Class 1: Introduction

CS1120 Spring 2010
University of Virginia
Computer Science

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http://www.cs.virginia.edu/cs1120

What is *Computer Science*?
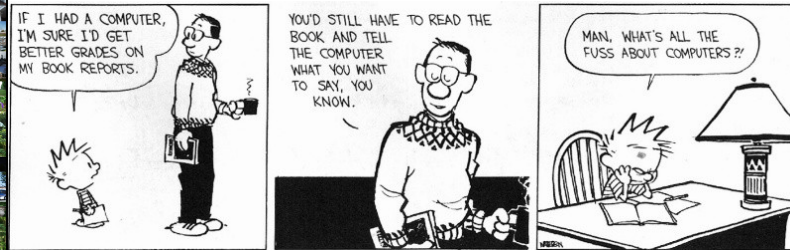
Let *AB* and *CD* be the two given numbers not relatively prime. It is required to find the greatest common measure of *AB* and *CD*.

If now *CD* measures *AB*, since it also measures itself, then *CD* is a common measure of *CD* and *AB*. And it is manifest that it is also the greatest, for no greater number than *CD* measures *CD*.

Euclid's Elements, Book VII, Proposition 2 (300BC)

The note on the *inflected* line is only difficult to you, *because it is so easy*. There is in fact nothing in it, but you think there must be some grand mystery hidden under that word *inflected*!

Whenever from any point *without* a given line, you draw along to any point *in* the given line, you have *inflected* a line *upon a given line*.

Ada Byron (age 19), letter to Annabella Acheson (explaining Euclid), 1834

By the word operation, we mean any process which alters the mutual relation of two or more things, be this relation of what kind it may. This is the most general definition, and would include all subjects in the universe... Supposing, for instance, that the fundamental relations of pitched sounds in the science of harmony and of musical composition were susceptible of such expression and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent.

Ada Byron, 1843

I ask you: What's the difference between Euclid and Ada?

I have no idea what you're talking about when you say the word "ask".

Bill Gates (deposition at Microsoft's anti-trust trial)

Today's Class

- Ada and Euclid
- Engineering and Science
- Moore's Law and Computing Power
- The Liberal Arts
- Course Expectations
- Recursive Definitions and Languages
- Nuclear Weapons
- Formal Languages and Systems

Geometry vs. Computer Science

- Geometry (mathematics) is about *declarative* knowledge: "what is"

  If now *CD* measures *AB*, since it also measures itself, then *CD* **is** a common measure of *CD* and *AB*

- Computer Science is about *imperative* knowledge: "how to"

Geometry vs. Computer Science

- Geometry (mathematics) is about *declarative* knowledge: "what is"

  If now *CD* measures *AB*, since it also measures itself, then *CD* **is** a common measure of *CD* and *AB*

- Computer Science is about *imperative* knowledge: "how to"

Computer Science has little to do with beige (or spiffy black) boxes called "computers" and is not a real science.

Computer Science

"How to" knowledge:

- Ways of describing information processes (computations)

  Language

- Ways of predicting properties of information processes

  Logic

Science, Engineering or Other?

Science?

- **Science** involves understanding nature through observation
  - About *real* things like bowling balls, black holes, antimatter, electrons, comets, etc.
- Math and Computer Science are about *fake* things like numbers, graphs, functions, lists, etc.
  - Computer Science is a useful tool for *doing* real science, but is not a real science

Engineering?

"**Engineering** is **design under constraint...** Engineering is synthetic - it strives to create what can be, but it is constrained by nature, by cost, by concerns of safety, reliability, environmental impact, manufacturability, maintainability and many other such 'ilities.' ..."

William Wulf and George Fisher, 2002

Liberal Arts Trivia: Music

- Q. What is the name of a musical scale with twelve pitches, each a semitone or half step apart? Such a scale is nondiatonic, consisting entirely of half-step intervals and having no tonic due to the symmetry or equal spacing of its tone.

Liberal Arts Trivia: Psychology

Say the *color* each word is printed in:
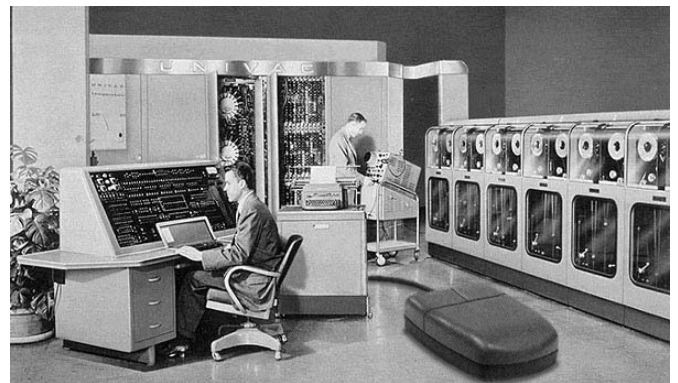
Green Red Blue
Purple Blue Purple

Blue Purple Red
Green Purple Green

Q. Name the effect that refers to the fact that naming the color of the first group of words is easier and quicker than the second.

Let's Start With Classic Computers

Apollo Guidance Computer, 1969

1 Cubic Foot

Why did they need to fit the guidance computer in the rocket?

Measuring Computers

- 1 **bit** = smallest unit of information
  – True or False
  – 0 or 1
  – If we start with 2 possible choices, and get 1 bit, we can eliminate one of the choices

How much power?

- Apollo Computer: 61440 bits of changeable memory
- Lab machines have 1 GB (RAM)
  - 1 Gigabyte = 1024 Megabytes,
    1 Megabyte = 1024 Kilobytes,
    1 Kilobyte = 1024 Bytes,
    1 Byte = 8 bits

  > You will understand this notation soon…but don't worry if you don't now

  > (* 1024 1024 1024 8)

  8589934592   ~ 8.6 Billion bits

  > (round (/ (* 1024 1024 1024 8) 61440))

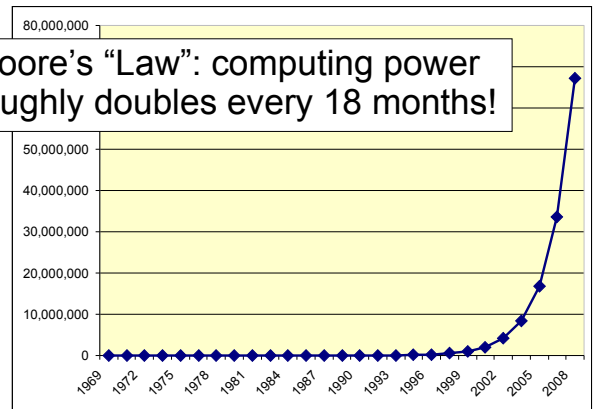 **139810**   You have 139 810 times more power than AGC

If Apollo Guidance Computer power is 1 inch, you have 2.2 miles!

Computing Power 1969-present (in Apollo Control Computer Units)

Moore's "Law": computing power roughly doubles every 18 months!

Constraints Computer Scientists Face

- Not like those for engineers:
  - Cost, weight, physics, etc.
  - If today's ~20 Million times what people had in 1969 isn't enough for you, wait until 2011 and you will have ~80 Million times…
- More like those for Musicians and Poets:
  - Imagination and Creativity
  - Complexity of what we can understand

So, what is computer science?

- ~~Science~~
  - No: it's about fake things like numbers, not about observing and understanding nature
- ~~Engineering~~
  - No: we don't have to deal with engineering-type constraints
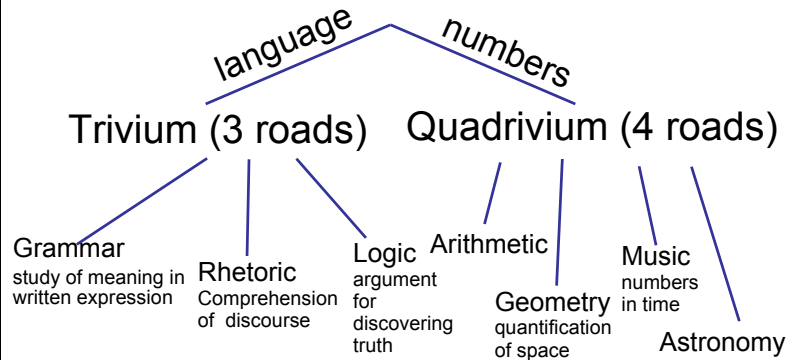- Liberal Art

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Liberal Arts: ~1100 AD

- **Illiberal Arts**
  - arts for the non-free: pursued for economic reasons
- **Liberal Arts**
  - arts for the *free*: pursued for intrinsic reasons

The Liberal Arts

language   numbers

Trivium (3 roads)   Quadrivium (4 roads)

Grammar
study of meaning in
written expression

Rhetoric
Comprehension
of discourse

Logic
argument
for
discovering
truth

Arithmetic

Geometry
quantification
of space

Music
numbers
in time

Astronomy

We will see all of these in this class!

Course Expectations

Course Roadmap

Computer Science from Euclid and Ada } 1 Class
_to_ } PS 1-6
Quantum Computing } Lecture
and
the World Wide Web } PS 7-9

Liberal Arts (Intellectual) Illiberal Arts ($$$$)
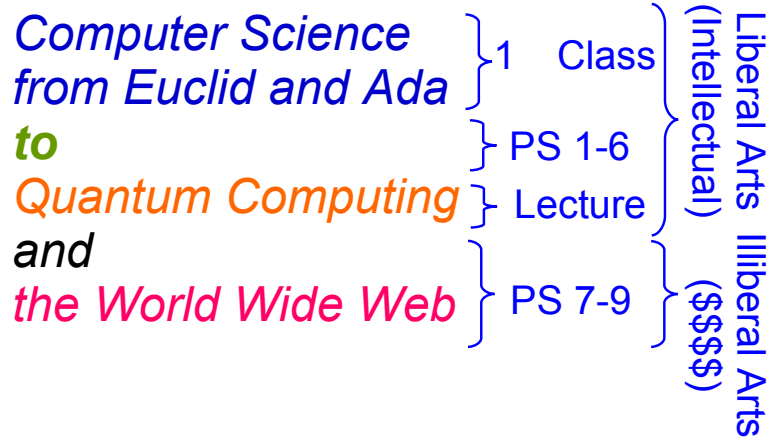
Difficulty

I would warn them that its a lot of work esp for an intro class.

I would say it has the work load of a 4 credit class but is a very practical class if at least somewhat interested in comp. sci.

The problem sets were very time consuming and very tough.

The first problem set was easy enough, but most of the rest of them were extremely difficult. Each week, it seems that Wes would warn us that this next one was particularly hard. They were all hard!

This was an extremely difficult crash course in CS for a Cog Sci major. The Cog Sci department, in the very least, should not market the class as a CS course for non CS people

I honestly think the problem sets were very challenging and time consuming, but it was for the best. I was able to collaborate with people and really think through the problems. All the sets were good, it was just tough at times to complete.

I would recommend this class to some of my friends, though I would have to warn them that it isn't a course where they will be able to sit back and not do any work.

I would make sure that students know how much of a time commitment this is.

I would prepare people for putting many many many many hours towards the class.

Problem sets owned my life for a number of hours but were essential to more fully understanding how computer science, and more specifically, computer programming goes about. Although some were absurdly tough to get through such as 3 and 5 and 9, I feel I have actually learned an incredible amount while attempting to complete these problem sets.

I would recommend this class to student who were interested in taking computer science, but probably defer them if they were only doing it for a major requirement and were not interested at all.

I would recommend with a warning. This class is unquestionably the hardest class I have taken in 4 years of college and was the most time consuming in terms of work. However, actually getting your code to work was extremely rewarding. I would advise students to strongly consider the amount of time they are willing to put into this class before registering for it. However, with that said, I think this class was worth taking because of how much it teaches you about programming.

Other Options, if CS 1120 is a trap

- **CS 1110 ("Introduction to Programming")** still had 50 open lecture spots and three open sections
- **CS 1010 ("Introduction to Information Technology")** still had 3 open lecture spots
- **CS 1111 ("Introduction to Programming")** still had 85 open lecture spots

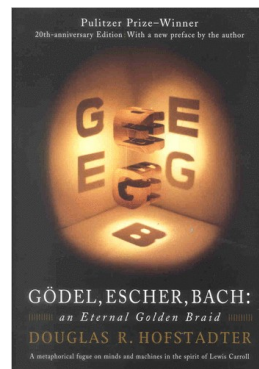---

Like Drinking from a Firehose

Don't be overwhelmed!
If you're willing to work,
you will do fine.

It may hurt a little bit, and a lot of water will go by you, but you won't go away thirsty!

Course Book

Introduction to Computing: Explorations in Language, Logic, and Machines

A new book written for this course by Professor David Evans (UVA)

$12.10 in black and white
$58.30 in color
$00.00 read PDF on-line

"GEB"
optional

"Course Book"
required

Help Available

- Me: Westley Weimer (call me "Wes")
  - Office Hours 1:30-2:00pm, Mon and Wed
  - Always available via email and **forum**, if I don't reply in 24 hours, send again and complain
- Teaching Assistants: Zak, Rachel, David, ...
  - Staffed lab hours in Thornton Stacks, OLS 001, Small?
  - Hours TBA
- Web site: **http://www.cs.virginia.edu/cs1120**
  - *Everything* goes on the web, you should visit it often
- **Your classmates** (read the course pledge carefully!)

What I Expect of You

1. Everything on the Course Pledge
   - You should actually **read it** not just sign it (you will lose points on the problem sets if your submission reveals that you didn't read it!)

2. You are a "Jeffersonian Student"

   1. Believe knowledge is powerful
   2. Interested in lots of things, ahead of your time
   3. Want to use what you learn to do good things
   4. Care more about what you learn than grades and degree requirements
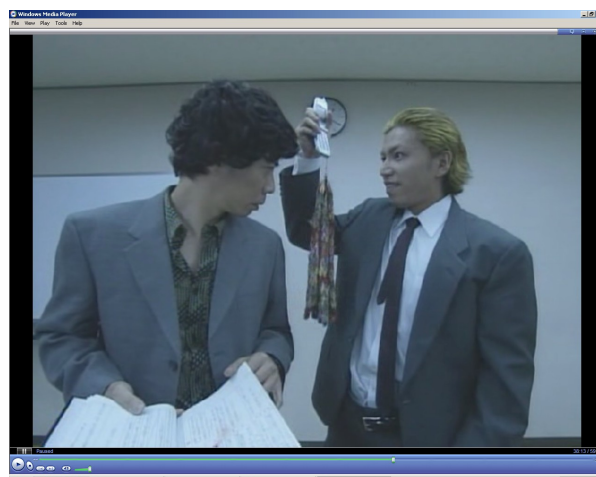
Background Expected

- Language:
  - Reasonable reading and writing in English
  - Understanding of subject, verb and object
- Math:
  - Numbers, add, subtract, multiply, divide
  - Exponentiation, logarithms (we will review)
- Logic: *and*, *or*, *not*
- Computer Literacy: read email, browse web

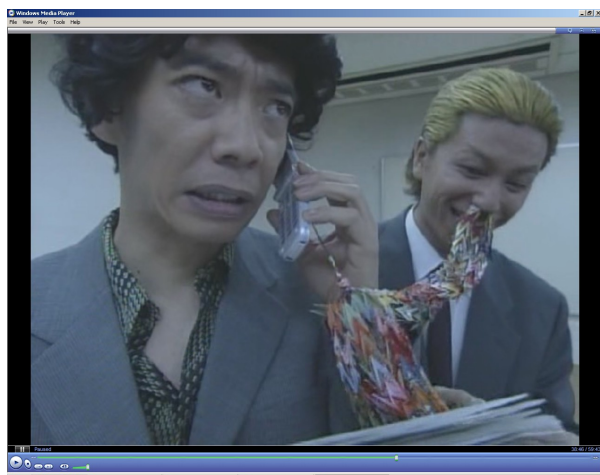 If I ever appear to expect anything else, stop me!

Many of you have fancy phones

No ringing: you will look foolish

A Course for Everyone!

- CLAS, SEAS, Commerce, Arch, etc.
- 1st, 2nd, 3rd, 4th, 5th Years, Community Scholars, Faculty
- No background expected … but challenging even for students with lots of previous CS courses
- Computer Science (future-) majors … but worthwhile even if you don't take another CS course

First Assignment

- Read Course Book Chapters 1-3 **by tomorrow**
- Problem Set 1 ("Making Mosaics") is due **3:30pm Monday February 1**
  - Get started early!
- Due before CLAS drop deadline
  - If the class is too crowded for you, or if you *can't make the office hours*, or if PS1 is too confusing, drop CS1120 now and take it later
  - If you are in the class now and you drop it now but plan to take it later, I will write you a note to skip you past the waitlist later
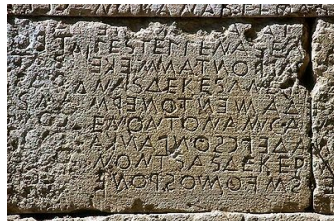

First Main Theme:
Recursive Definitions

What is the longest word in the English language?

Can you think of one longer than "**boustrophedon**" ?
From Greek βουστροφηδόν ("ox-turning"—that is, turning like oxen in ploughing), it is an ancient way of writing manuscripts and other inscriptions.
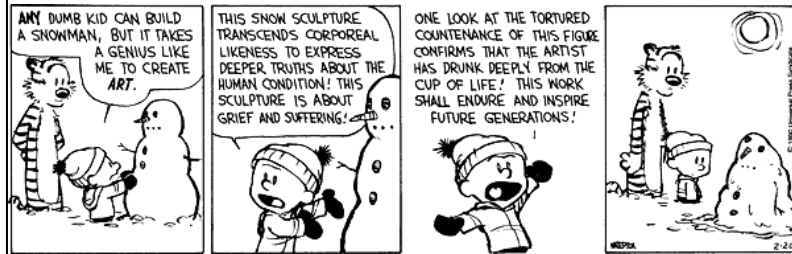

Ancient Greek boustrophedon inscription, Gortyn code, Crete, 5th c. B.C

According to Guinness

floccipoccinihilipilification
the act of rendering useless

Making Longer Words

antifloccipoccinihilipilification
the act of rendering not useless

antiantifloccipoccinihilipilification
the act of rendering   useless

Language is *Recursive*

No matter what word you think is the longest word, I can always make up a longer one!

word ::= **anti-***word*

If you have a word, you can always make up a new word by adding **anti** in front. Since the result is a word, you can make a longer new word by adding **anti-** in front again.

Recursive Definitions

- We can define things in terms of *(smaller versions of)* themselves
- **Recursive definitions** are different from circular definitions: they eventually end with something real

word ::= **anti-*word***

word ::= **floccipoccinihilipilification**

Recursive Definitions

Allow us to express infinitely many things starting with a few.

This is powerful!
We will see **lots** of examples in this course.

Liberal Arts Trivia: Astronomy

- Q. What is the name given to highly magnetized rotating neutron stars that emit a beam of electromagnetic radiation? The radiation can only be observed when the beam of emission is pointing towards the Earth, yielding a "lighthouse effect".

Liberal Arts Trivia: Literature

- Q. This French author's works touched on topics such as solidarity, the absurd, and totalitarianism. His works include L'Étranger, L'Homme révolté, and Caligula. In 1957 he became the second-youngest recipient of the Nobel Prize for Literature and the first African-born writer to win it.

Megabytes vs. Megatons

- A brief diversion back to Moore's Law
- Computing: 30,000,000 times increase in power since 1969
- Nuclear weapons?

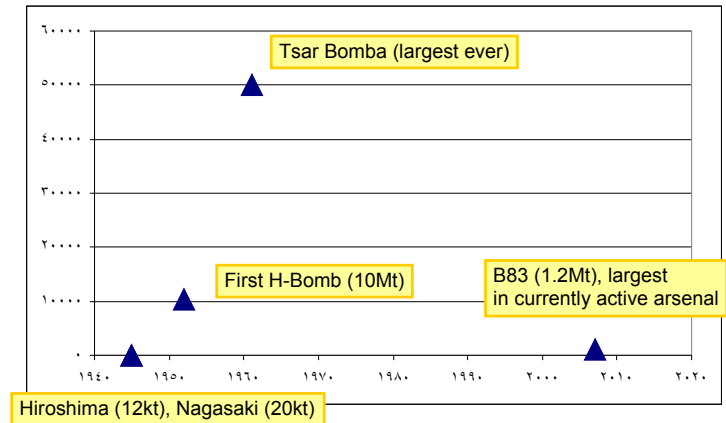Tsar Bomba 50 Megaton explosion, island in Arctic Sea, 1961

If Nuclear Weapons followed Moore's Law...

- 30M * 50 Megatons = 1.5 Teratons
- 1 Megaton TNT $= 4.184 * 10^{15}$ Joules
- 1.5 Teratons TNT $= 6.3 * 10^{21}$ Joules
- Energy from Sun to Earth
  $$= 4 \times 10^{18} \text{ Joules/ Year}$$
- One bomb today would equal all the energy to reach the Earth from the Sun since 400 AD

Actual Nuclear Weapons

- Tsar Bomba (largest ever)
- First H-Bomb (10Mt)
- B83 (1.2Mt), largest in currently active arsenal
- Hiroshima (12kt), Nagasaki (20kt)

If it takes 60 seconds to compute a photomosaic for Problem Set 1 today on a typical PC, estimate how long it will take CS1120 students in 2013 to compute the same photomosaic? How long will it take in 2016?

```
> (/ (* (- 2013 2010) 12) 18)
2
> (/ 60 (* 2 2))
15
> (/ (* (- 2016 2010) 12) 18)
4
> (/ 60 (* 2 2 2 2))
15/4
> (exact->inexact (/ 60 (* 2 2 2 2)))
3.75
```

Difference in years * 12 = number of months
Number of months / 18 = number of doublings according to Moore's Law

60 seconds today, 2 doublings by 2013
15 seconds in 2013

60 seconds today, 4 doublings by 2016
3.75 seconds in 2016

Reality check: Moore's "law" is just an "observation". We'll see one reason later today why it won't continue forever.

MU!

Formal Systems and Languages

Are there any non-recursive natural languages? What would happen to a society that spoke one?

Not for humans at least.
They would run out of original things to say.

Chimps and Dolphins are able to learn non-recursive "languages" (some linguists argue they are not really "languages"), but **only humans can learn recursive languages** (as far as we know).

Running out of Ideas

"It has all been said before."

Eventually true for a non-recursive language.

Never true for a non-trivial recursive language.
There is always something original left to say!

Production Systems

- A **Post Production System** is one way of defining a language.

- Set of symbols
  - *Primitives*

- Set of rules for manipulating symbols
  - Hofstadter: Rules of Production, Rules of Inference
  - Also: Rules of Combination

The MIU System

- Symbols: M, I, U
- Rules of Production:
  - **Rule I:** If you have a string ending in I, you can add a U at the end.
  - **Rule II:** Suppose you have Mx. Then you may add Mxx to your collection.
  - **Rule III:** If III occurs in one of the strings in your collection you may make a new string with U in place of III.
  - **Rule IV:** If UU occurs inside one of your strings, you can drop it.

MIU System Example

Start with MUI, produce MIU

Rules of Production:
    Rule I: If you have a string ending in I, you can add a U at the end.
    Rule II: Suppose you have Mx. Then you may add Mxx to your collection.
    Rule III: If III occurs in one of the strings in your collection you may make a new string with U in place of III.
    Rule IV: If UU occurs inside one of your strings, you can drop it.

Any Questions?

- Before next class:
  - Read Chapters 1-3
  - Complete Course Registration Survey
  - Read Lab Guide, start PS1
- PS1 due Monday Feb 01