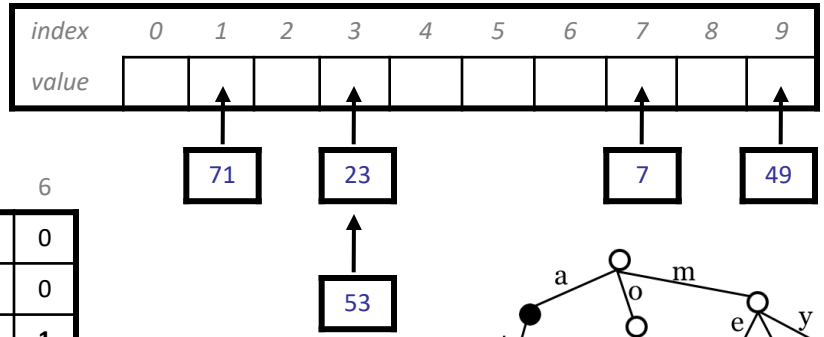


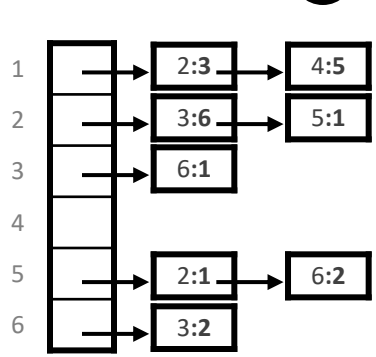
We Learned How Those Collections Are Implemented

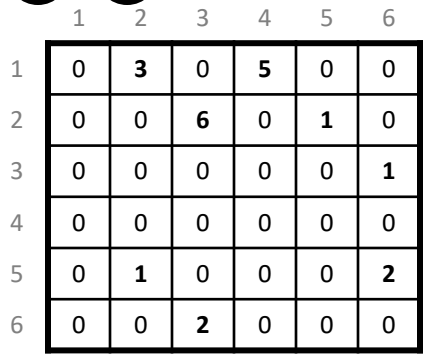
- The internal **data structures** that can implement those collections:
  - array (Vector)
  - linked list (LinkedList, Stack, Queue)
  - tree (Map, Set, Lexicon)
  - hash table (HashSet, HashMap)
  - edge list / adjacency list / matrix (Graph)

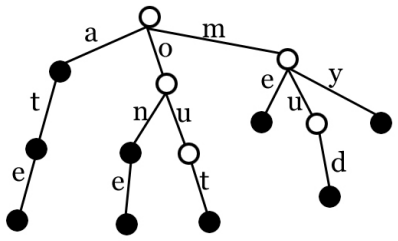








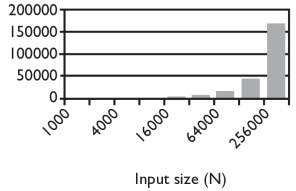


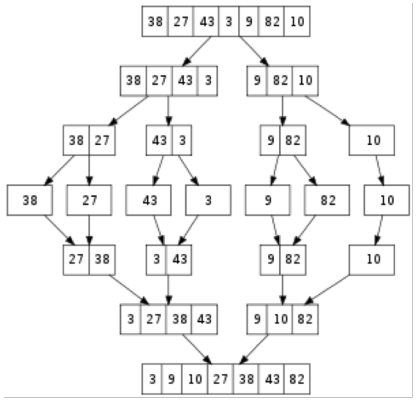


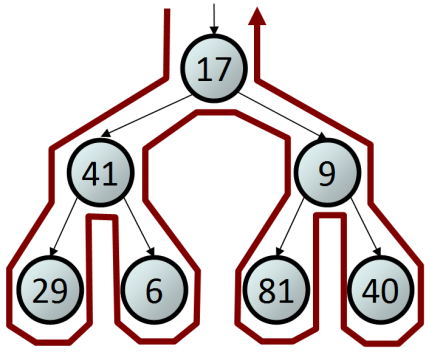
We Learned About Algorithms

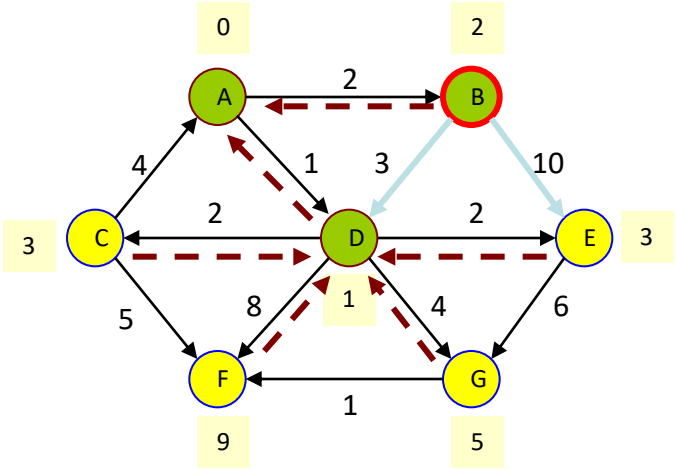
- Several useful **algorithms** that operate on data:
  - searching
  - sorting; topological sort
  - tree traversals
  - graph path searching: DFS, BFS, Dijkstra's, A*
  - algorithm analysis
  - Big-Oh notation

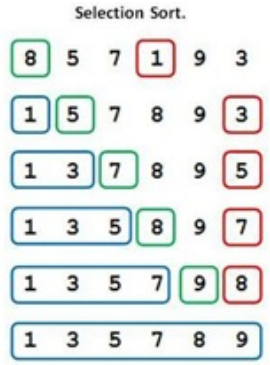
N	Runtime (ms)
1000	0
2000	16
4000	47
8000	234
16000	657
32000	2562
64000	10265
128000	41141
256000	164985





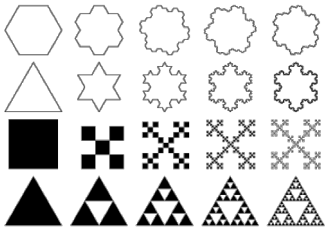


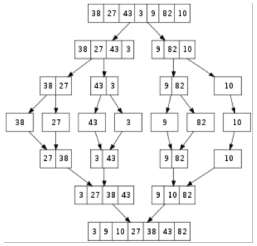


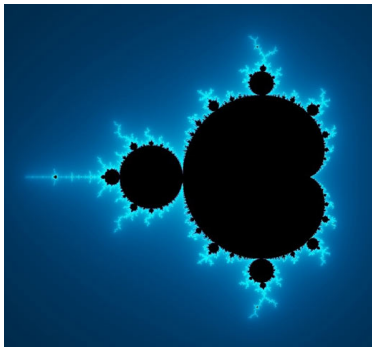


We Learned About Recursion (By Learning About Recursion)

- Self-similarity and **recursion**
  - fractals
  - recursive data (e.g. files and folders)
  - exhaustive search
  - backtracking
  - recursive data structures



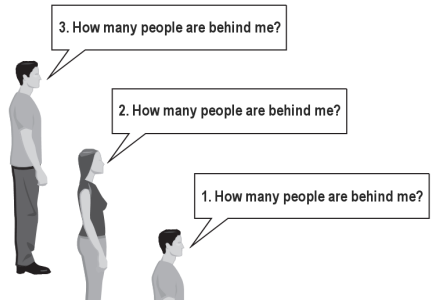




```
void reverseLines(ifstream& input) {      // call 1
    string line;
    if (getline(input, line)) {           // "Roses are red,"
        reverseLines(input);              // make call 2 and wait
        cout << line << endl;
    }
}
```

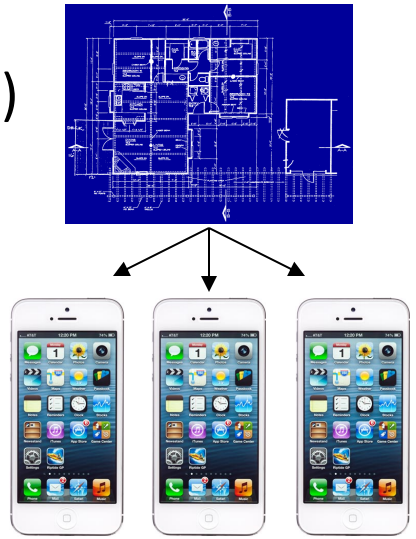
```
void reverseLines(ifstream& input) {      // call 2
    string line;
    if (getline(input, line)) {           // "Violets are blue."
        reverseLines(input);              // make call 3 and wait
        cout << line << endl;
    }
}
```

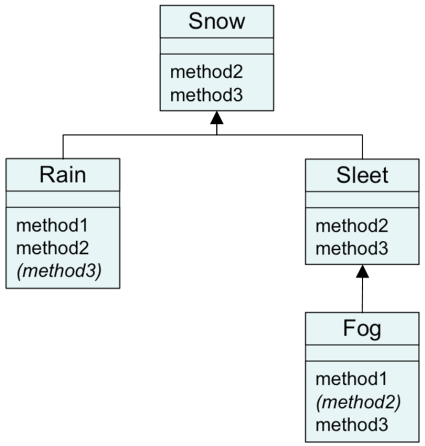
```
void reverseLines(ifstream& input) {      // call 3
    string line;
    if (getline(input, line)) {           // "CS 106X"
        reverseLines(input);              // make call 4 and wait
        cout << line << endl;
    }
}
```

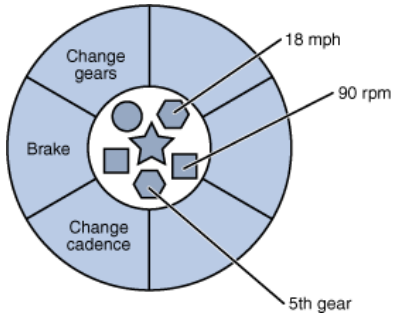


We Learned About Object-Oriented Programming

- A bit about **object-oriented** programming
  - member variables (state), member functions (behavior)
  - abstraction
  - private and public access
  - constructors and destructors
  - interface (.h) versus implementation (.cpp)
  - const
  - operator overloading
  - inheritance and polymorphism
  - template classes



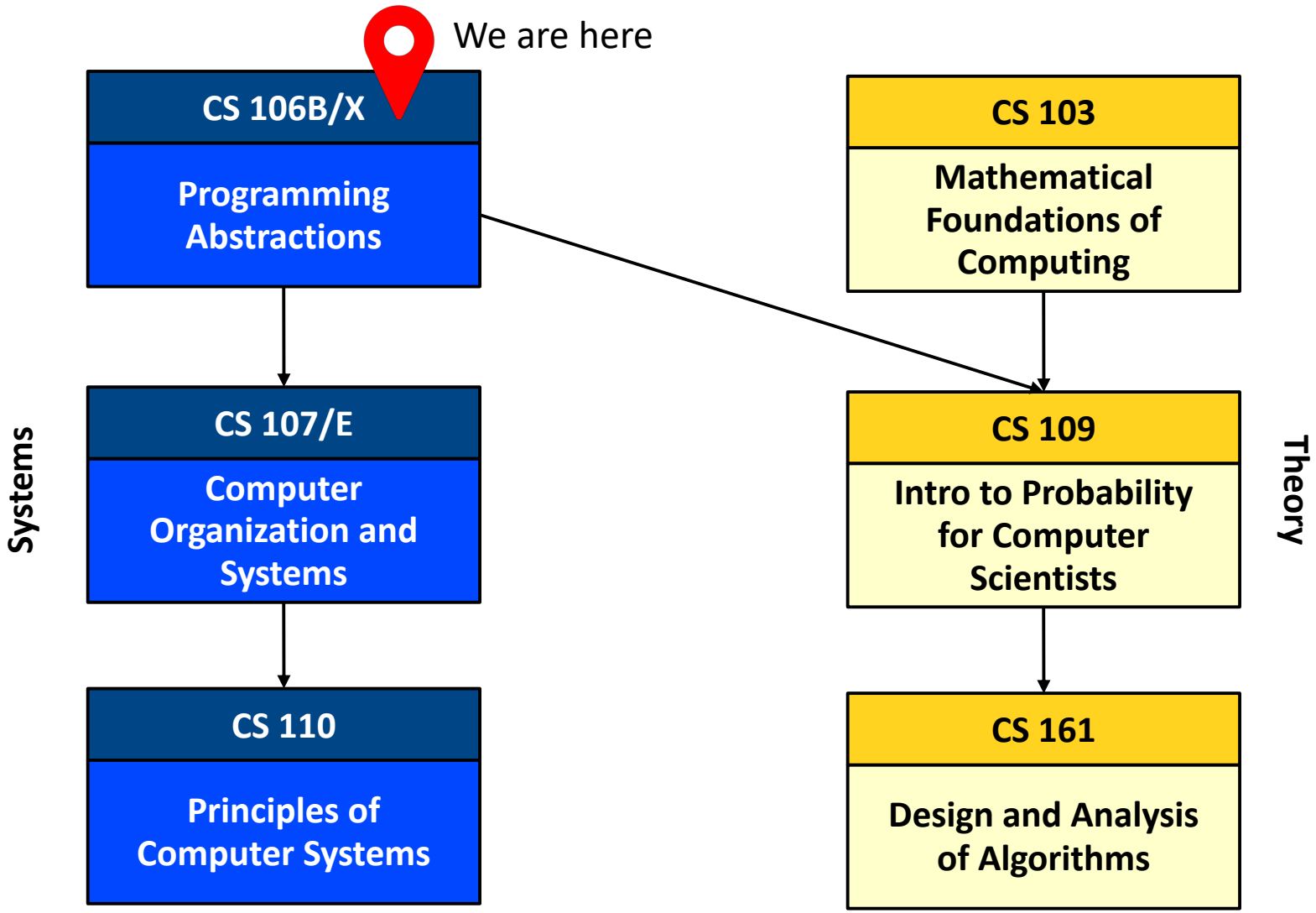




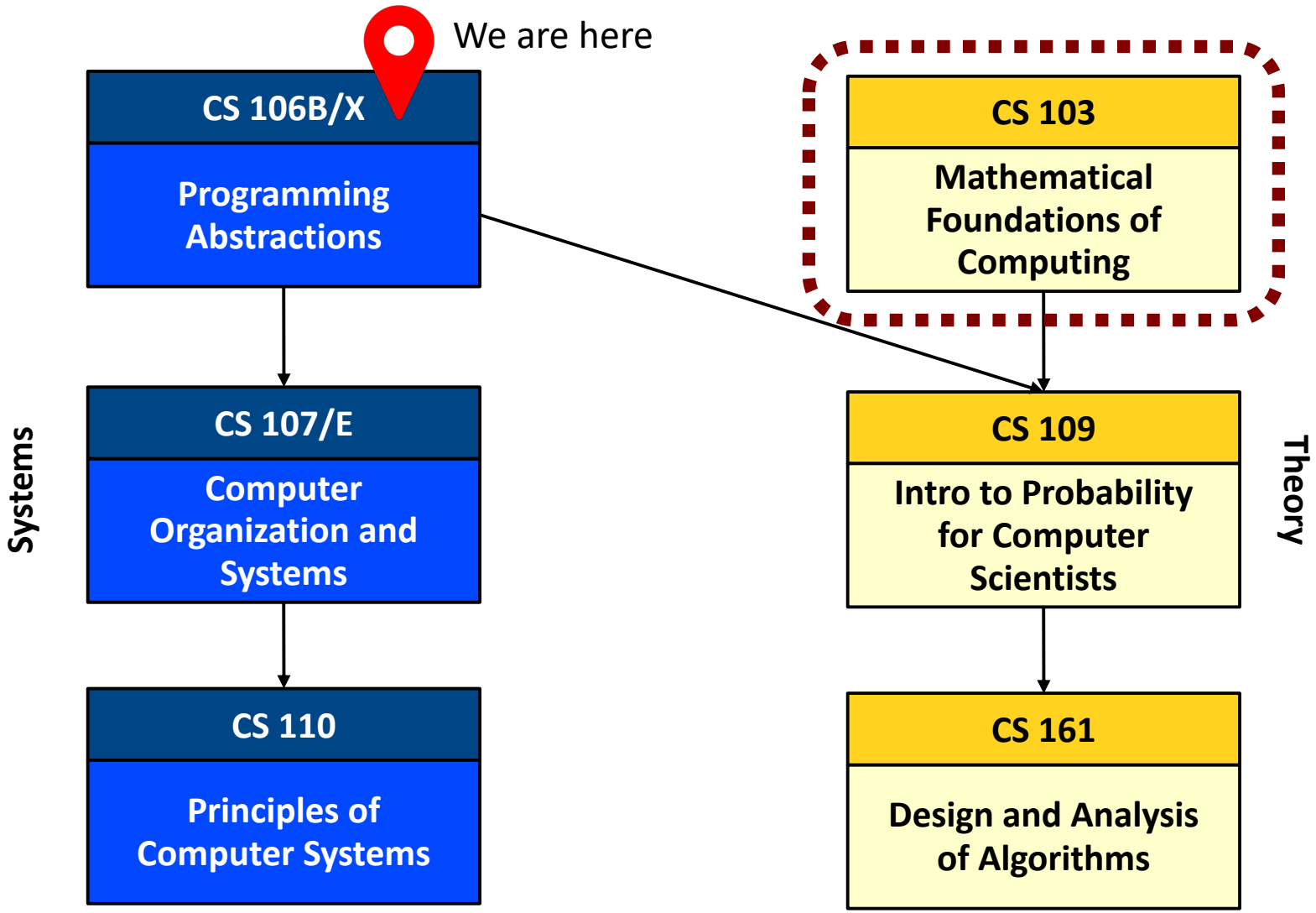
Plan For Today

- **Recap:** CS 106X
- **Next Steps**
- Parting Words
- Ask-Anything
- Course Evaluations

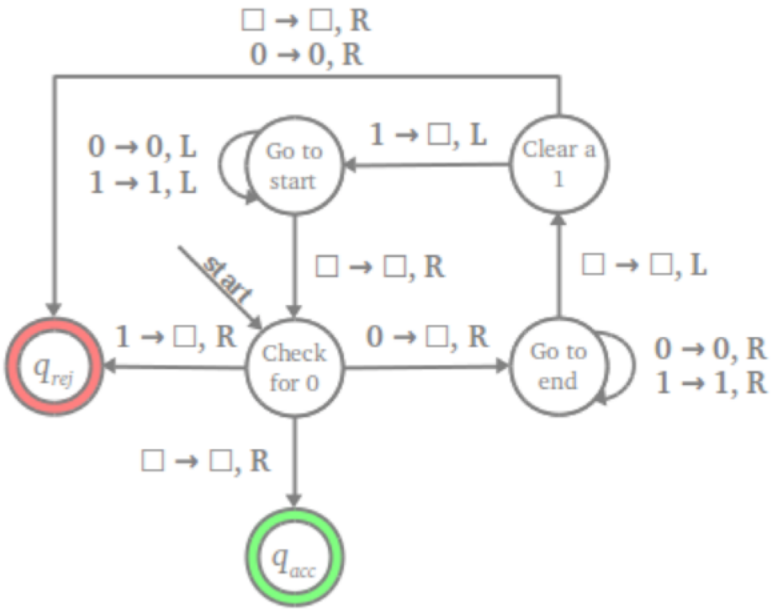
What's Next?


We are here
CS 106B/X
Programming Abstractions
CS 103
Mathematical Foundations of Computing
CS 107/E
Computer Organization and Systems
CS 109
Intro to Probability for Computer Scientists
CS 110
Principles of Computer Systems
CS 161
Design and Analysis of Algorithms
Systems
Theory

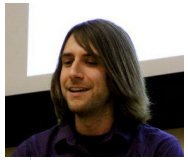
What's Next?


We are here
CS 106B/X
Programming Abstractions
CS 103
Mathematical Foundations of Computing
CS 107/E
Computer Organization and Systems
CS 109
Intro to Probability for Computer Scientists
CS 110
Principles of Computer Systems
CS 161
Design and Analysis of Algorithms
Systems
Theory

CS 103



Cynthia Lee



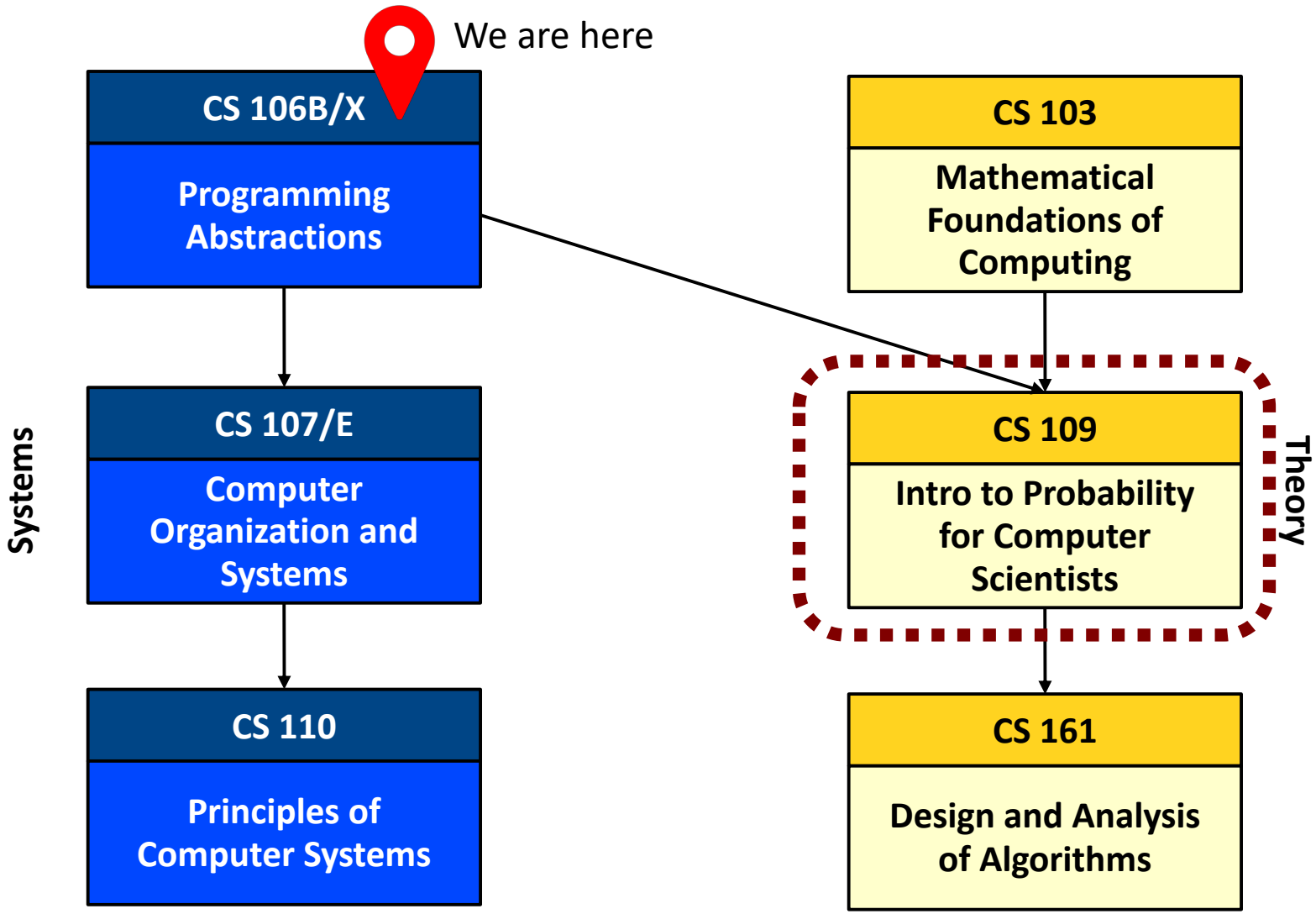
Keith Schwarz

CS103

Mathematical Foundations of Computing

- Can computers solve any problem?
- How can we prove this?
- What makes some problems harder to solve than others?

What's Next?


We are here
CS 106B/X
Programming Abstractions
CS 107/E
Computer Organization and Systems
CS 110
Principles of Computer Systems
Systems
CS 103
Mathematical Foundations of Computing
CS 109
Intro to Probability for Computer Scientists
CS 161
Design and Analysis of Algorithms
Theory

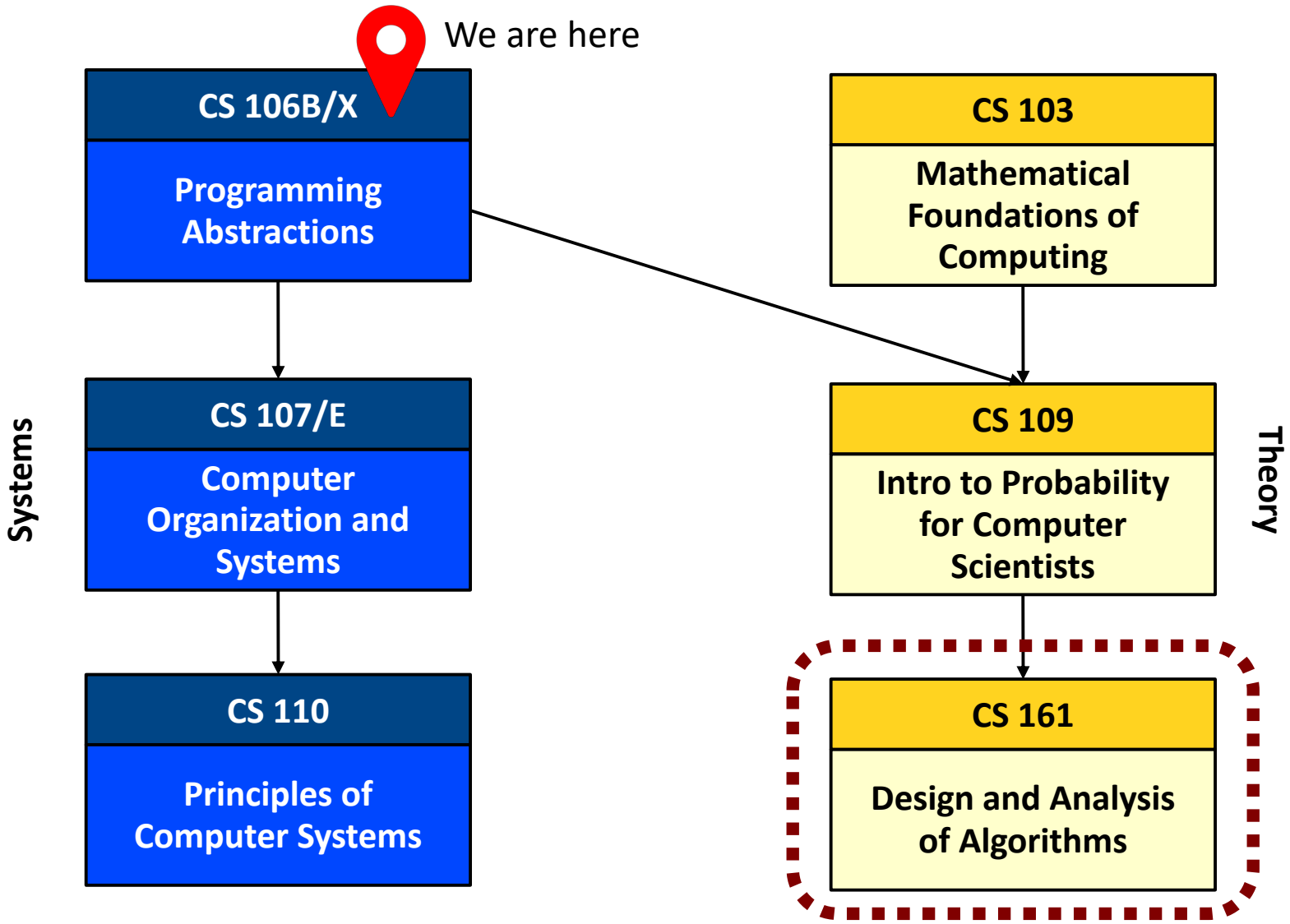
CS 109


Chris Piech


Mehran Sahami

- How can we better model and analyze data?
- How can we program computers to learn?
- How can we predict the likelihood of certain outcomes?

What's Next?

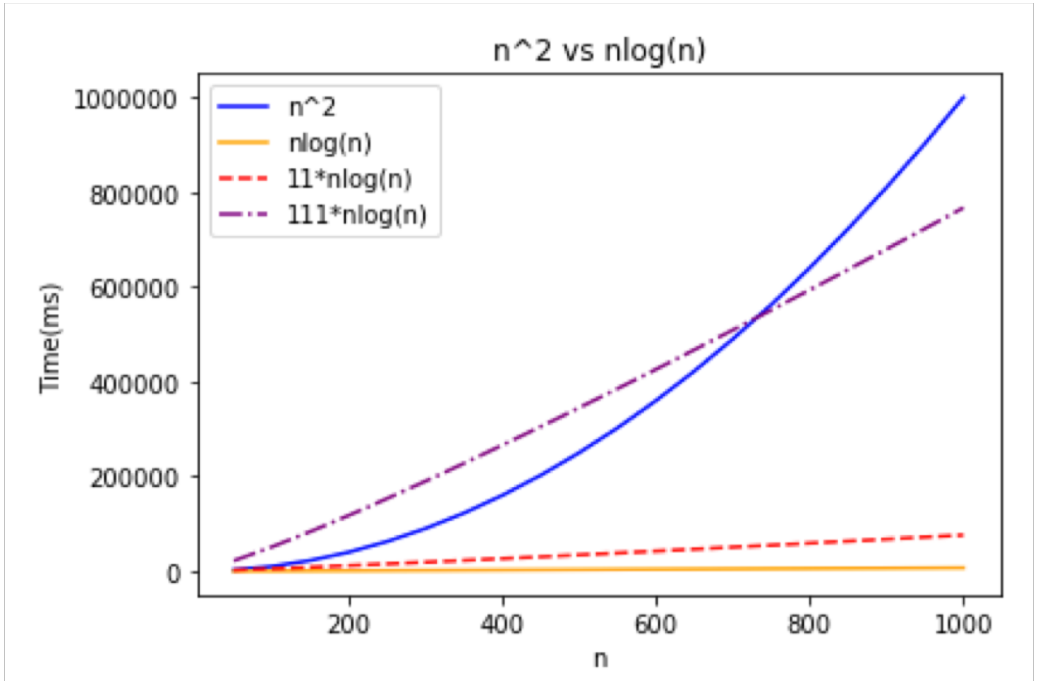

We are here
CS 106B/X
Programming Abstractions
CS 103
Mathematical Foundations of Computing
CS 107/E
Computer Organization and Systems
CS 109
Intro to Probability for Computer Scientists
CS 110
Principles of Computer Systems
CS 161
Design and Analysis of Algorithms
Systems
Theory

CS 161

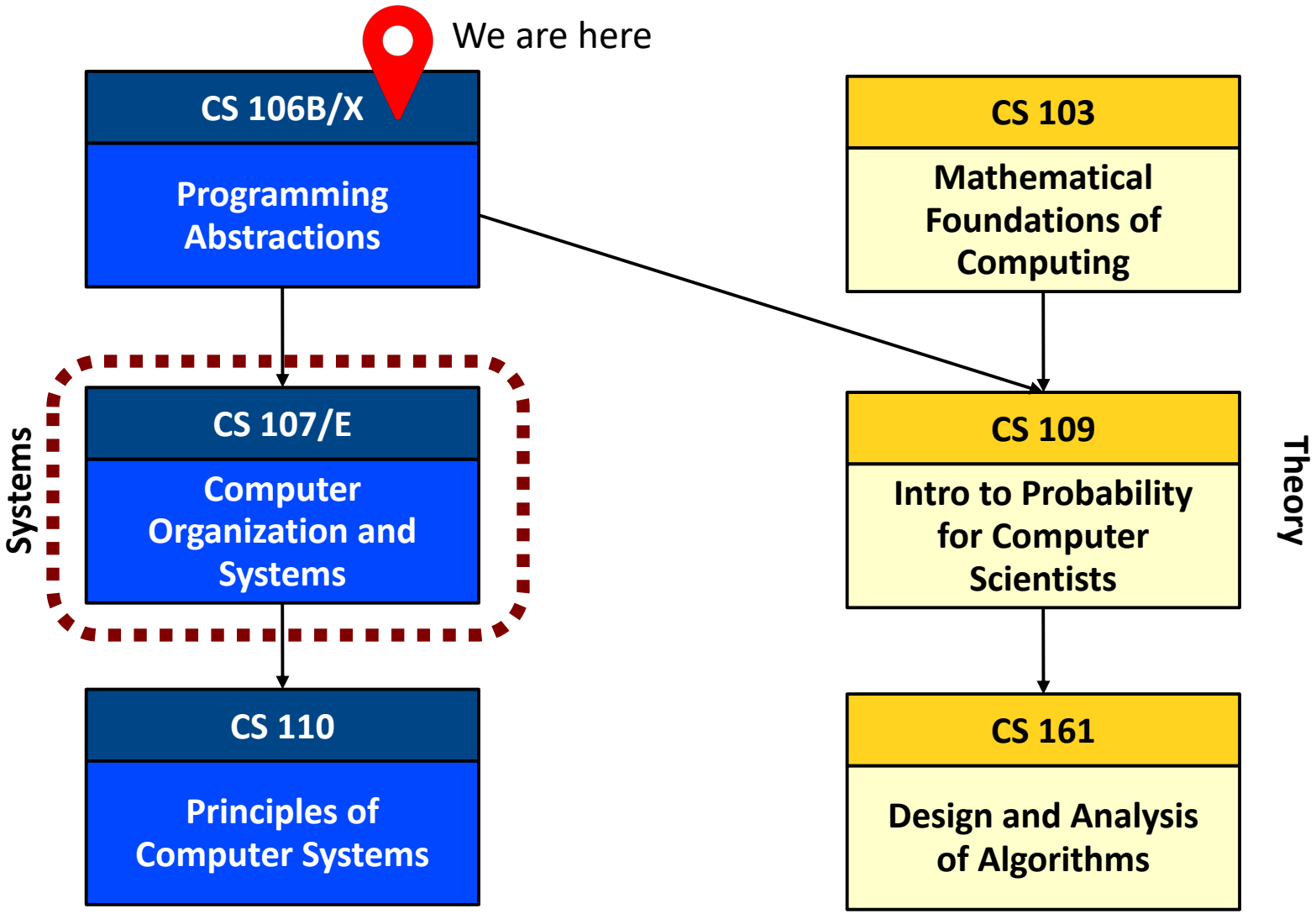
- How can we measure the efficiency of algorithms?
- How can we design our own algorithms?
- What useful algorithms are there?
- How can we prove that algorithms are correct?

Aviad Rubinstein

Mary Wootters



What's Next?


We are here
CS 106B/X
Programming Abstractions
CS 103
Mathematical Foundations of Computing
CS 107/E
Computer Organization and Systems
CS 109
Intro to Probability for Computer Scientists
Systems
Theory
CS 110
Principles of Computer Systems
CS 161
Design and Analysis of Algorithms

CS 107

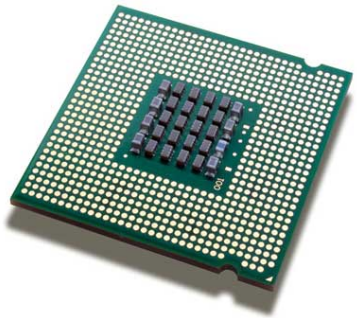
- How do computers represent data under the hood?
- How can we effectively manage bits, bytes, and memory?
- How does a processor execute our code?

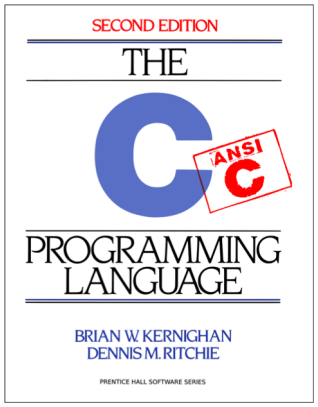

Julie Zelenski


Chris Gregg


Cynthia Lee


Nick Troccoli





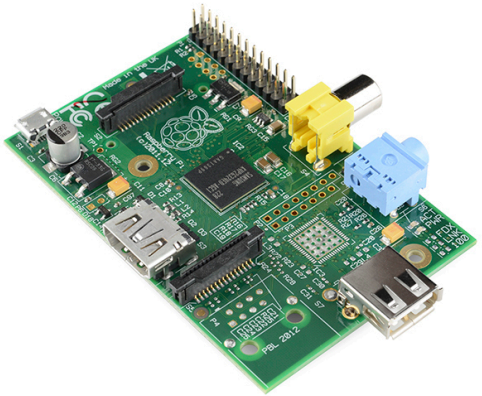
CS 107E

- **CS 107E**
  - develop for a **Raspberry Pi**
  - similar concepts, but in a setting of embedded devices
  - entry by **application** (limited enrollment)

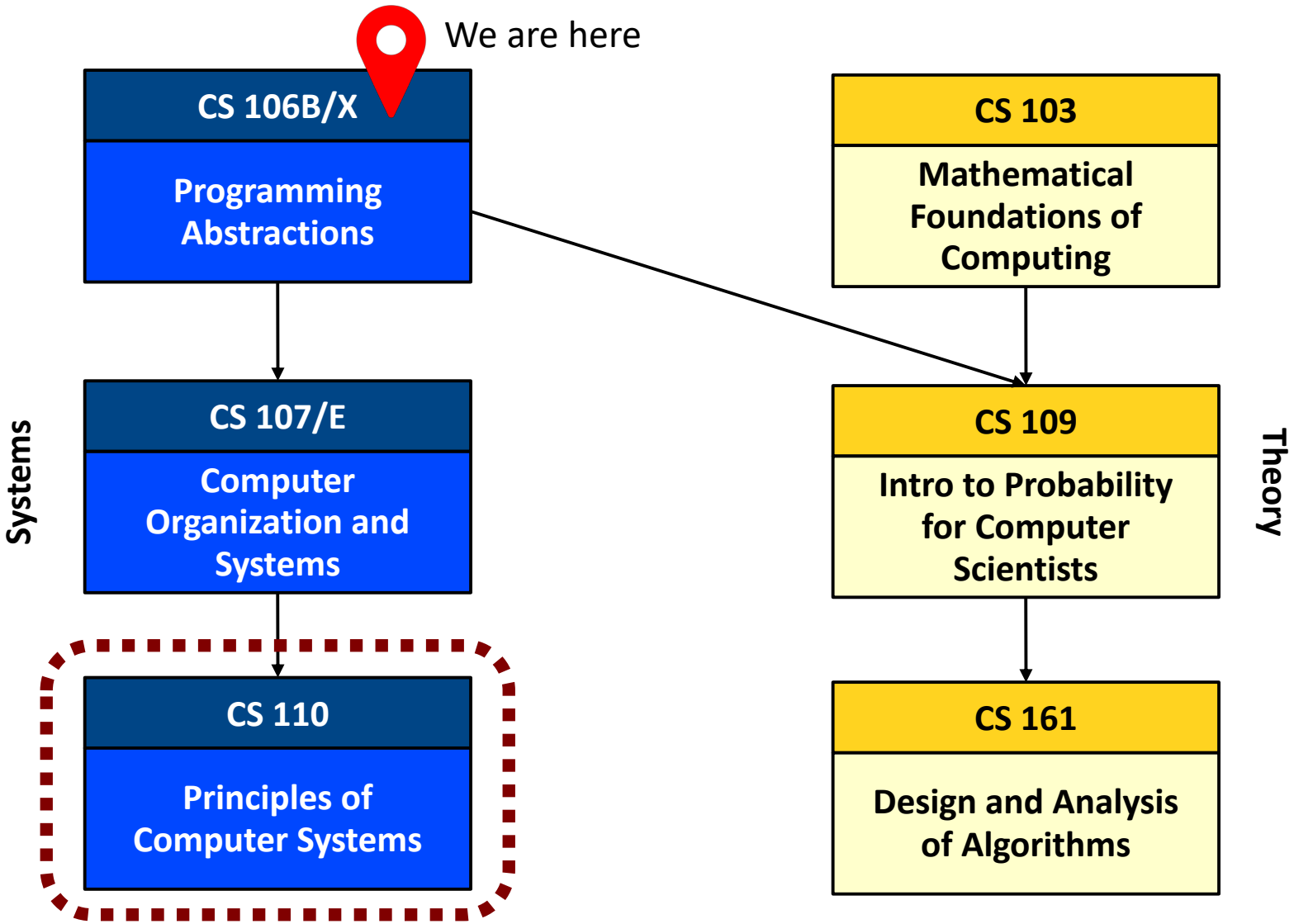

Julie Zelenski


Chris Gregg


Pat Hanrahan



What's Next?

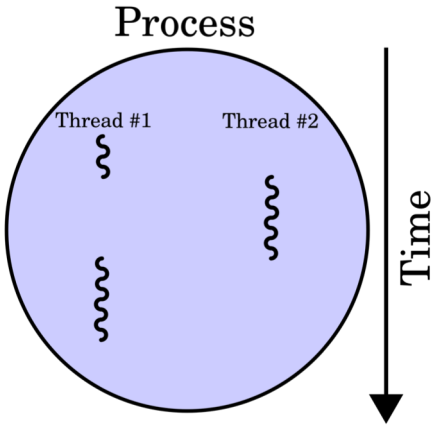

We are here
CS 106B/X
Programming Abstractions
CS 103
Mathematical Foundations of Computing
CS 107/E
Computer Organization and Systems
CS 109
Intro to Probability for Computer Scientists
CS 110
Principles of Computer Systems
CS 161
Design and Analysis of Algorithms
Systems
Theory

CS 110

- How can we implement multithreading in our programs?
- How can multiple programs communicate with each other?
- How can we implement distributed software systems to do things like process petabytes of data?
- How can we maximally take advantage of the hardware and operating system software available to us?

Jerry Cain

Chris Gregg



https://en.wikipedia.org/wiki/Multithreading_(computer_architecture)#/media/File:Multithreaded_process.svg

Other CS Courses

- **CS 108**: Object-Oriented System Design
  - how to build large OO applications in Java; testing; GUIs; threads
- **CS 142**: Web Development
- **CS 221**: AI: Principles and Techniques
- **CS 147**: Human-Computer Interaction (HCI)
- **CS 181**: Computers, Ethics, and Public Policy
  - piracy, hacking, online privacy, wiretapping, ...
- **CS 193**: Special Topics
  - mobile apps, web dev, big data, ...
- **CS 40/41/42/92SI**: Student Initiated (JS, web, Python, ...)

cs9: job prep

Patrick Young
(CS 108)

Christina Wodtke
(CS 247; CS 377G)

Emma Brunskill
(CS 234)

Marty Stepp
(CS 193A)

Percy Liang
(CS 221)

Studying CS

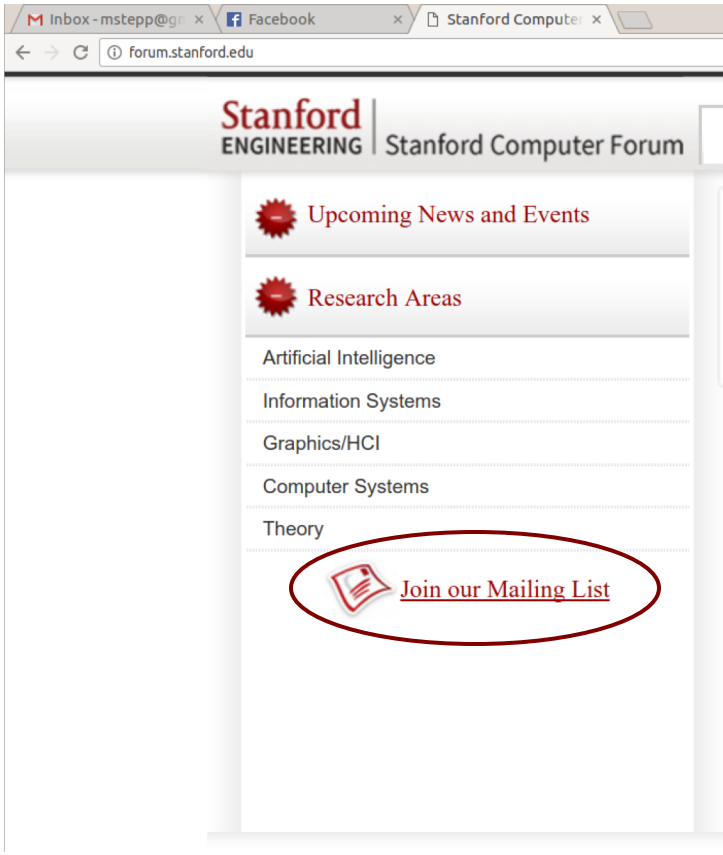
- Major or Minor: https://cs.stanford.edu/degrees/ug/
- Coterminal Degree: https://cs.stanford.edu/degrees/ug/Coterm.shtml
- other related majors:
  - **Symbolic Systems** (CS + psychology + linguistics + AI + Human-Computer Interaction)
  - **MCS** (Mathematical and Computational Science)
  - **MS&E** (Management Science and Engineering)
  - **EE** (Electrical Engineering)

Outside of Stanford

- Online courses
  - Coursera, Udacity, edX
  - Stanford CS lectures on YouTube
- Online tutorials
  - Codecademy
  - Khan Academy
  - Stack Overflow
  - W3 Schools
- Practice coding
  - TopCoder
  - Project Euler
  - CodeFights
  - HackerRank
  - CodeStepByStep :)

Internships

- You could get a summer job based on what you learned this year.
  - A lot of CS interview questions are about 106X-esque topics:
    - pointers / linked lists, recursion, binary trees, graphs, ...
- Computer Forum (forum.stanford.edu)
  - Job Fairs twice a year
  - Mailing list for job opportunities
  - Many companies would want to hire you ☺



Freshman internships

- **Microsoft Explore**
  - https://careers.microsoft.com/students/explore
- **Google Engineering Practicum**
  - https://careers.google.com/jobs#!t=jo&jid=/google/engineering-practicum-intern-summer-2018
- **Google Summer of Code**
  - https://developers.google.com/open-source/gsoc/
- **Facebook University for Engineering**
  - https://m.facebook.com/careers/university/fbueng
- **Twitter Freshman Engineering Internships**
  - https://careers.twitter.com/en/university.html
- **Intel Early Internship for Software Engineering (IRISE)**
  - http://www.intel.com/content/www/us/en/jobs/locations/united-states/students/internships/
- **Amazon University Internships**
  - http://www.amazon.jobs/team/university-internships
- **Pinterest Engage Internship**
  - https://careers.pinterest.com/careers/details/

Freshman internships 2

- **Khan Academy internships**
  - https://www.khanacademy.org/careers/interns
- **NSA internships**
  - https://www.nsa.gov/careers/
- **Breakout Mentors** (mentor students age 9-14 as they learn programming)
  - http://breakoutmentors.com/

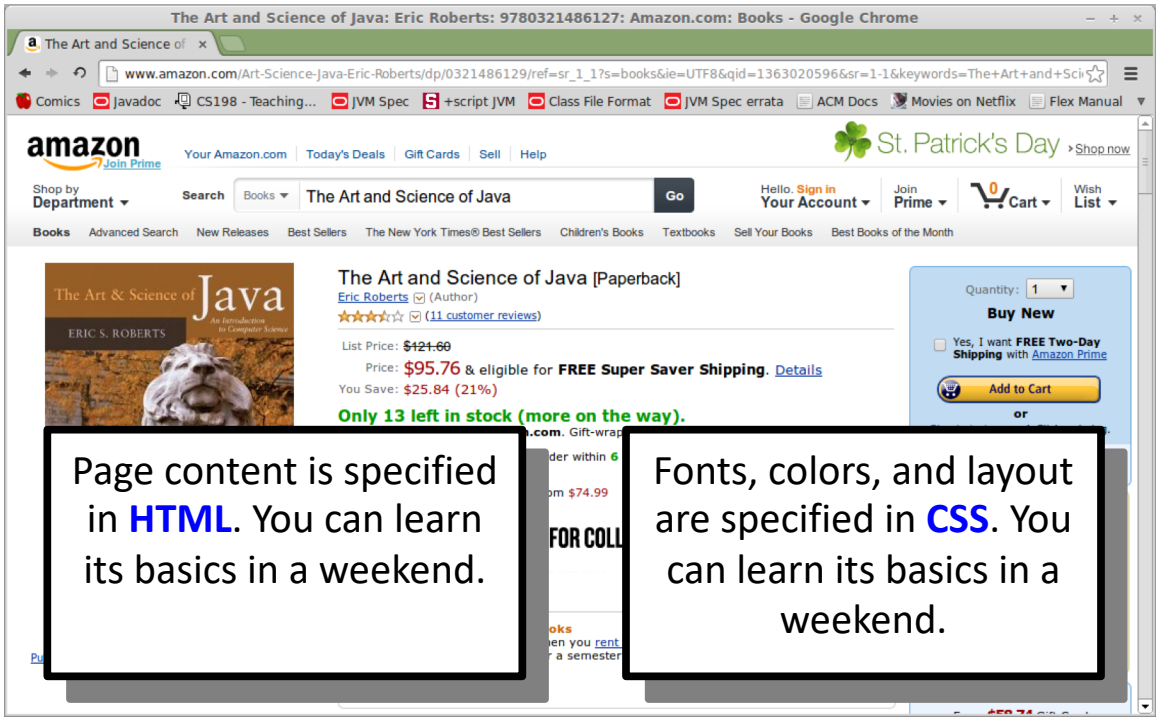
- possible others
  - http://www.computersciencedegreehub.com/internships-fortune-500-companies/

- **Quora:** What tech companies offer internships to freshmen?
  - https://www.quora.com/What-tech-companies-offer-internships-to-freshmen

- **Quora:** What can I do to get an internship over the summer?
  - https://www.quora.com/As-a-college-freshman-majoring-in-CS-what-can-I-do-to-potentially-get

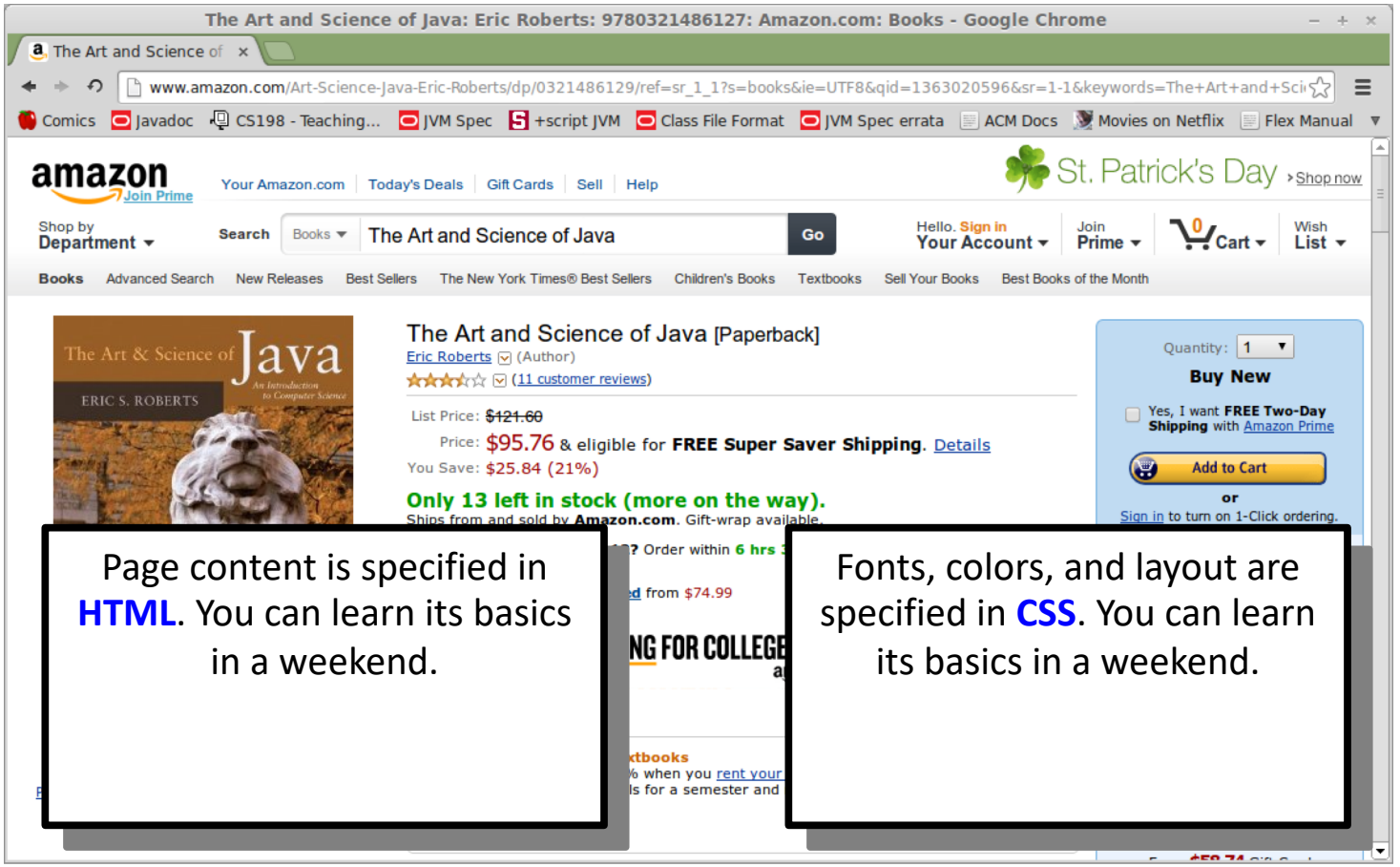
Teach yourself

- If there is a CS topic that interests you, go learn more about it!
  - Example: Learn how to make a web site (resume? blog? photos?)
  - Example: Rewrite 106A HW in C++; rewrite 106X HW in Java/Python
  - Example: grab cool data from reddit /r/datasets and process it



Teach yourself HTML/CSS

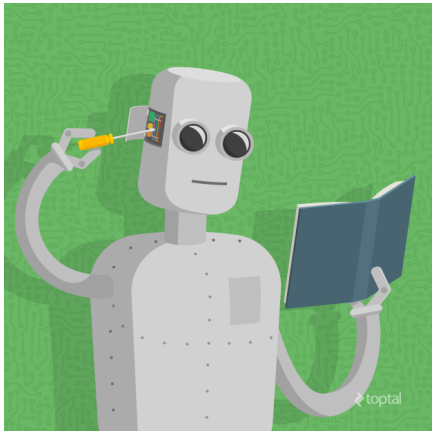
- **Challenge:** Write yourself a simple web page and resume in HTML.
  - Post it on Stanford web space! http://stanford.edu/~yourUserName/

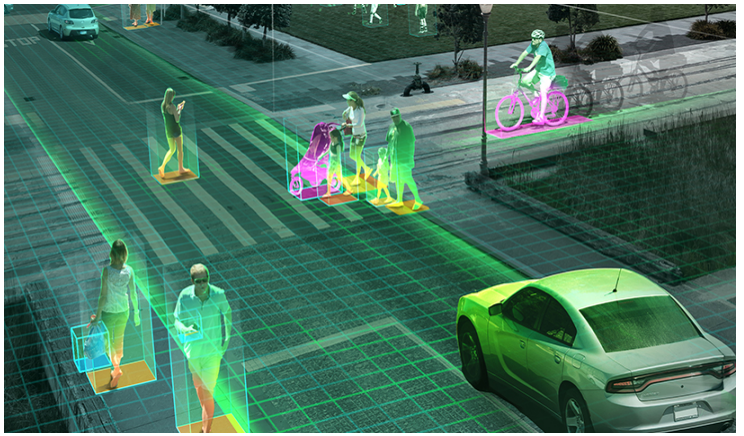


Read about CS topics

- **Challenge**: Pick a CS topic or sub-field,
  and go read about the basics of it over the break.
  - *suggestion:* Pick a topic that aligns with a Stanford CS "track."

Machine Learning, **Neural Networks**, **Computer Vision**, ...



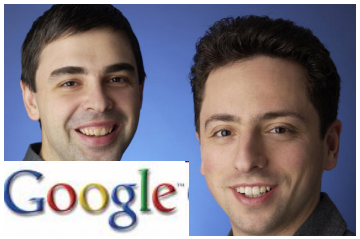


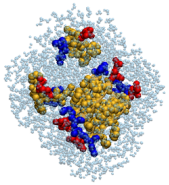
Apply to be an SL

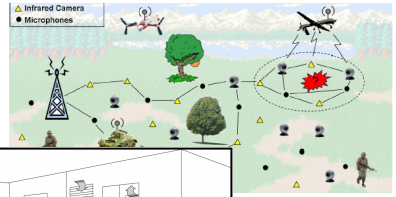
- Apply to be a **Section Leader**! cs198.stanford.edu
- Thanks to our awesome section leaders this quarter, and especially to our head TA, **Zach Birnholz**!

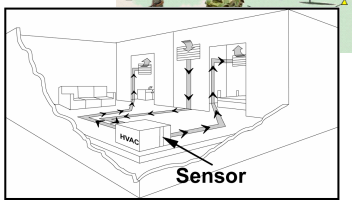
Computer Science Is Everywhere

- security
- quantum computing
- robotics
- graphics and vision
- networking
- data mining
- developing world
- neurobiology
- ... many more









Plan For Today

- **Recap:** CS 106X
- Next Steps
- **Parting Words**
- Ask-Anything
- Course Evaluations

Anyone can be a computer scientist.

Computer science is **using computing to solve problems.**

Anyone **is welcome** to be a computer scientist.

We hope CS106X **excited you** about learning more computer science!

Plan For Today

- **Recap:** CS 106X
- Next Steps
- Parting Words
- **Ask-Anything**
- Course Evaluations

Ask-Anything

“What are differences between cs major tracks?”

Ask-Anything

"What are differences

Each track has the same fundamentals, but lets you branch off based on interest. For example, if you want to learn about large systems like compilers and operating systems, "Systems" is a good fit. If you're interested in the role of computers in human life and how we interact with them, HCI is a good fit.

Ask-Anything

"What are some foolproof ways to come up with good tests?"

Ask-Anything

"What are some foolproof ways to come up with good tests?"

Pretend you're an adversary; what ways could you try to provide invalid input, or use the functions in an unintended manner? *Try* to cause unintended behavior.

Ask-Anything

"How to get involved in research/summer programs at Stanford?"

Ask-Anything

"How to get involved in research/summer programs

CURIS (Undergraduate Research in CS) is a year-round program that matches students with departmental research projects. Visit https://curis.stanford.edu, or email/go talk to professors who are doing work you're interested in at their office hours! Be proactive and reach out to people you're interested in working with.

Ask-Anything

"How would you recommend to prepare for technical coding interviews?"

Ask-Anything

"How would you recommend to prepare for technical coding interviews?"

Don't just practice coding problems; practice explaining your ideas as you come up with them, ideally at a whiteboard. Interviewers look at how you develop and explain your ideas, not just whether you get the right answer.

Ask-Anything

"What makes a good computer scientist?"

Ask-Anything

"What makes a good computer scientist?"

1. The knowledge of how computing fits in an interdisciplinary world.
2. An eagerness to learn new things.

Plan For Today

- **Recap:** CS 106X
- Next Steps
- Parting Words
- Ask-Anything
- **Course Evaluations**

Course Evaluations

We hope you can take the time to fill out the end-quarter CS 106X course evaluation. We sincerely appreciate any feedback you have about the course, and read every piece of feedback we receive. We are always looking for ways to improve!

Thank you!