Where to Go from Here
Announcements

• Office hours Today and Tomorrow:
  • 12-5PM in Gates 160
Goals for this Course

- **Learn how to model and solve complex problems with computers.**
- To that end:
  - Explore common abstractions for representing problems.
  - Harness recursion and understand how to think about problems recursively.
  - Quantitatively analyze different approaches for solving problems.
How do we model real-world problems in software?
We're going to need a way to model \textbf{sequences of data}.

So let's study stacks, queues, and vectors.
15 - 3 + 4 * 5 / 6
Buying Cell Towers

137  42  95  272  52
What about associative data? Or unordered data?

This is where maps, sets, and lexicons come in.
dik·dik
opts
post
pots
spot
stop
tops
How do we model networks?

We can use graphs, which we can build out of those tools we just saw!
But how does all of this work?
Idea

- Element array
- Allocated length: 4
- Logical length: 2
- 137 42
Linked Lists at a Glance

- A **linked list** is a data structure for storing a sequence of elements.
- Each element is stored separately from the rest.
- The elements are then chained together into a sequence.
We need a way to compare solutions. So let's invent big-O notation.
So... how do they compare?
Neither of the implementations is strictly better than the other!
How might we make maps and sets?
As before, neither of these structures is clearly better than the other!

This hits on a key point: **Engineering is all about trade-offs.**
Cool! Now we have a bunch of tools for modeling problems!

So how do we go about solving them?
Parking Randomly

\[x + 1\]
Nifty! Some problems are self-similar!
So how do we solve them?
int sumOfDigits(int n) {
    if (n < 10)
        return n;
    else
        return (n % 10) + sumOfDigits(n / 10);
}
void moveTower(int n, char from, char temp, char to) {
    if (n > 0) {
        moveTower(n - 1, from, to,
                  temp);
        moveDisk(from, to);
        moveTower(n - 1, temp, to,
                  from);
    }
}
All we need to do is figure out a base case and a recursive step!
What else can we do with recursion?
Self-similarity is **everywhere!**
Programming is all about exploring new ways to model and solve problems.

The skills you have just learned will follow you through the rest of your programming career.
Also, the concepts learned in this class come up *everywhere* in Computer Science.

The material you've learned opens up a *huge* number of new topics to learn!
Trees
Trees

- Trees + Computational Geometry = k-d Trees
Trees

- Trees + Graphics = Adaptive Shadow Maps

Trees

- Trees + Information Theory = Huffman Encoding

Trees

- Trees + Machine Learning = Hierarchical Clustering

http://adios.tau.ac.il/clustree/Clustree_files/image014.jpg
Graphs
Graphs

- Graphs + Networking = Computer Networks

http://icawww1.epfl.ch/cn2/0910/
Graphs

- Graphs + Machine Learning = Probabilistic Graphic Models

http://song.bayesian.net/index.php/Bayesian_net
Graphs

- Graphs + Computer Vision = Image Segmentation

http://ailab.snu.ac.kr/intro.php
So what comes next?
Courses to Take
The CS Core

Systems

CS106B
Programming Abstractions

CS107
Computer Organization and Systems

CS110
Principles of Computer Systems

Theory

CS103
Mathematical Foundations of Computing

CS109
Intro to Probability for Computer Scientists

CS161
Design and Analysis of Algorithms
The CS Core

**Systems**

- **CS106B**
  - Programming Abstractions
- **CS107**
  - Computer Organization and Systems
- **CS110**
  - Principles of Computer Systems

**Theory**

- **CS103**
  - Mathematical Foundations of Computing
- **CS109**
  - Intro to Probability for Computer Scientists
- **CS161**
  - Design and Analysis of Algorithms
The CS Core

- **Systems**
  - **CS106B**: Programming Abstractions
  - **CS107**: Computer Organization and Systems
  - **CS110**: Principles of Computer Systems

- **Theory**
  - **CS103**: Mathematical Foundations of Computing
  - **CS109**: Intro to Probability for Computer Scientists
  - **CS161**: Design and Analysis of Algorithms
Can computers solve all problems?

Why are some problems harder than others?

How can we be certain about this?
It's all Bits and Bytes!

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01001001010010110100010001001001
01001011
How do we encode text, numbers, programs, etc. using just 0s and 1s?

Where does memory come from?
How is it managed?

How do compilers, debuggers, etc. work?
What CS107 Isn't

• CS107 is *not* a litmus test for whether you can be a computer scientist.
  • You can be a *great* computer scientist without enjoying low-level systems programming.

• CS107 is *not* indicative of what programming is “really like.”
  • CS107 does a lot of low-level programming. You don't have to do low-level programming to be a good computer scientist.

• CS107 is *not* soul-crushingly impossibly hard.
  • It's hard. It does not eat kittens.

• *Don't be afraid to try CS107!*
Other CS Courses
CS108
Object-Oriented Systems Design

• *How do you build large software systems in a team?*

• Introduction to
  • Unit-testing frameworks
  • Object-oriented design.
  • Multithreaded applications.
  • Databases and web applications.
  • Source control.

• Excellent if you're interested in learning industrial programming techniques.
Many offerings throughout the year, focused on specific technologies:

- CS193A: Android Programming
- CS193C: Client-Side Web Technologies
- CS193I: iOS Programming
- CS193L: Lua Programming
- CS193P: iPhone and iPad programming

Great for learning particular technologies.
CS147
Intro to Human-Computer Interaction

- How do you design software to be usable?
- What are the elements of a good design?
- How do you prototype and test out systems?
The CS Minor
The CS Coterm
Outside Stanford
Learning More

- MOOCs: Coursera, Udacity, and edX all offer CS courses.
  - e.g. Check out Udacity's Web Development course at https://www.udacity.com/course/cs253.
- Explore and play around! There are great resources for getting unstuck on the internet.
  - e.g. Stack Overflow (http://www.stackoverflow.com) is a place to ask for help on programming-related questions.
- Read a book! There are great books that introduce most programming languages and frameworks.
Taking Classes

• Want to come back to Stanford? Take classes through SCPD!
My Email Address

adgress@cs.stanford.edu
Some Words of Thanks