CS is Problem Solving

- *Mathematics:*
  - *Formal languages, proofs.*
- *Engineering:*
  - *Designing & building hardware and software.*
- *Science*
  - *Observing, hypothesizing, testing.*

Debugging is Problem Solving

- Syntax Errors (program won't even run)
  - 8 * \ !! 6
- Semantic Errors (runs to completion)
  - I said '5 + 6' but meant '5 * 6'
- Runtime Errors (runs but crashes)
  - K = -1
  - Give me the kth letter in "hello"

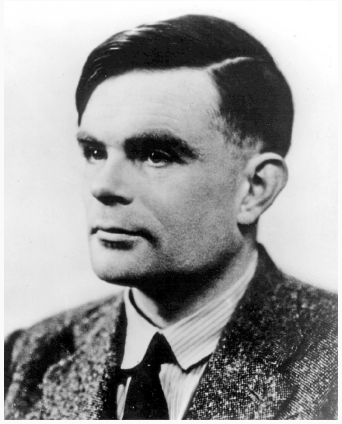
Some points from the text...

Computer Program Elements

- Input – get data from somewhere.
- Ouput – put data somewhere.
- Math – perform basic operations.
- Branching – if <condition> do <input, output, math>
- Repetition – repeatedly do <input, output, math>

Some snapshots of computer scientists and computer science...

Alan Turing (1912–1954)



http://www.turing.org.uk/

Programming is ...

- Creative
  - Designing and building cool stuff.
- Intellectually Challenging
  - Finding bugs can be really hard.
- Experimental
  - Writing code and predicting results.
- Problem solving
  - A most satisfying human activity.

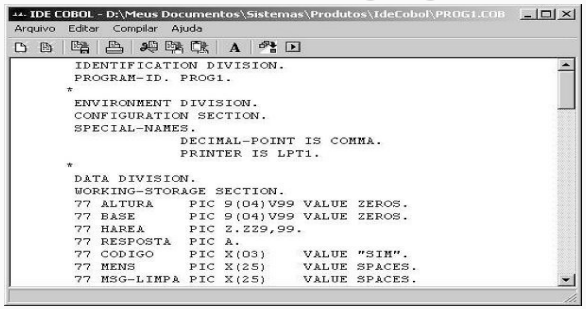
Pioneers in computer science

Alan Turing
(1912-1954)

Pioneers in computer science

Grace Murray Hopper

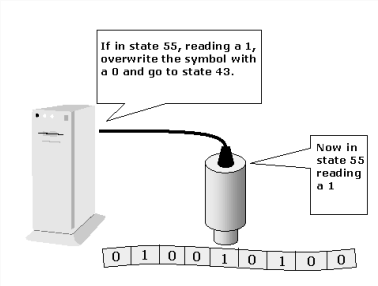
COBOL – Common Business Oriented Language



- Programming Language Theory: The study of computing languages.
- Language paradigms: Procedural, functional, object-oriented, logic programming.

Turing's Decidability Result

- *There is no algorithmic procedure to decide whether any given statement is true.*
- Theory of computation: What can be computed?
- Analysis of algorithms: What problems are tractable?



http://www.lambdaassociates.org/

Turing Machine

Grace Murray Hopper (1906–1992)

The Turing Test

- Turing, 1950, *Mind*: Within 50 years a computer would be able to pass the test.

Hardware layers of a computer

A computer may look very complex, but its hardware is comprised of layers of simple components.

- bits
- switches
- gates
- circuits
- the processor and memory

Allen Newell (1927 – 1992) and Herbert Simon (1916 - 2001)

- Artificial intelligence – designing solutions to intractable problems.
- AI Problems – vision, natural language understanding, speech recognition, learning, chess playing, jeopardy...

Basics Elements of a Computer

Binary notation

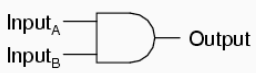
For example, numbers are represented in 0's and 1's in the following way.

0	⇔	0
1	⇔	1
2	⇔	10
3	⇔	11
4	⇔	100
5	⇔	101
	...	

Gates

A gate is a tiny device made out of switches designed to perform a very simple task.

2-input AND gate



A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

http://www.eng.cam.ac.uk/

Bits

A bit is the smallest unit of information used in computers. A bit is either 0 or 1.

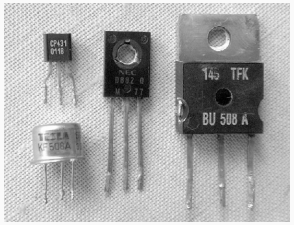
Information of any format (numbers, texts, images, sounds, etc.) is represented in a collection of bits; that is, a sequence of 0's and 1's.

Swiches

A switch is a device that changes the status of a bit from 0 to 1 and vice versa.

In the early days (1940s and 1950s), *vacuum tubes* and *transistors* were used as switches.

http://www.tablix.org/



http://www.wikipedia.org/

The processor and memory

The processor and memory are the most critical components of a computer. Both are made out of circuits.

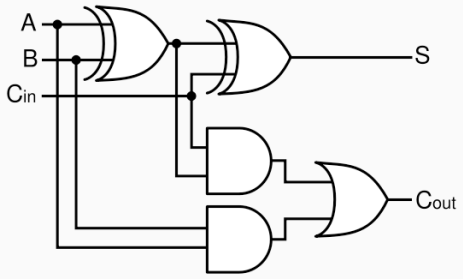
- A *processor* executes computer programs (which are basically algorithms written in a computer language).
- *Memory* stores a large amount of information (in bits). Programs as well as data are stored in memory.

John von Neumann
Margittai Neumann János Lajos

http://www.wikipedia.org/

Circuits

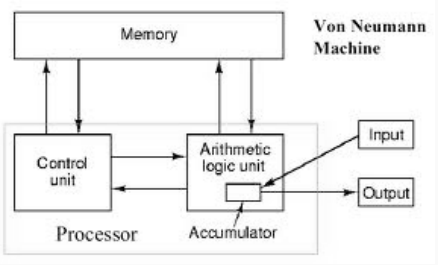
A *circuit* is a tiny device made out of gates designed to perform a simple task.



http://www.wikipedia.org/

von Neumann model

All computers share the following basic design called the *von Neumann* model (named after the Hungarian/American mathematician John von Neumann (1903–1957)).



Instruction cycle

Under this model, the processor executes a program by repeating the following cycle.

1. fetch — reads an instruction from the memory
2. decode — decodes the instruction to figure out its meaning.
3. execute — performs the task specified in the instruction.
4. store — stores the result of the above execution in the memory.