What is Computer Science at Duke?

**Google**

- What we tell you it is
  - A bunch of courses useful in some majors
- What you want it to be or imagine it to be
  - Independent study, new courses, interdepartmental major
- What will it be in one year or two?
  - New courses, new professors, new majors, …
- What is it outside of Duke?
  - Similar but different!

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Big Ideas in Computer Science

- “Mathematics is the Queen of the Sciences”
  - Carl Friedrich Gauss
- What is Computer Science?
  - Why study it, what is it, why is it interesting (or not)?
- Historically
  - What can we program, what can we program efficiently
- Present
  - Lots of data, lots of connectivity, lots of inferences
- Future
  - Where do we go from here?

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What can be programmed?

- What class of problems can be solved?
  - G5, 1000Mhz Pentium III, Cray, pencil?
  - Alan Turing proved some things, hypothesized others
    - Halting problem, Church-Turing thesis
- What class of problems can be solved efficiently?
  - Problems with no practical solution
    - What does practical mean?
  - Problems for which we can’t find a practical solution
    - Solving one solves them all
    - Would you rather be rich or famous?

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Schedule students, minimize conflicts

- Given student requests, available teachers
  - write a program that schedules classes
  - Minimize conflicts
- Add a GUI too
  - Web interface
  - ...
  - ...

I can’t write this program because I’m too dumb
One better scenario

I can’t write this program because it’s provably impossible.

Another possible scenario

I can’t write this program but neither can all these famous people.

Entscheidungsproblem

- What can we program?
- What can’t we program?
- Can we write a program that will determine if any program P will halt when run on input S?
  - Input to halt: P and S
  - Output: yes/no halts

What Computers Can’t Do?

Digitizing Books One Word at a Time

The words above come from scanned books. By typing them, you help to digitize old texts.
Good sites: http://del.icio.us/

- What is social bookmarking?
  - Why is del.icio.us interesting?
  - Who posts, who visits?

- What about a website of interesting websites?
  - What would you expect to find there?
  - Would the site list itself?

- What about sites that list/link to themselves?
  - What about a site with all sites that list themselves?

Bad sites: http://haz.ardo.us

- Sites listing bad sites (don’t visit them?)
  - Where would this be useful?
  - What about censorship (internationally?)
  - Is this a good site or a bad site?

- What about sites that list/link themselves?
  - Is haz.ardo.us there?

- Website of all the sites that don’t list themselves?
  - Is notlisted.com listed on notlisted.com?

The halting problem: writing doesHalt

```java
public class ProgramUtils {
    /**
     * Returns true if program halts on input,
     * otherwise returns false (program loops)
     */
    public static boolean doesHalt(String progname, String input) {
    }
}
```

- A compiler is a program that reads other programs as input
  - Can a word counting program count its own words?

- The doesHalt method might simulate, analyze, ...
  - One program/function that works for any program/input

How to tell if Foo stops on 123 456

```java
public static void main(String[] args) {
    String prog = "Foo.java";
    String input = "123 456"
    if (ProgramUtils.doesHalt(prog, input)) {
        System.out.println(prog + " stops");
    } else {
        System.out.println(prog + " 4ever");
    }
}
```

- Can user enter name of program? Input?
  - What's the problem with this program?
Consider the class `Confuse.java`

```java
public static void main(String[] args) {
    String prog = "Foo.java";
    if (ProgramUtils.doesHalt(prog, prog)) {
        while (true) {
            // do nothing forever
        }
    }
}
```

- We want to show writing `doesHalt` is impossible
  - Proof by contradiction:
  - Assume possible, show impossible situation results
- Can a program read a program? Itself?

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Can we write `Confuse.java`?

- Legal if `doesHalt` exists
  - What have we assumed?
- What are consequences of running `confuse` on itself?
  - Trouble?

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Not impossible, but impractical

- Towers of Hanoi
  - How long to move n disks?
- What combination of switches turns the light on?
  - Try all combinations, how many are there?
  - Is there a better way?

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Travelling Salesperson

- Visit every city exactly once
- Minimize cost of travel or distance
- Is there a tour for under $2,000? Less than 6,000 miles?
- Is close good enough?
  - Within 10% of optimal
  - Within 50% of optimal
  - ...

Try all paths, from every starting point -- how long does this take?

```
a, b, c, d, e, f, g
b, a, c, d, e, f, g ...
```
Travelling Salesman: XKCD 399

BRUTE-FORCE SOLUTION: \( O(n!) \)

DYNAMIC PROGRAMMING ALGORITHMS: \( O(n^22^n) \)

SELLING ON EBAY: \( O(1) \)

Question: \( P = NP \) ?

If yes, a whole class of difficult problems, the NP-complete problems, can be solved efficiently.

If no, none of the hard problems can be solved efficiently.

14.19

Theory and Practice

- Number theory: pure mathematics
  - How many prime numbers are there?
  - How do we factor?
  - How do we determine primeness?

- Computer Science
  - Primality is “easy”
  - Factoring is “hard”
  - Encryption is possible

14.20

Useful Computer Science

- [Google Maps](http://maps.google.com/maps)?daddr=7824+Anise+Ave,+Los+Angeles,+CA+90045&saddr=13480+maxella+ave,+marina+del+rey&f=d&hl=en&ie=UTF8&z=14&om=1

- Marriot, Marina Del Rey
  - 7824 Anise Ave
  - Los Angeles

14.09
How does this work?

- [http://tinyurl.com/2t57jc](http://tinyurl.com/2t57jc)

In Re Boucher 2007 WL 4246473

Courses of Study

- What do you take first?
- What’s next?
- In between?
- Who teaches what?