COMP 102: Computers and Computing
Lecture 1: Introduction

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Class web page: www.cim.mcgill.ca/~siddiqi/102.html

Outline for today

- What are computers? What is computing?
- What will this course contain?
- Interesting success stories from the field of computer science.
- A brief history of computers and computing.

About Me

- How did I get here?
  - Cathedral and John Connon School, Bombay
  - B. Sc. in Electrical Engineering (Lafayette College)
  - Masters/Ph.D. in Electrical Engineering (Brown University)
  - Prof. at McGill 1998-…
- What else do I teach?
  - Intro to Computer Systems (COMP-273)
  - Fund of Computer Vision (COMP-558)
  - Shape Analysis (COMP-766)
- What kind of research am I interested in?
  - Computer Vision, Medical Imaging, Artificial Intelligence, Brain Imaging

The Shape Analysis Group

http://www.cim.mcgill.ca/~siddiqi

Am I taking the right course?

- I want to learn how to program.
- I want to know how to use Word and Excel.
- I want to build intelligent robots.
- I want to design cool Web pages.
- I want to understand how the human brain works.

Goals for the course

- Discuss interesting facts and ideas related to *computers and computing.*
  - How computers represent data.
  - How we can give instructions to computers.
  - What problems computers can (or not) solve.
- Improve your computer-literacy quotient.
- Explore current applications of computer science and computing.

Course Syllabus

Part 1: What do we know about computation?

- Storing information (bits, bytes, memory)
- Manipulating data (searching, sorting and more)
- Hiding data (how and why)
- Computer Systems
- Examining what problems can be solved and how fast.

Part 2: What can we do with computation?

- Designing simulations
- Robotics, artificial intelligence
- Computer vision and imaging
- Other applications

Evaluation method

- Four assignments (40%)
  - Individual work.
  - Some theory, some application.
  - No formal programming required.
  - Late policy: assignments are due in class on due date, -20% for each day late.
- In-class midterm examination 1 (30%)
- In-class midterm examination 2 (30%)

Other details about the course

- Textbook:

  None required.

- Office hours:
  - Kaleem Siddiqi: McConnell 420. *See web page for day/time.*
  - TA: See web page.

- Course material and announcements available on class website:

  www.cim.mcgill.ca/~siddiqi/102

The ancestors of the computer

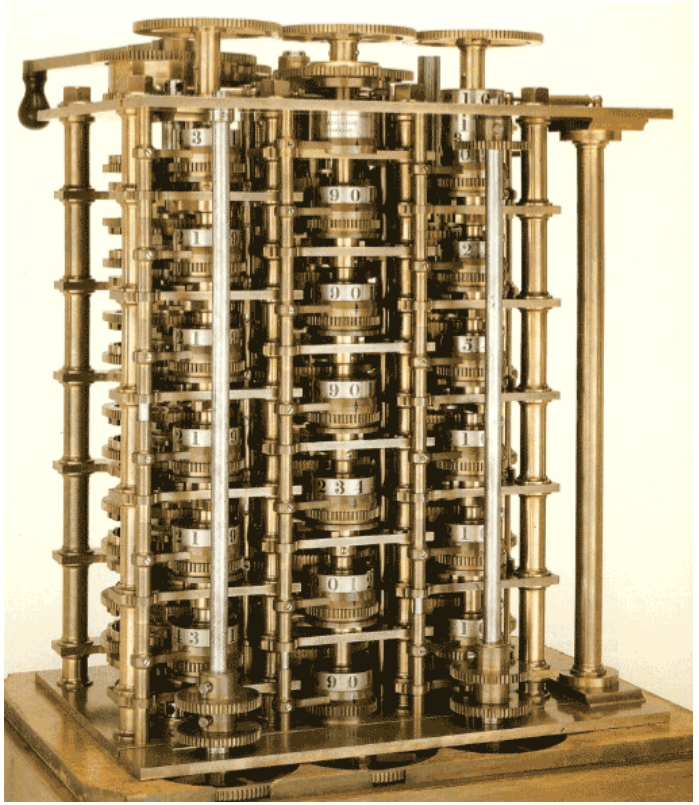
- Counting machines (abacus, etc.)
- Analog computers to perform astronomical calculations.
- Intricate mechanical automatons.
- Why aren't these computers? What's missing?

Charles Babbage (1791-1871)

- Lived in England.
- He was a polymath (solved problems from Astronomy to Zoology, in particular mathematics, philosophy, engineering).
- Held Newton's chair at Cambridge.
- Invented:
  - The cowcatcher,
  - Flat-rate postage,
  - Operations research
- His design for the analytical engine presaged much of the design of modern digital computers.

The Difference Engine

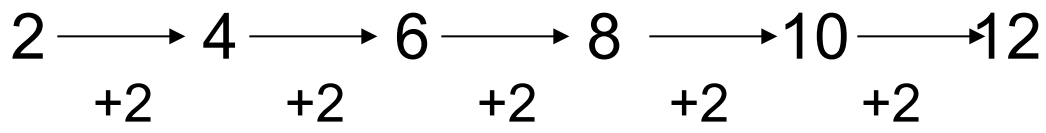
- Originally a **computer** was a job description of a person who created numerical tables, e.g. $log_2(x)$
- Babbage had a scheme to **automate table creation** using **finite differences**.
  - The Difference Engine No.1 required 25,000 parts, 15 tons, 8 feet high, and was never built.
  - His redesigned Difference Engine No.2 was built in 1990 and actually worked!



Difference Engine: Main idea

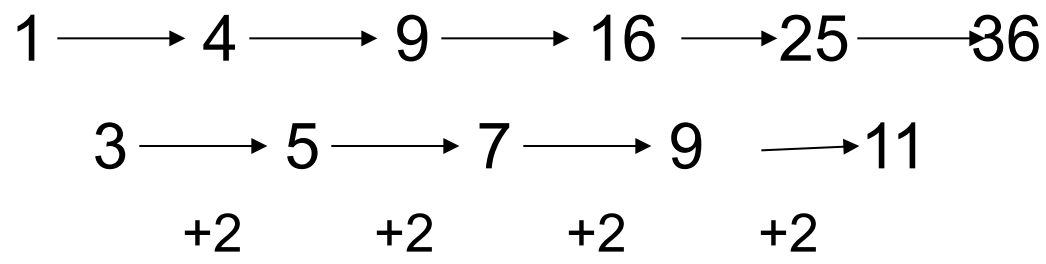
- Let's play a game:
- 0, 1, 2, 3, 4, …?
- 3, 5, 7, 9, 11, …?
- 1, 4, 9, 16, 25, …?
- 1, 3, 6, 10, 15, ….?

Generating Even Numbers



- Instructions:
  1. Start with **2**.
  2. To get the next number, add **2** to the previous one.

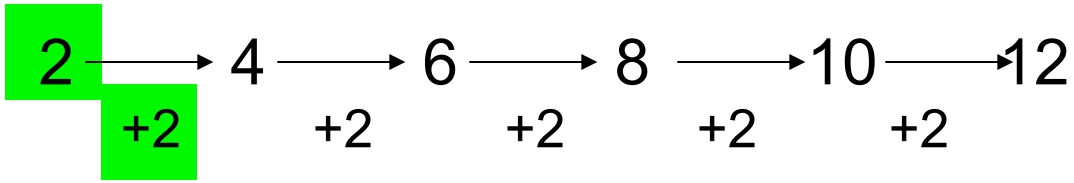
Generating Squares



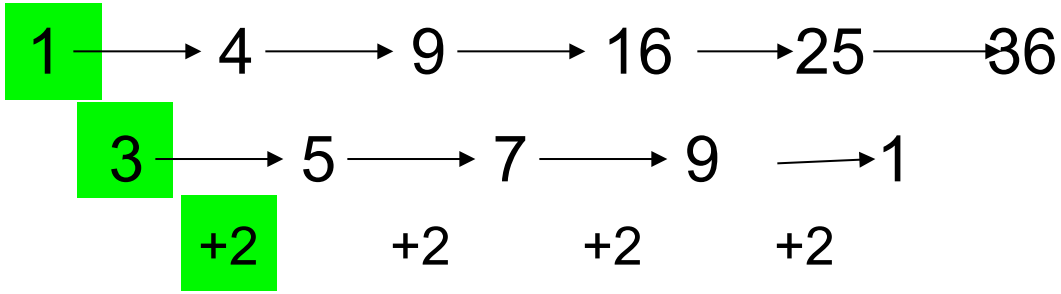
- Instructions:
  1. Start with **1**.
  2. Start the increment with 3.
  3. To get the next square, add the increment.
  4. To get the next increment, add 2 to the previous increment.

Naming the sequences

- The Evens: “2 2”



- The Squares: “1 3 2”



Programming the Different Engine

- To produce the Evens, we enter “2 2” into the Difference Engine and turn the crank.
- For the Squares, enter “1 3 2”
- For the Triangle numbers, enter “1 2 1”

Why is this “programming”?

- There’s a way to say what you want to say, in a way the machine understands.

- Simple operations (in this case, repeated addition) used to build up more complex objects.

- If I had to characterize Computer Science in 1-word: REDUCTION.

Limitations of the Difference Engine

- It was never built! (Or at least, not until 1990).

- It was engineered for a very specific task.
  - It can only compute polynomial functions.
  - Some other functions (e.g. log, trig functions) can be approximated by polynomials.
  - To perform very different calculations, we would need to re-build the machine.

The Analytical Engine

- Much more general, with many of the characteristics of the modern-day computers.
  - Input: program and data can be entered through punched cards.
  - Output: through printer, curve plotter and bell.
  - Internal memory.
  - Arithmetical unit, capable of basic mathematical operations.

- Never built, more of a thought experiment by Babbage.

The first programmer: Ada Lovelace (1815-1852)

- Ada August, Countess of Lovelace
  - Daughter of the writer Lord Byron.

- Designed many sequences of Babbage's machine's basic operations.

- Used a number of modern software design elements, e.g. the loop.

  What's a loop? Repeat an operation until a specified condition is met.

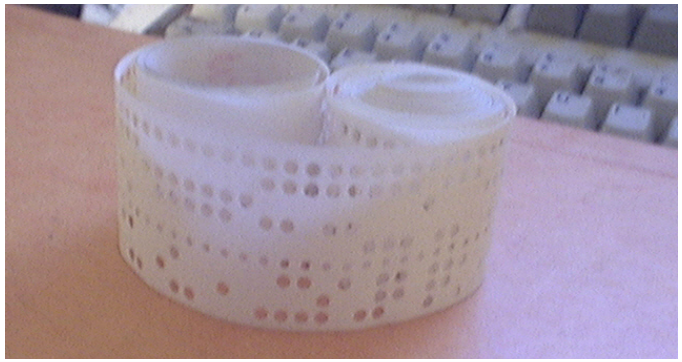
1940: First demo of remote computing

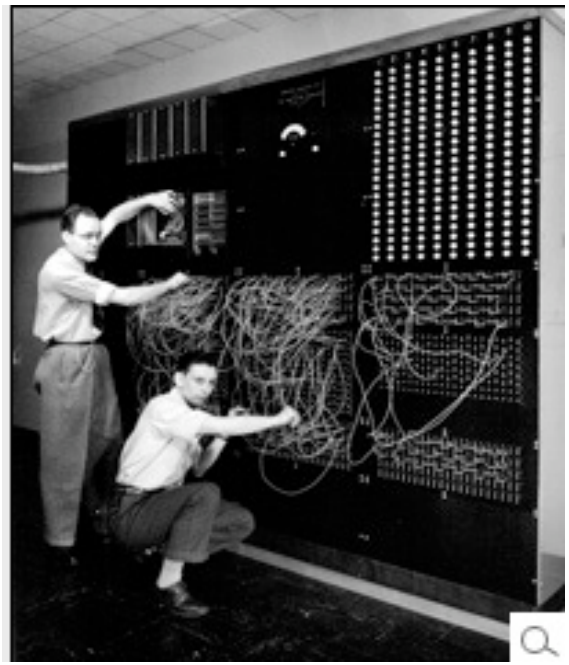
- The Complex Number Calculator.
- Designed by Bell Telephone Labs.
- On its own, just a fancy calculator.
- Noteworthy because calculations were performed remotely (NYC - Darthmouth) using a Teletype connected via phone lines.

The Complex Number Calculator (CNC) close

1944: Room-sized computers

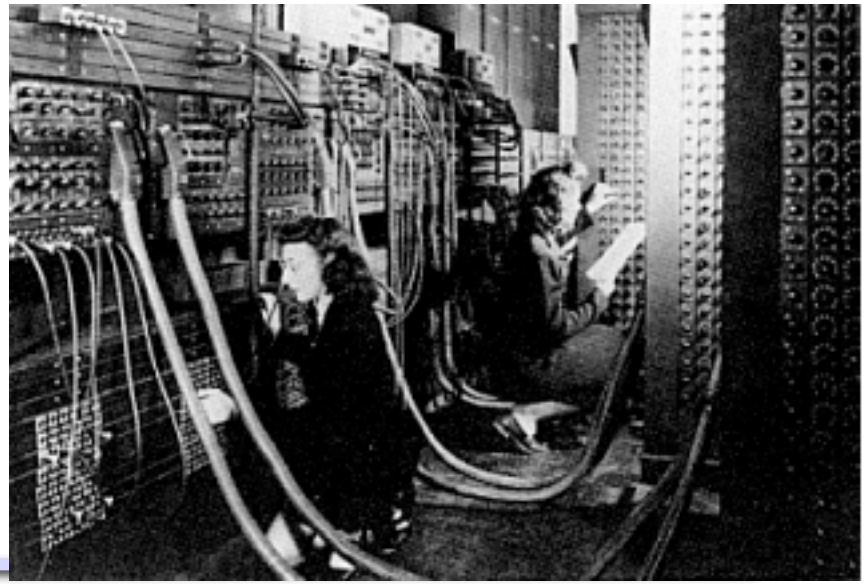
- Harvard Mark-1.
- 765,000 component parts:
  - switches, relays, rotating shafts, clutches
  - hundreds of miles of wire
- Used to produce mathematical tables.
- Programmable by punched-paper tape.





1948: ENIAC

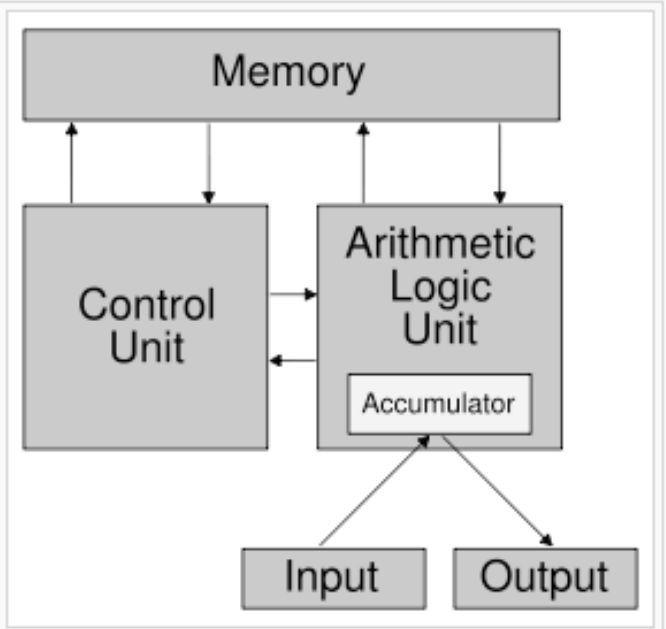
- The Electronic Numerical Integrator And Computer (ENIAC)
- First purely electronic digital computer.
- Built at the University of Pennsylvania to calculate artillery firing tables for the US Army.
- 80 feet wide, 27 tons, 120,000 pieces.
- 300 times faster than the Mark 1 at addition.
- Programmable by rewiring (switches and cables).
- No memory.



1945: von Neumann's stored-program computer

- Early computers had fixed programs.
- Key idea is to hold the program in memory as a series of instructions.
- The control unit (i.e. "computer") treats these instructions in the same way as other data.
- Allows the program to change (even as it is running.)

John von Neumann in the 1940s

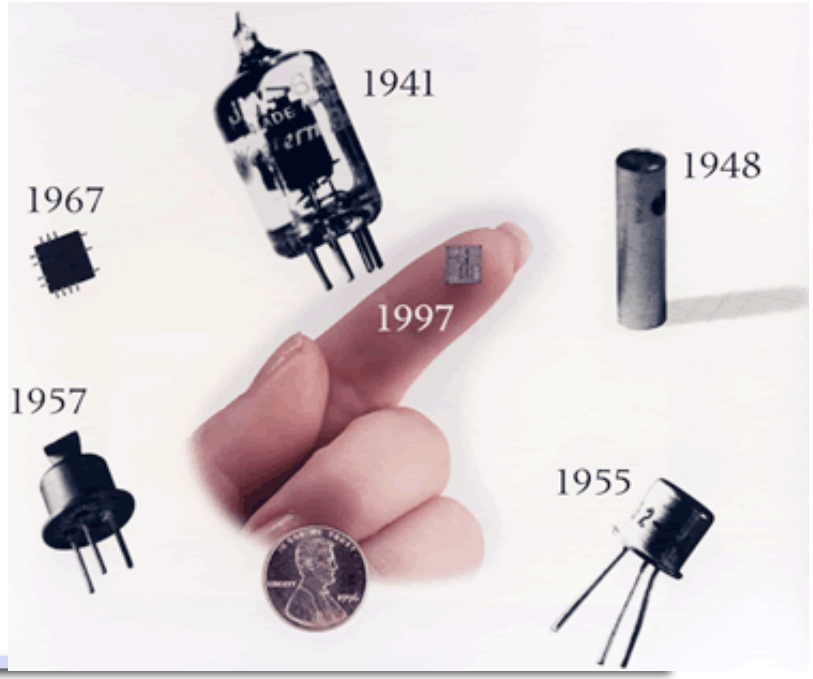


Design of the von Neumann architecture

The Transistor Revolution

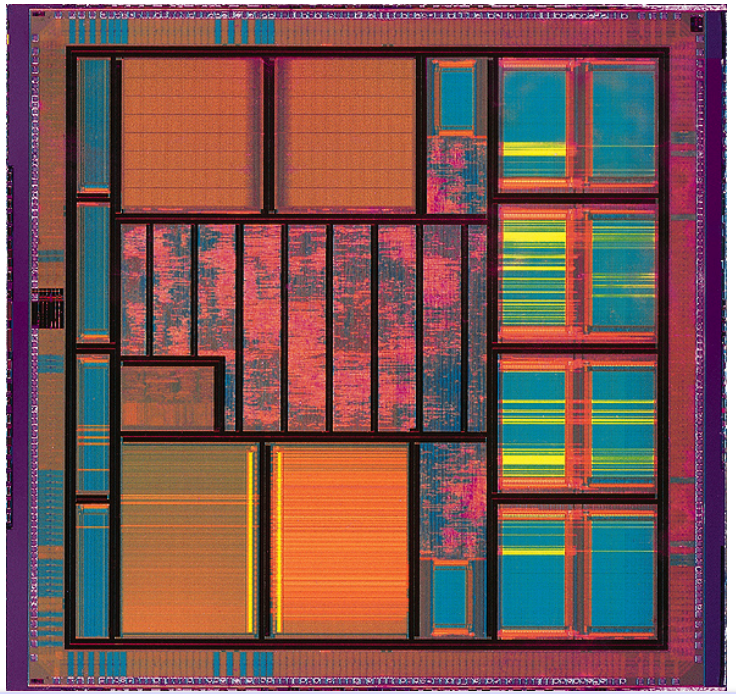
- Early days: computers worked with vacuum tubes.
  - Think of this as an “on/off” switch.
  - Switch is caused by electrons.
  - So we call this “electronics”.
  - Vacuum tubes were about size of a modern light bulb.
  - ENIAC had 17,000 vacuum tubes.

- 1947: engineers at Bell Laboratories invent the transistor.
  - Also an electronic on/off switch.
  - Much smaller, less hot, less expensive.
- 21st century:
  - Intel’s Core 2 Duo processor (2006): 253 million transistors.



Integrated Circuits

- Integration of large numbers of tiny transistors into a small chip
- Mass production capability, reliability, and building-block approach to circuit design ensured the rapid adoption of standardized ICs



Personal Computing

- By late 1970's, price of computer processors was much more affordable. Companies were starting to produce "microcomputers".
  - But not clear whether there was a market for personal computers.
  - Computers were still seen as "number-crunchers".

- In early 80's, hobbyists starting buying machines like Apple II and IBM PC.

- Two key developments:
  - Graphical User Interfaces ("GUI")
  - Application software

What came next?

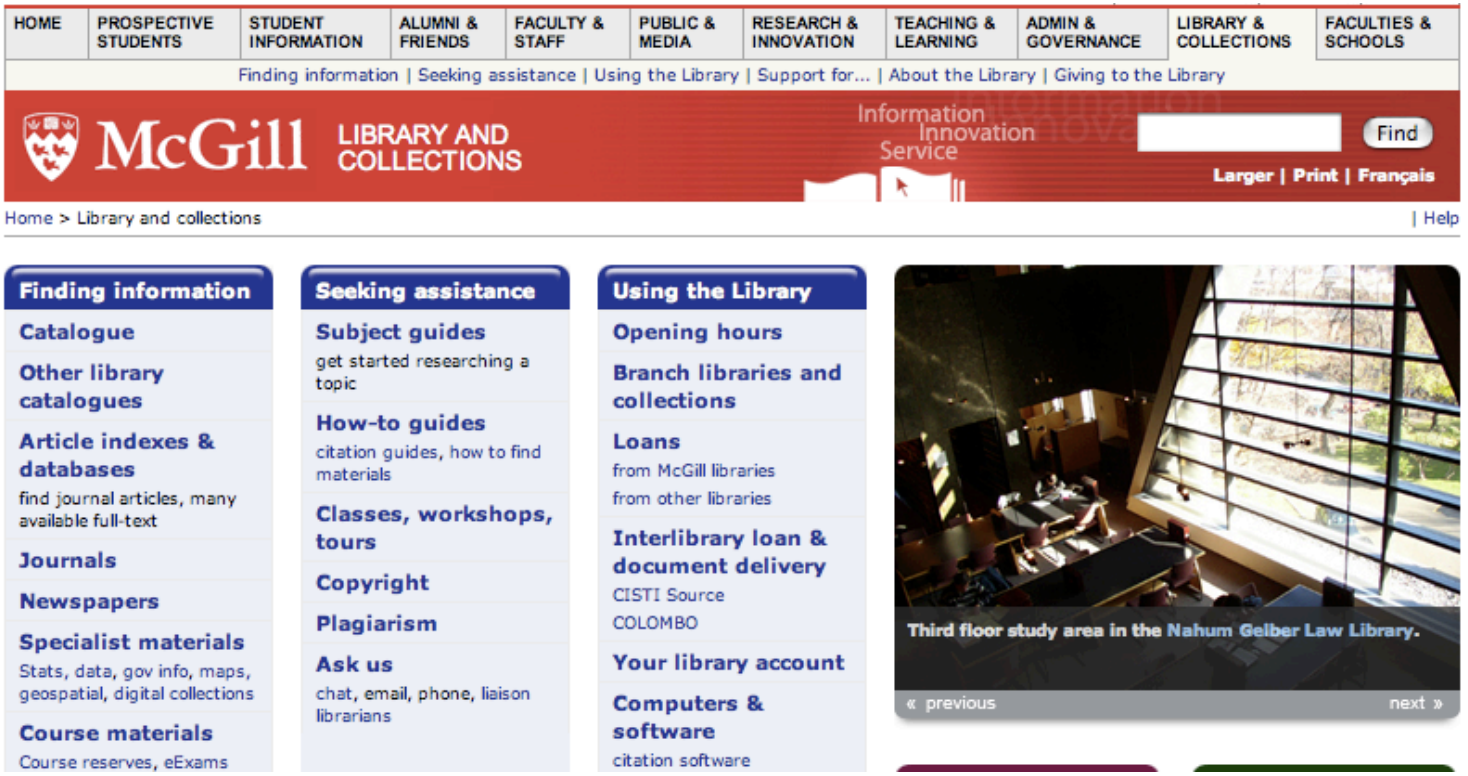
- 1977: “There is no reason for any individual to have a computer in his home.” Ken Olsen, CEO of Digital Equipment Corporation

- 2012: How many computers have you used today?

Computers and your education

Google

WIKIPEDIA



Computers and your health

http://www.cim.mcgill.ca/~shape/projects.html

Computers and your social life

Computers and the entertainment industry

Godzilla, 1954

Godzilla, 1998

Let's start with a few basic concepts

- What is **computing**?
  - Take an input

    e.g. text, numbers, image, sound
  - Calculate for a while

    e.g. add/subtract, filter/amplify, summarize
  - Produce an output

    e.g. new text, new numbers, error message
  - Store the results

- The **computer** is the machine which allows us to do all of this.

We begin the course by trying to understand these different components.

Something to think about

- Define computer science's contribution to the world in one-word:

  REDUCTION

  - Computer scientists solve problems by reducing them to simpler problems.
  - Use simple operations to build up more complex objects.

"We are trying to build a machine to do all kinds of different things simply by programming rather than by the addition of extra apparatus," Turing, 1947.

We will see this concept arise in a number of instances throughout the semester.

Quick quiz

- What is the “Nobel prize” of Computer Science?

Take-home message

- Understand how the difference engine works.

- Understand the link between what we can compute

  >> polynomials vs full weather prediction

  and how we compute it

  >> difference engine vs modern computer with millions of transistors

Final comments

- For the rest of the semester, we explore the current state of computing.
  - Some emphasis on hardware&engineering, more emphasis on the science behind computer science.
- Coming up next:
  - What is data, and how is it represented?
- Material and images from these slides was taken from:
  - *http://www.cs.rutgers.edu/~mlittman/courses/cs442-06/*
  - *http://www.computerhistory.org*
  - *http://www.columbia.edu*
  - *http://www.calvin.edu/academic/rit/webBook*
  - *http://en.wikipedia.org*
  - *http://www.cs.mcgill.ca/~jpineau/comp102/*