BBM 101 – Introduction to Programming I

Fall 2014, Lecture 1

Instructors: Aykut Erdem, Erkut Erdem, Fuat Akal

TAs: Burcak Asal, Selman Bozkir, Cumhur Yigit Ozcan, Selim Yilmaz

Today

- **Introduction**
  - About the class
  - Organization of this course

- **What is computation?**
  - What is knowledge?
  - What is a computer?
  - What is a program?
  - History of computing

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About the course

- Like most freshmen classes in Computer Science (CS) or Computer Engineering (CEng), this class will focus on solving problems and implementing their solutions as computer programs.
  - How to program
- However, you should know that CS and computer programming are not the same thing!
- So what is Computer Science?

What is Computer Science (CS)?

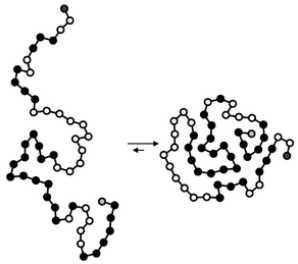
"Computer science is not really about computers – and it's not about computers in the same sense that physics is not really about particle accelerators, and biology is not about microscopes and Petri dishes ... and geometry isn't really about using surveying instruments.

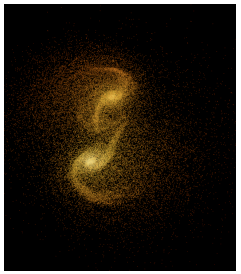
Now the reason that we think computer science is about computers is pretty much the same reason that the Egyptians thought geometry was about surveying instruments: when some field is just getting started and you don't really understand it very well, it's very easy to confuse the essence of what you're doing with the tools that you use."

– Hal Abelson (1986) Introduction of video of lectures on the Structure and Interpretation of Computer Programs (MIT).

Why study CS?

- **Its impact is broad and far-reaching.**
  - Internet. Web search, packet routing, distributed file sharing, ...
  - Biology. Human genome project, protein folding, ...
  - Computers. Circuit layout, file system, compilers, ...
  - Computer graphics. Movies, video games, virtual reality, ...
  - Security. Cell phones, e-commerce, voting machines, ...
  - Multimedia. MP3, JPG, DivX, HDTV, face recognition, ...
  - Social networks. Recommendations, news feeds, advertisements, ...
  - Physics. N-body simulation, particle collision simulation, ...
  - ⋮



Why study CS?

- They may unlock the secrets of life and of the universe.
- Computational models are replacing mathematical models in scientific inquiry.

$$E = mc^2$$

$$F = ma$$

$$F = \frac{Gm_1m_2}{r^2}$$

$$\left[-\frac{\hbar^2}{2m}\nabla^2 + V(r)\right]\Psi(r) = E\,\Psi(r)$$

20th century science
(formula based)

```
for (double t = 0.0; true; t = t + dt)
   for (int i = 0; i < N; i++)
   {
      bodies[i].resetForce();
      for (int j = 0; j < N; j++)
        if (i != j)
           bodies[i].addForce(bodies[j]);
   }
```

21st century science
(algorithm based)

> “ Algorithms: a common language for nature, human, and computer. ”
>
> — Avi Wigderson

Why study CS?

- For fun and profit.

Apple Computer

facebook

Cisco Systems

Google

Nintendo

Jane Street

IBM

Morgan Stanley

NETFLIX

Adobe

RSA Security

D E Shaw & Co

ORACLE

Pandora

Akamai

YAHOO!

amazon.com

Microsoft

Pixar Animation Studios

Adopted from: Sedgewick and Wayne

About this course

- This course serves as an introduction to the fundamentals of computer science and programming.
- The class will use the C programming language as a medium to provide a basic understanding of basic concepts in computer science.

- **Requirements**
  - Little or no programming experience!
  - Solid high school algebra and a reasonable aptitude for mathematics

- **BBM 103 Introduction to Programming Practicum**
  - The students will gain hand-on experience via a set of programming assignments.

About this course (cont'd.)

- **Goals of the course:**
  - What is computation?
  - The role of computation

- **Skills to develop:**
  - Computational thinking
  - Understand codes
  - Understand abilities and limits
  - Maps problems into computation

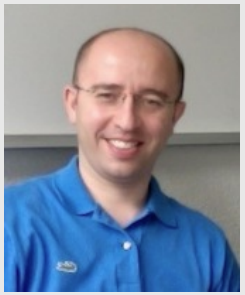
- **What is computation?**
  - What does it mean to think like a computer scientist?
  - Computational problem solving

BBM 101-103 Team

Instructors

Aykut ERDEM
(Section 1)

Erkut ERDEM
(Section 2)



Fuat AKAL
(Section 3)

TAs

Burcak ASAL

Selim YILMAZ

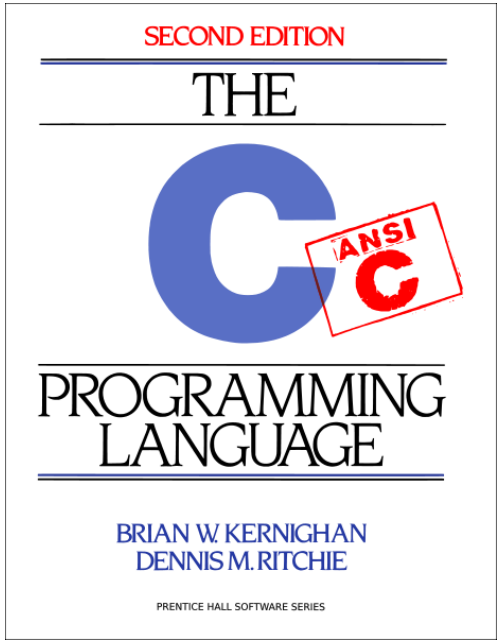
Selman BOZKIR

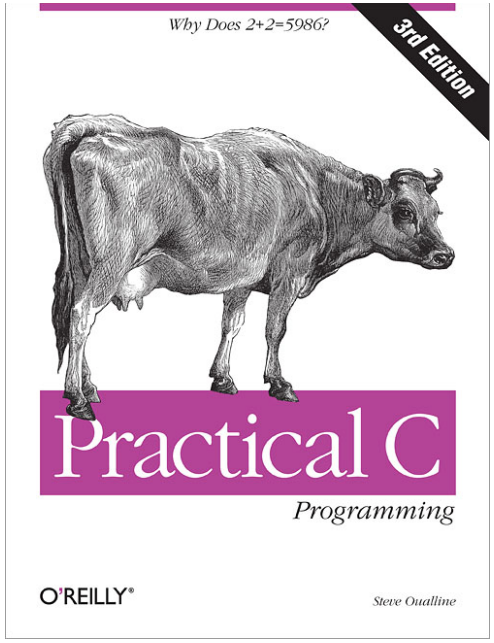
Cumhur Yigit OZCAN

- **Office hours:** to be determined

Reference Book

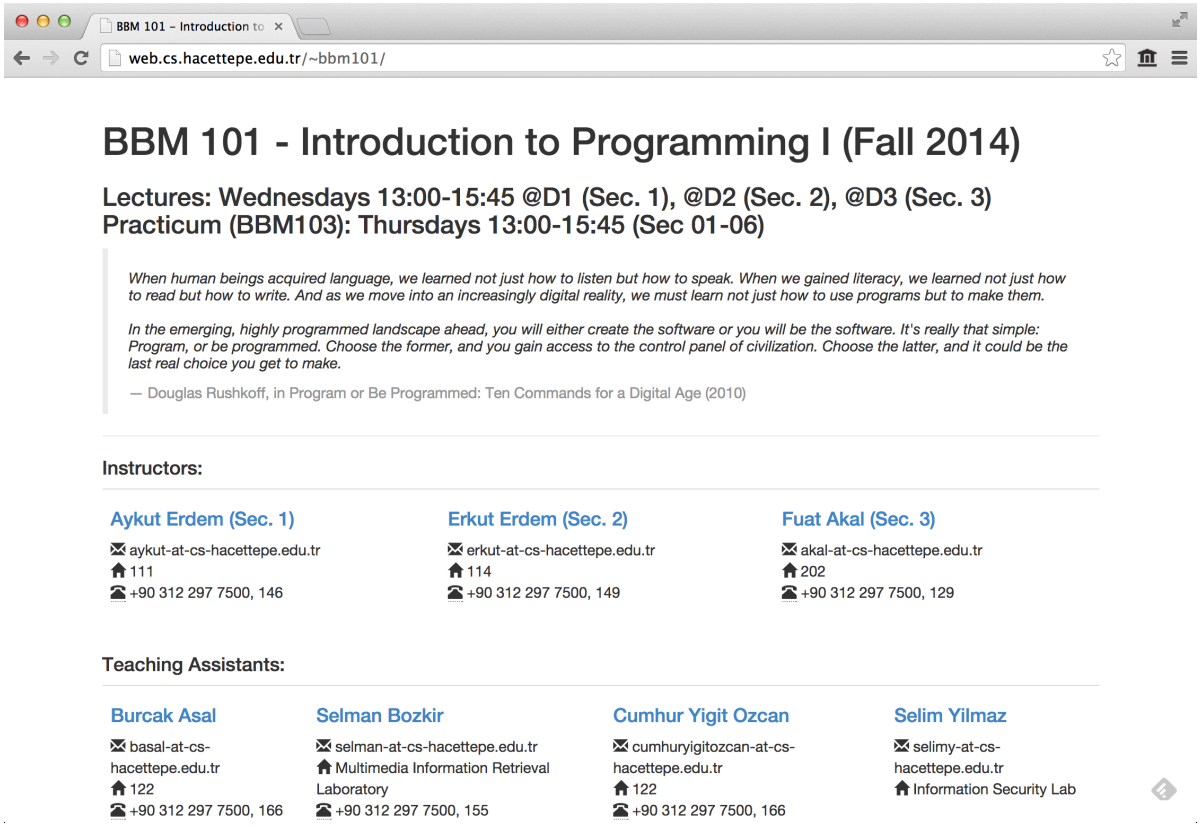
- The C Programming Language, 2nd Edition, Brian Kernighan and Dennis Ritchie, Prentice Hall, 1988
- Practical C Programming 3rd Edition, Steve Oualline, O'Reilly Media, 1997





Communication

- The course webpage will be updated regularly throughout the semester with lecture notes, programming assignments and important deadlines.
- http://web.cs.hacettepe.edu.tr/~bbm101



Getting Help

- **Office hours**
  - See webpage for the schedule

- **BBM 103 Introduction to Programming Practicum**
  - Course related recitations, practice with example codes, etc.

- **Communication**
  - Announcements and course related discussions through piazza

    BBM 101/103: https://piazza.com/hacettepe.edu.tr/fall2014/bbm101

Course work and grading

- **3 midterm exams (10 + 30 + 15 = 55%)**
  - Closed book and notes
  - In class on October 15th, November 12nd, December 3rd, respectively.

- **Final exam (40%)**
  - Closed book and notes
  - To be scheduled by Registrar

- **Class participation (5%)**
  - Contribute to Piazza discussions
  - Attend and participate in lectures

Course Overview

- **Part I**
  - Introduction *(0.5 week)*
  - What is computation? *(0.5 week)*
  - Binary representations *(0.5 week)*
  - The Von Neumann architecture *(0.5 week)*
- **Part II**
  - Sequential structure *(1 week)*
  - Selective structure *(1 week)*
  - Repetitive structure *(1 week)*
  - Functions *(1.5 weeks)*
  - Pointers and Arrays *(2 weeks)*
  - Structures *(1 week*)
  - Input and Output *(0.5 week)*
  - Strings *(0.5 week)*

Midterm exam #1

Midterm exam #2

Midterm exam #3

BBM 103 Introduction to Programming Practicum

- **Programming assignments (PAs)**
  - Five assignments throughout the semester.
  - Each assignment has a well-defined goal such as solving a specific problem.
  - You must work alone on all assignments stated unless otherwise.

- **Important Dates *(Tentative)***
  - PA 1: October 1st
  - PA 2: October 22nd
  - PA 3: November 5th
  - PA 4: November 19th
  - PA 5: December 3rd

Policies

- **Work groups**
  - You must work alone on all assignments stated unless otherwise
- **Submission**
  - Assignments due at 23:59 on Thursday evening
  - Electronic submissions (no exceptions!)
- **Lateness penalties**
  - Get penalized **10% per day**
  - No late submission later than **3 days after due date**

Cheating

- **What is cheating?**
  - Sharing code: by copying, retyping, looking at, or supplying a file
  - Coaching: helping your friend to write a programming assignment, line by line
  - Copying code from previous course or from elsewhere on WWW
- **What is NOT cheating?**
  - Explaining how to use systems or tools
  - Helping others with high-level design issues
- **Penalty for cheating:**
  - Helping others with high-level design issues
  - Removal from course with failing grade
- **Detection of cheating:**
  - We do check
  - Our tools for doing this are much better than most cheaters think!

Always keep in mind

- This is your **first** CS course.
- In order to get the most out of the course, **try to stay ahead**.
  - By the weekend, make sure you have reviewed the material covered in the lectures of the preceding week.
- If you have any questions or just want to chat about the course, do not hesitate to **go to office hours**.
- **Nothing is easy, but don't give up!**

We aim high!

Photo courtesy of Flickr user richardlamprecht

- Our goal is to make BBM 101 one of the **highly respected** and one of the **most enjoyable** courses in the department!

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What is knowledge?

- **Declarative knowledge**
  - Axioms (definitions)
  - Statements of fact

"y is the square root of x if and only if y*y = x"

does not help to find the square root!

What is knowledge?

- **Declarative knowledge**
  - Axioms (definitions)
  - Statements of fact

"y is the square root of x if and only if y*y = x"

does not help to find the square root!

- **Imperative knowledge**
  - How to do something
  - A sequence of specific instructions (what computation is about)

Babylonian method

Get x as an input

1. Begin with an arbitrary positive number y_0 *(an initial guess)*
2. If $y_n^2 \approx x$, stop *(found the solution - y_n)*
   Else let $y_{n+1} = (y_n + x/y_n)/2$ *(use the arithmetic mean to approximate the geometric mean).*
3. Repeat step (2)

What is knowledge? (cont'd.)

- **Another example** – Estimating greatest common divisor (gcd)

Declarative definition

"d is the gcd of a and b if and only if d is the largest possible integer satisfying a = d*x and b = d*y with x and y being two positive integers"

Imperative definition: Euclid's formula

Get 2 positive integers a,b, a>=b as input

1. Divide a by b, call the remainder R
2. If R=0, stop *(found the solution - b)*
   Else let a=b and b= R
3. Repeat step ii

Use Euclid's formula to compute gcd(48,18).

Then, what is a computer?

- A device that executes a sequence of computations and instructions.
- Modern computers are electronic and digital.
- Does pencil and paper count as a computer?

Slide credit: B. Huang

Programs

- These sequences of instructions and computations is called a **program**.

- We'll be designing programs in this course.

- These programs will be based on **algorithms**.
  - **Algorithm** - a step-by-step problem-solving procedure.

Slide credit: B. Huang

When did the term ‘Computer’ originate?

- The definition from The Oxford Dictionary:

  ***“Computer (noun)**. A person who makes calculations, especially with a calculating machine.”*

Courtesy of the Library of Congress

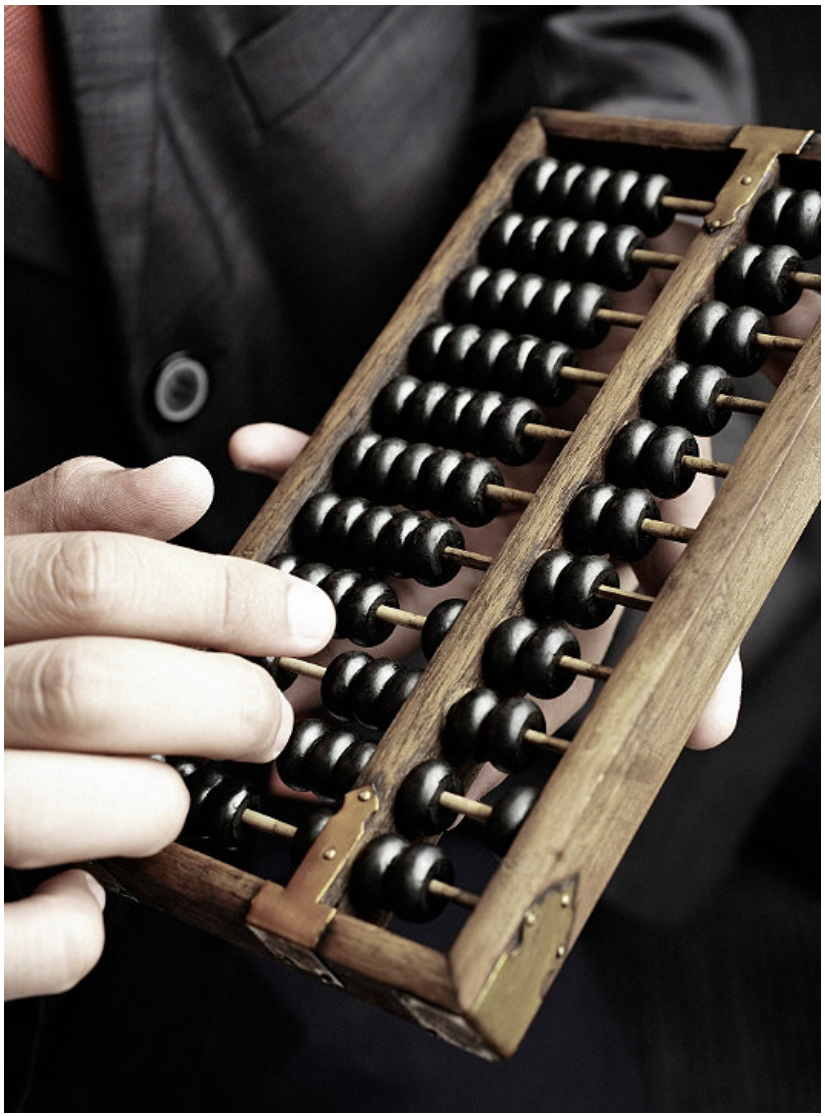
Fixed program computers

- Developed to solve a specific problem (set).

- Very old roots, old perspectives, …
  - Abacus
  - Antikythera mechanism
  - Pascaline
  - Leibniz Wheel
  - Jacquard's Loom
  - Babbage Difference Engine
  - The Hollerith Electric Tabulating System
  - Atanasoff-Berry Computer (ABC)
  - Turing bombe
  - etc.

Abacus (500 BC)

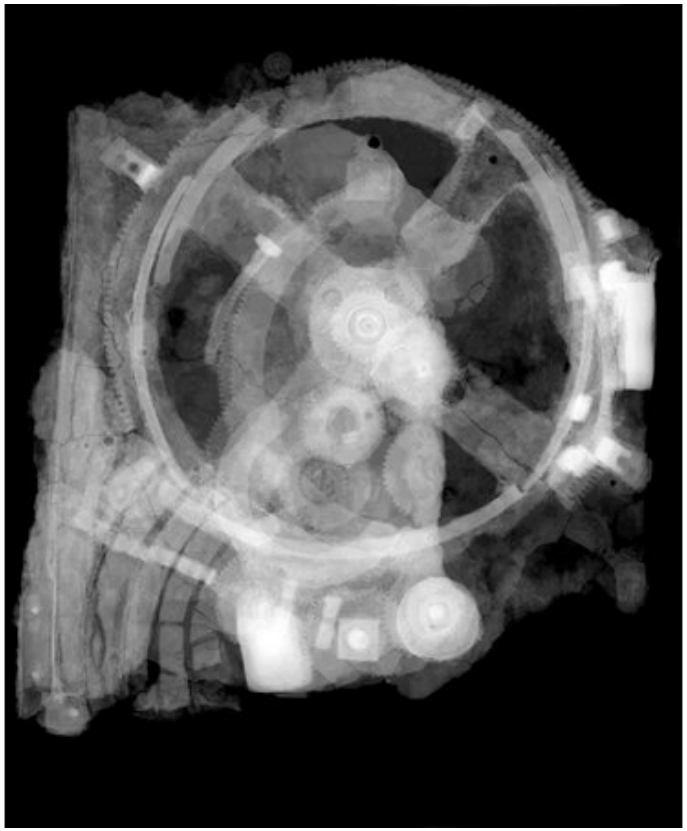
- First pocket calculator
- Still used by businessmen in Asia.



Antikythera mechanism (100 BC)

- First analog computer
- An ancient mechanical computer designed to calculate astronomical positions

© Rien van de Weygaert



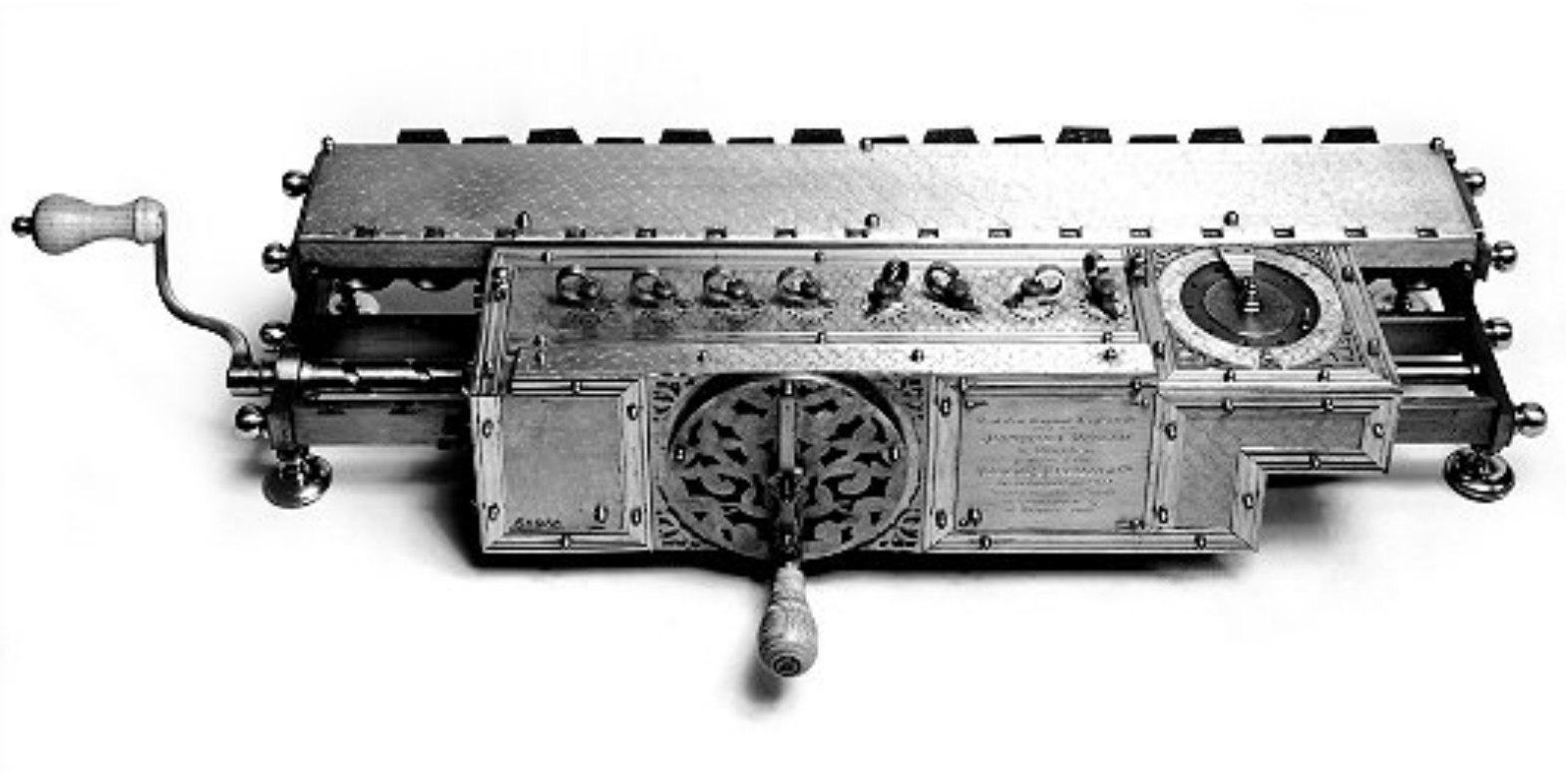
© Antikythera Mechanism Research Project

Pascaline (1642)

- Blaise Pascal, 1642
- A mechanical calculator for performing two arithmetic operations: addition and subtraction

Leibniz Wheel (1694)

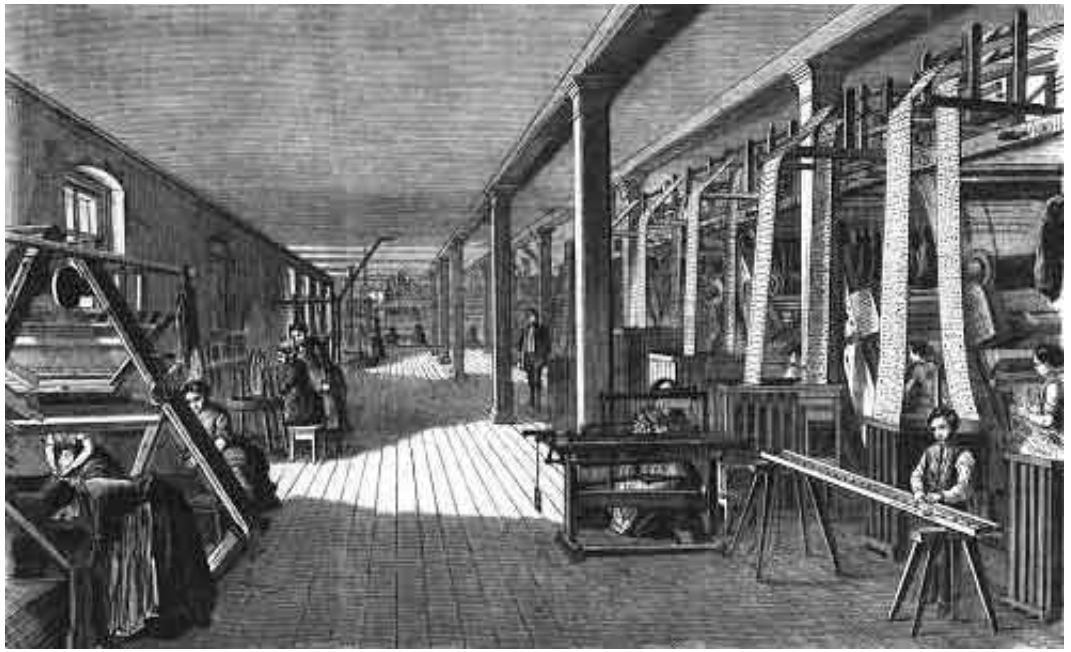
- Gottfried Wilhelm von Leibniz, 1694
- A mechanical calculator for performing all four arithmetic operations: addition, subtraction, multiplication and division



Courtesy of the Deutsches Museum, München

Jacquard's Loom (1801)

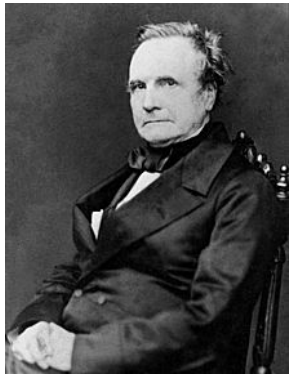
- Developed in 1801 by Joseph-Marie Jacquard.
- The loom was controlled by a loop of punched cards.
- Holes in the punched cards determined how the knitting proceeded, yielding very complex weaves at a much faster rate



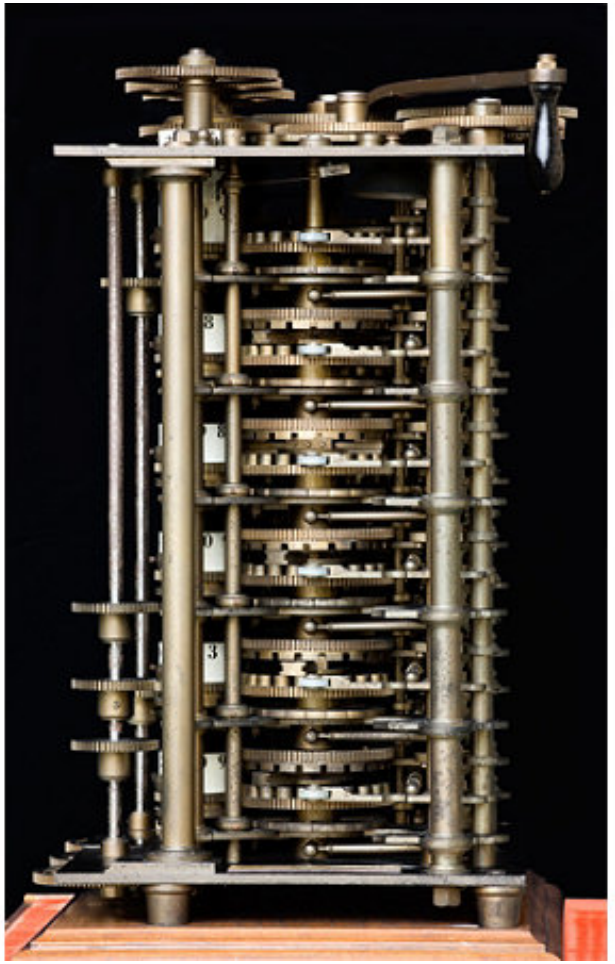
A Jacquard Loom workshop - Germany, 1858.

Adopted from: T. Cortina

Babbage Difference Engine (1832)



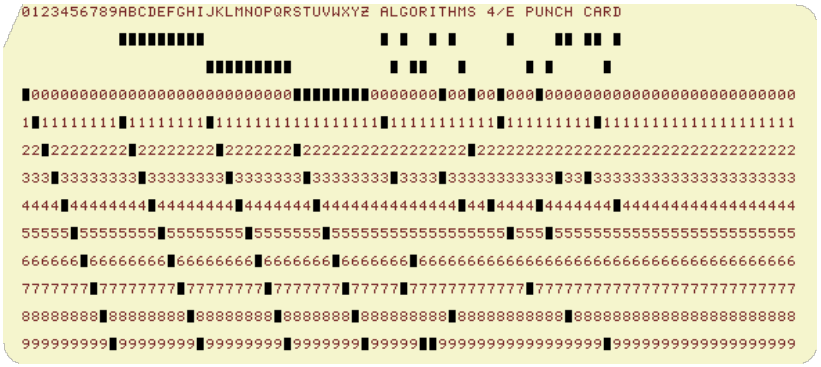
- Charles Babbage, 1832
- A mechanical calculator designed to tabulate polynomial functions (can be used for solving polynomial equations, curve fitting, etc.)
- A working difference engine was built in 1991 to celebrate the 200th anniversary of Babbage's birth (London Science Museum).
- It could hold 8 numbers of 31 decimal digits each and could thus tabulate 7th degree polynomials to that precision.



The Hollerith Electric Tabulating System

- **1880 Census.** Took 1,500 people 7 years to manually process data.
- **Herman Hollerith.** Developed counting and sorting machine to automate.
  - Use punch cards to record data (e.g., gender, age).
  - Machine sorts one column at a time (into one of 12 bins).
  - Typical question: how many women of age 20 to 30?

Hollerith tabulating machine and sorter

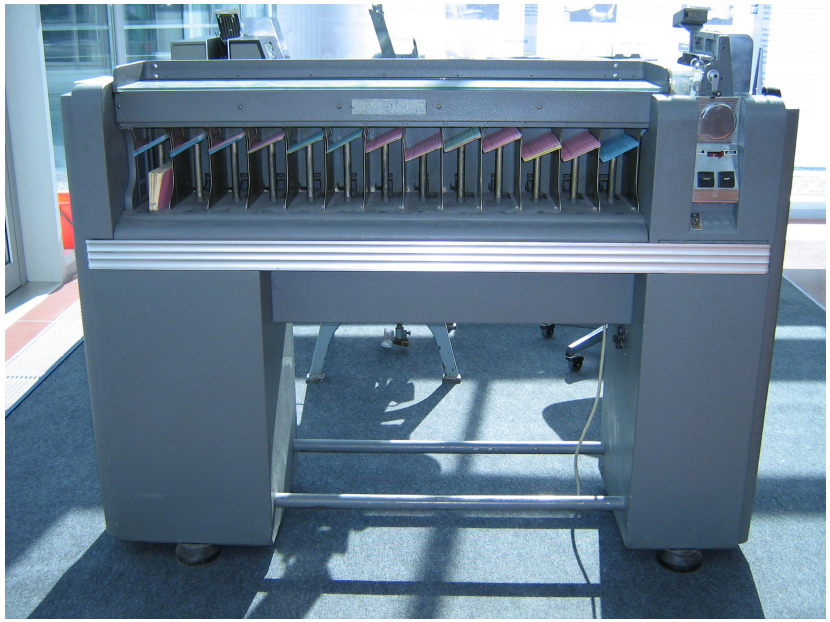


punch card (12 holes per column)

- 1890 Census. Finished months early and under budget!

Modern Punch Cards

- Punch cards. [1900s to 1950s]
  - Also useful for accounting, inventory, and business processes.
  - Primary medium for data entry, storage, and processing.
- Hollerith's company later merged with 3 others to form Computing Tabulating Recording Corporation (CTRC); the company was renamed in 1924.



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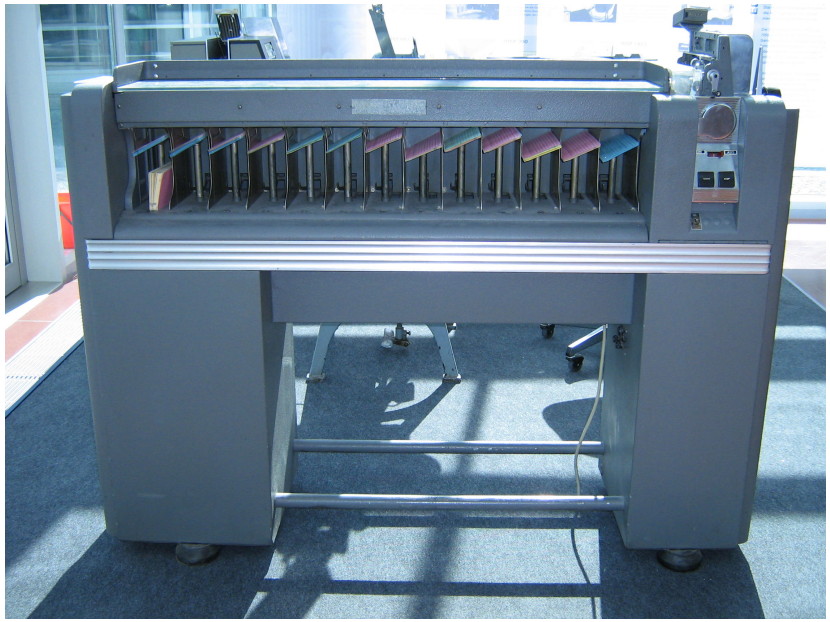
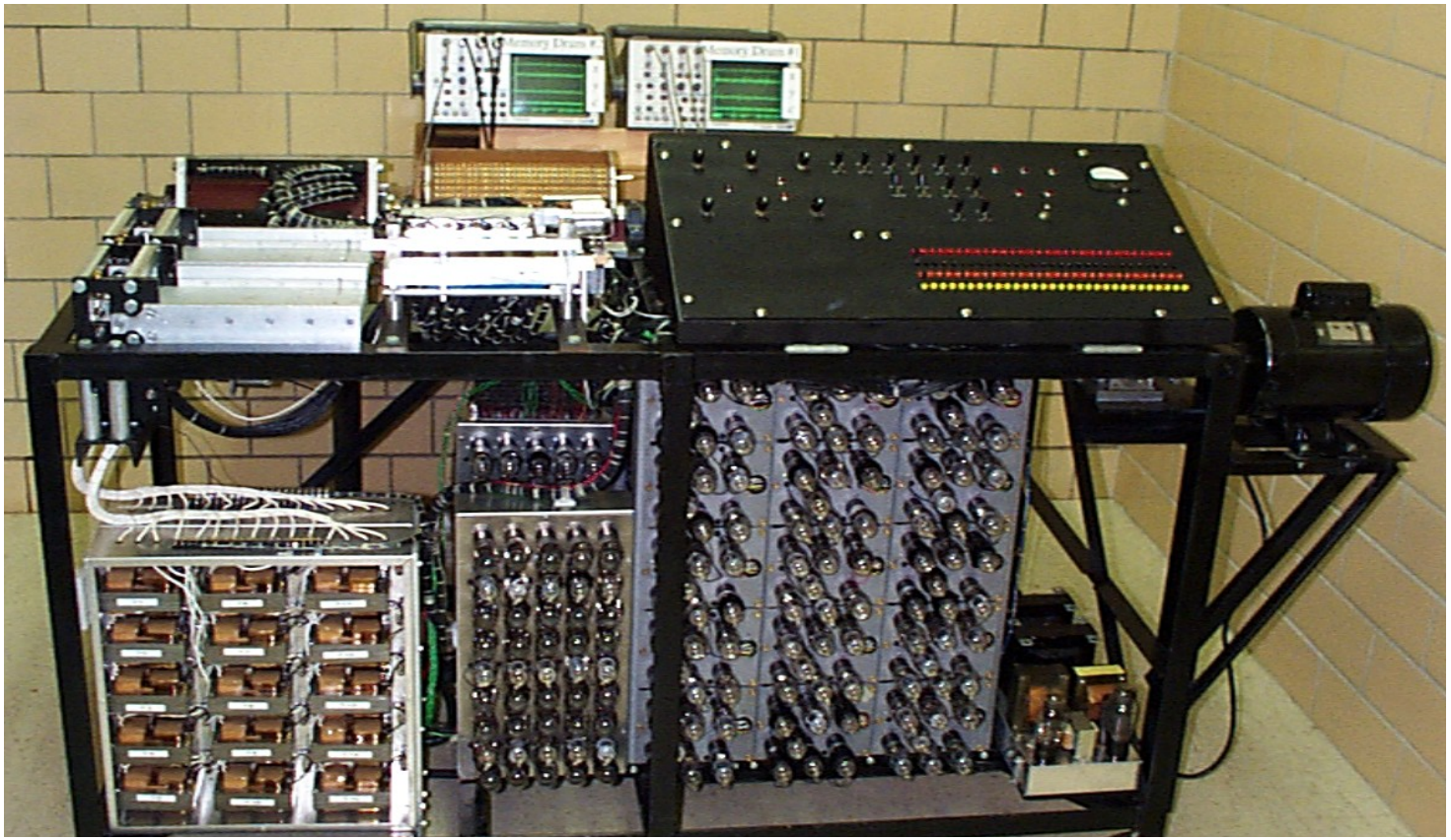


IBM 80 Series Card Sorter, 1949
(650 cards per minute)

Atanasoff-Berry Computer (ABC) (1939)

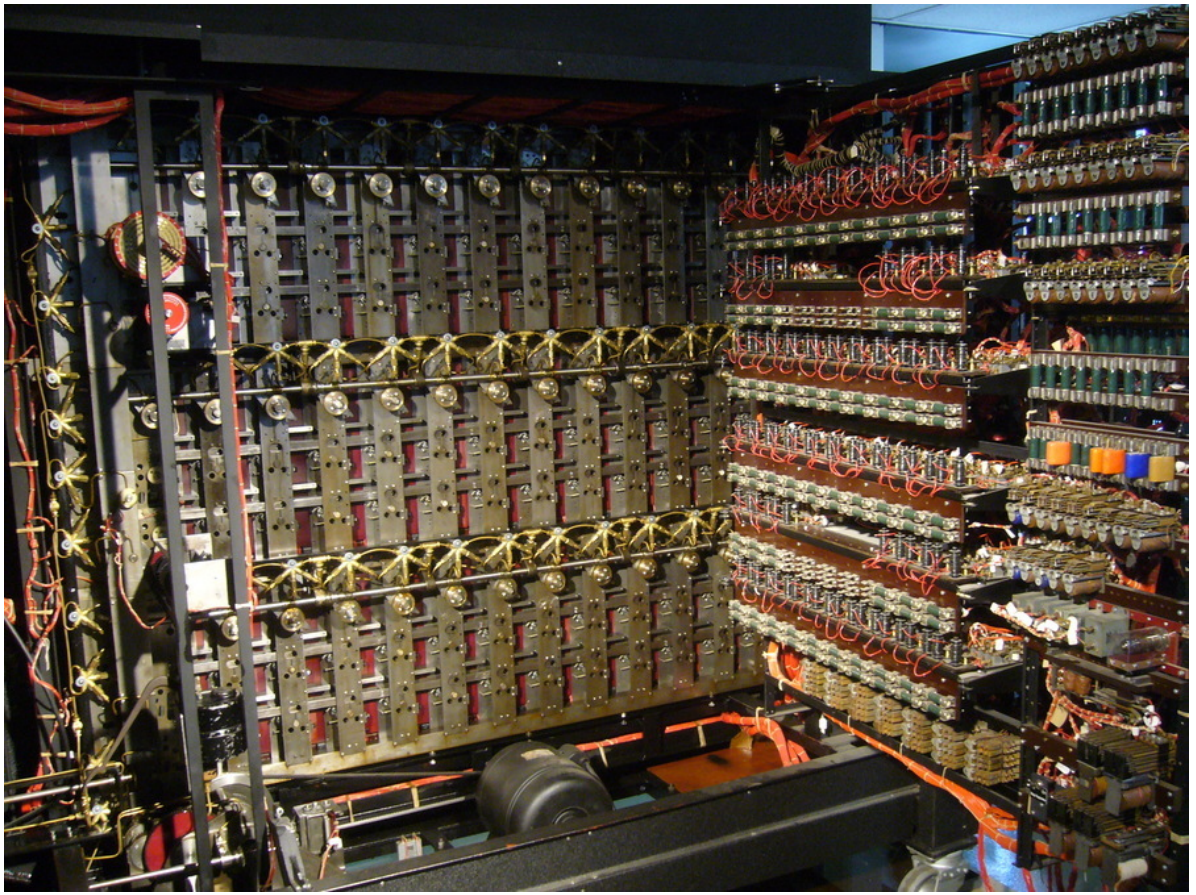
- John Vincent Atanasoff and Clifford Berry, 1939-1942
- One of the first electronic digital computing devices
- Designed to solve a system of linear equations



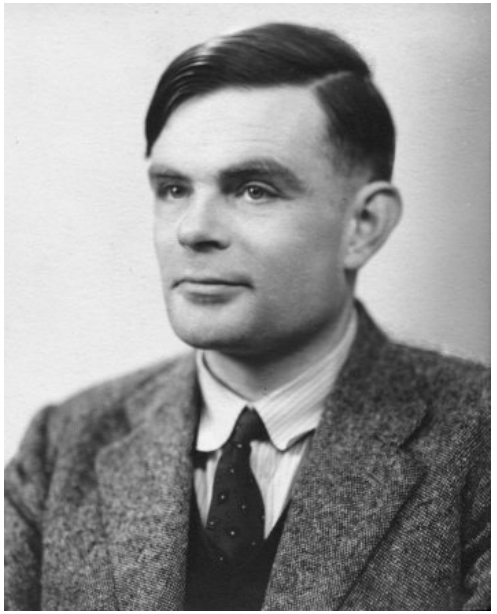
Turing bombe (1941)

- Alan Turing, 1939
- Developed to crack German Enigma codes during WW II.

Enigma machine in use



Alan Turing



- 1912-1954
- Considered the “father” of modern computer science.
- Presented formalisms for the notions of computation and computability in the 1930’s.
- Worked at Bletchley Park in Great Britain during WWII to develop Collossus to help break the German Enigma Code.
- Developed the notion in 1950 of a test for machine intelligence now called the Turing Test.

- The Turing Award, the highest award in computing, is named in honor of Alan Turing.

Slide credit: G. Kesden

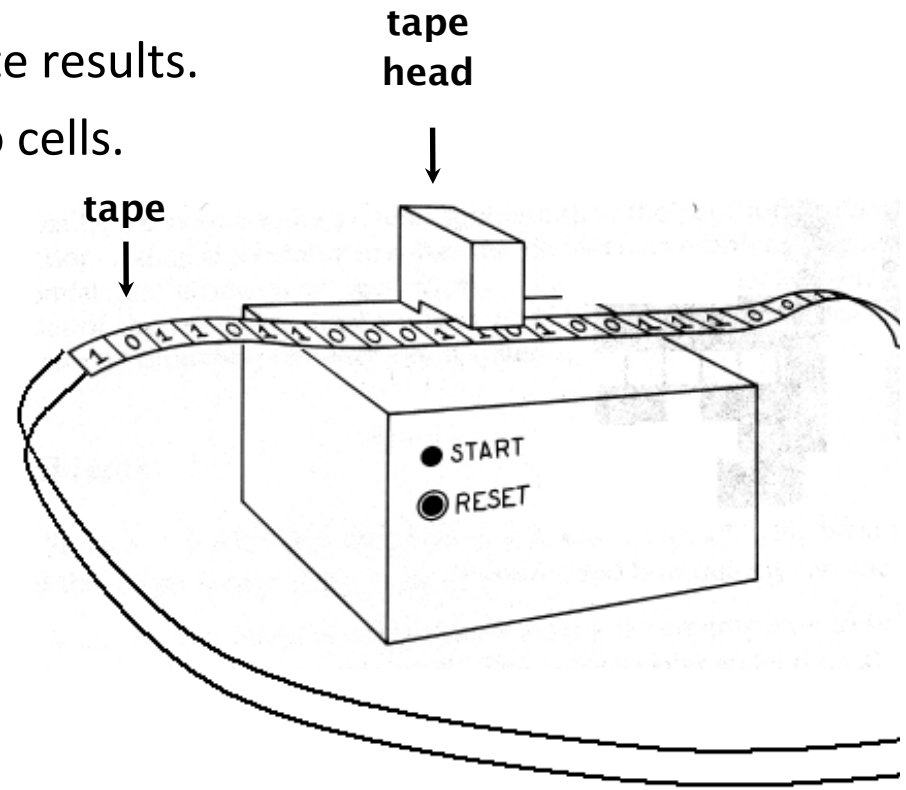
Stored Program Computers

- Problem solving

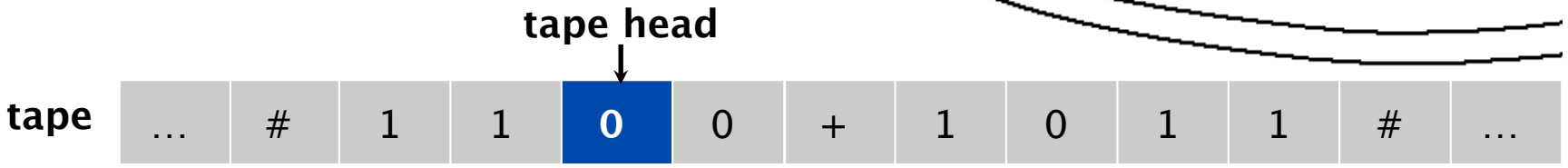
- What if input is a machine (description) itself?
- Universal Turing machines
  - An abstract general purpose computer

Universal Turing Machines

- Tape.
  - Stores input, output, and intermediate results.
  - One arbitrarily long strip, divided into cells.
  - Finite alphabet of symbols.



- Tape head.
  - Points to one cell of tape.
  - Reads a symbol from active cell.
  - Writes a symbol to active cell.
  - Moves one cell at a time.



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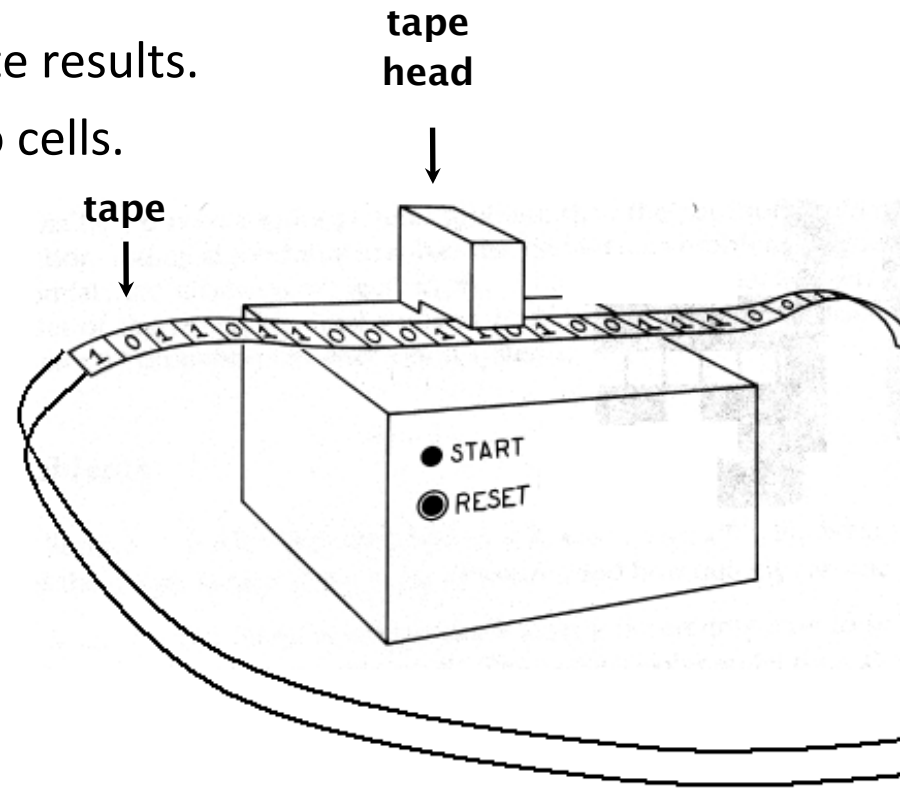

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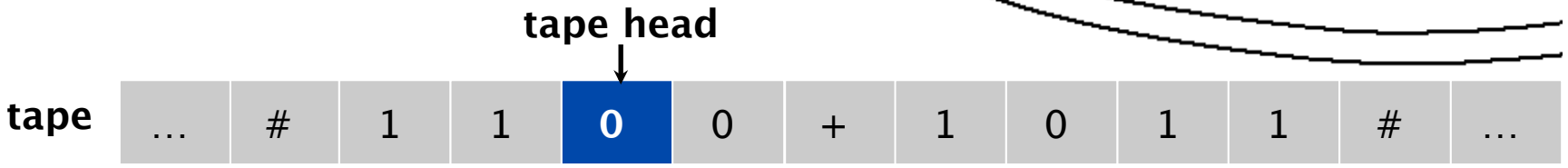


- Is there a more powerful model of computation? No!

Most important scientific result of 20th century?

Questions about computation

- What is a general-purpose computer?
- Are there limits on the power of digital computers?
- Are there limits on the power of machines we can build?


David Hilbert


Kurt Gödel


Alan Turing


Alonzo Church


John von Neumann

Church-Turing thesis (1936)

Turing machines can compute any function that can be computed by a physically harnessable process of the natural world.

- **Remark.** "Thesis" and not a mathematical theorem because it's a statement about the physical world and not subject to proof.
- Use simulation to prove models equivalent.
  - Android simulator on iPhone.
  - iPhone simulator on Android.
- **Implications.**
  - No need to seek more powerful machines or languages.
  - Enables rigorous study of computation (in this universe).
- **Bottom line.** Turing machine is a simple and universal model of computation.

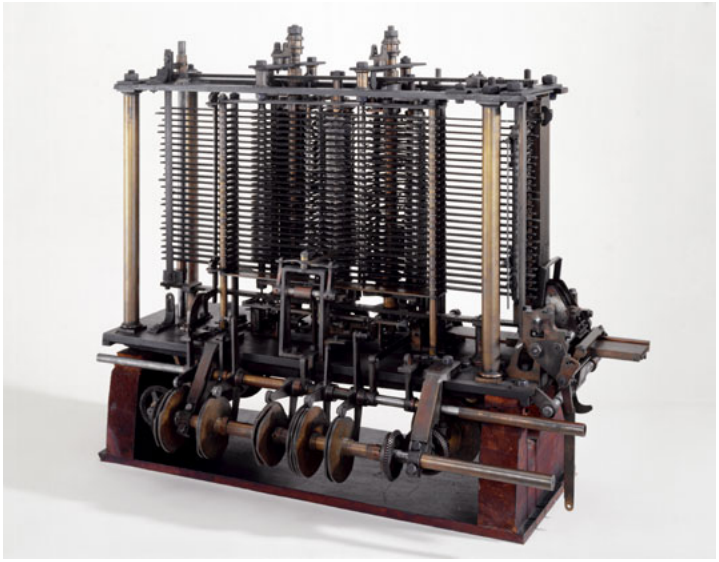
Church-Turing thesis: evidence

- 8 decades without a counterexample.
- Many, many models of computation that turned out to be equivalent.

model of computation	description
enhanced Turing machines	multiple heads, multiple tapes, 2D tape, nondeterminism
untyped lambda calculus	method to define and manipulate functions
recursive functions	functions dealing with computation on integers
unrestricted grammars	iterative string replacement rules used by linguists
extended L-systems	parallel string replacement rules that model plant growth
programming languages	Java, C, C++, Perl, Python, PHP, Lisp, PostScript, Excel
random access machines	registers plus main memory, e.g., TOY, Pentium
cellular automata	cells which change state based on local interactions
quantum computer	compute using superposition of quantum states
DNA computer	compute using biological operations on DNA

Babbage's Analytical Engine (1834, 1836)

- Designed around 1834 to 1836
  - was to be a universal machine capable of any mathematical computation
  - embodies many elements of today's digital computer
  - a control unit with moveable sprockets on a cylinder that could be modified
  - separated the arithmetic operations (done by the mill) from the storage of numbers (kept in the store)
    - store had 1000 registers of 50 digits each
  - Babbage incorporated using punched cards for input
    - idea came from Jacquard loom
- Never built by Babbage due to lack of funds and his eventual death in 1871



Adopted from: T. Cortina

Ada Lovelace

- 1815-1852
- Daughter of poet Lord Byron

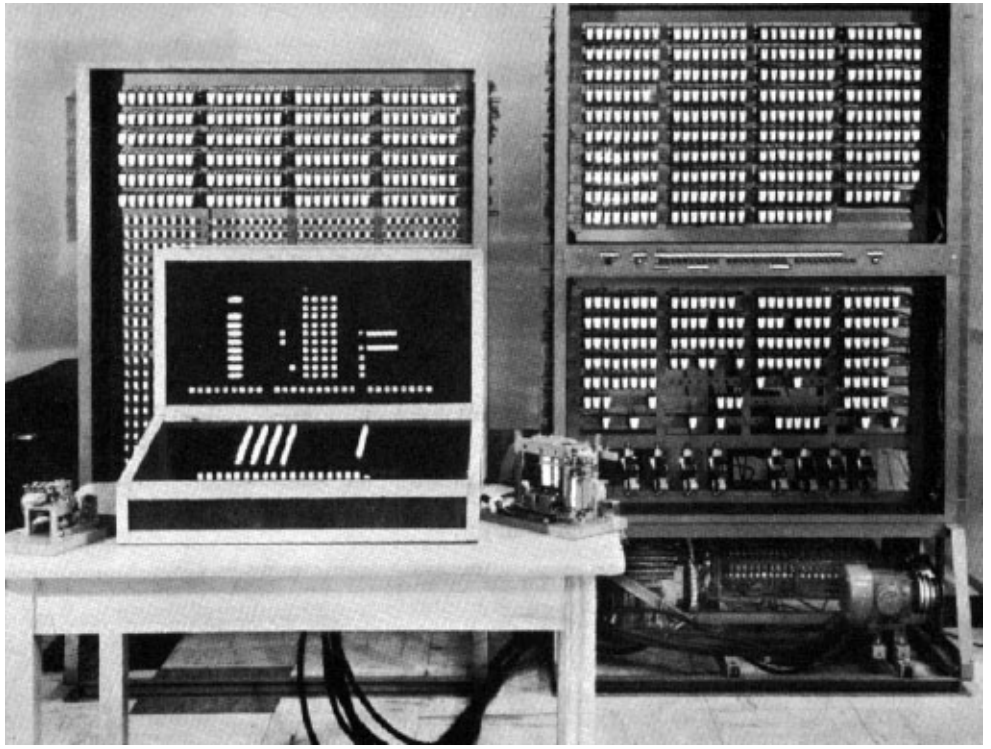
- Translated Menabrea's Sketch of the Analytical Engine to English
  - Quadrupled its length by adding lengthy notes and detailed mathematical explanations

- Referred to as the world's first programmer
  - Described how the machine might be configured (programmed) to solve a variety of problems.

Slide credit: G. Kesden

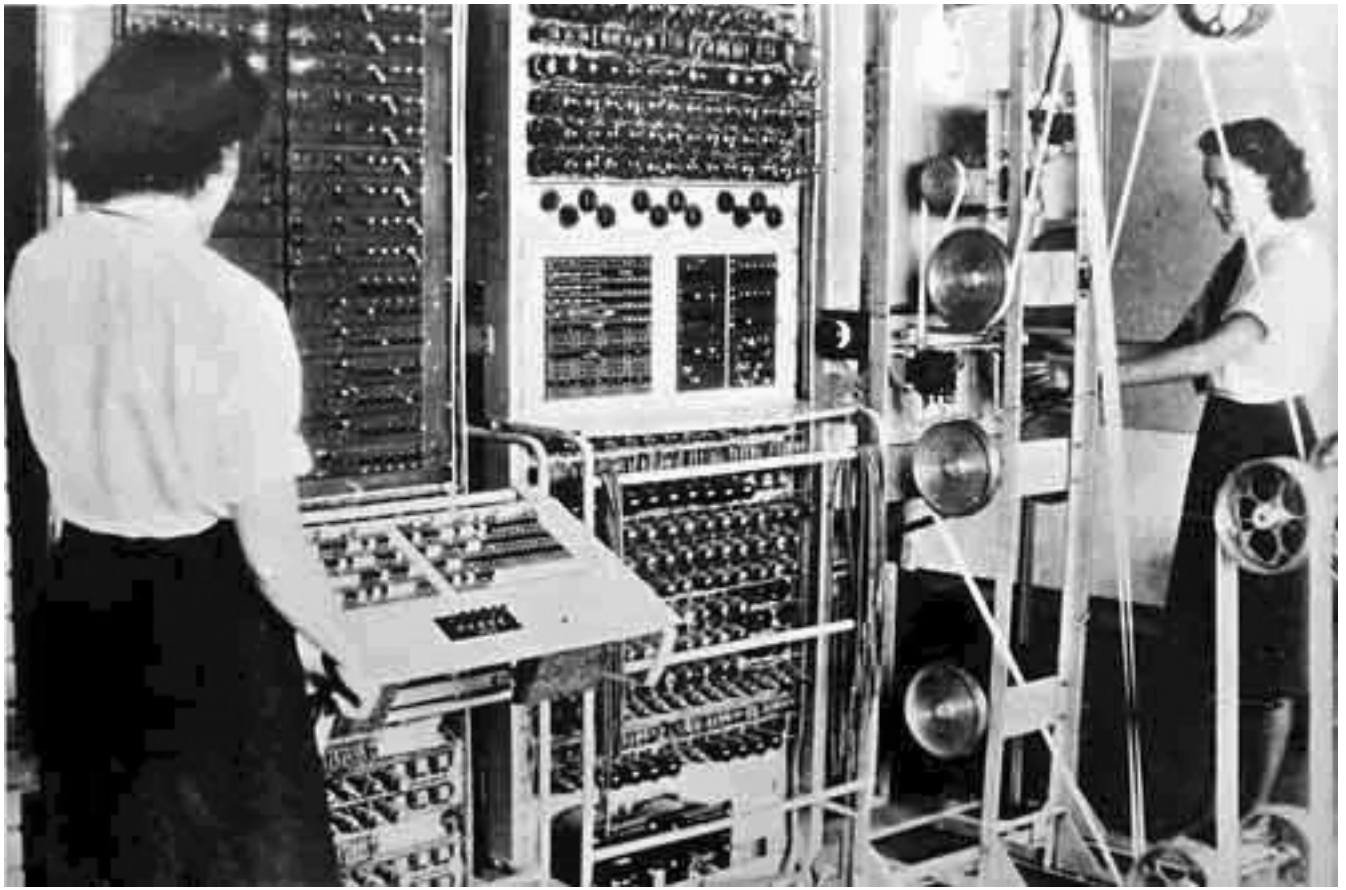
The Zuse Z3 Computer (1941)

- Konrad Zuse, 1941
- The original Z3 was destroyed in a bombing raid of Berlin in 1943.
- Zuse later supervised a reconstruction of the Z3 in the 1960s (currently on display at the Deutsches Museum in Munich)



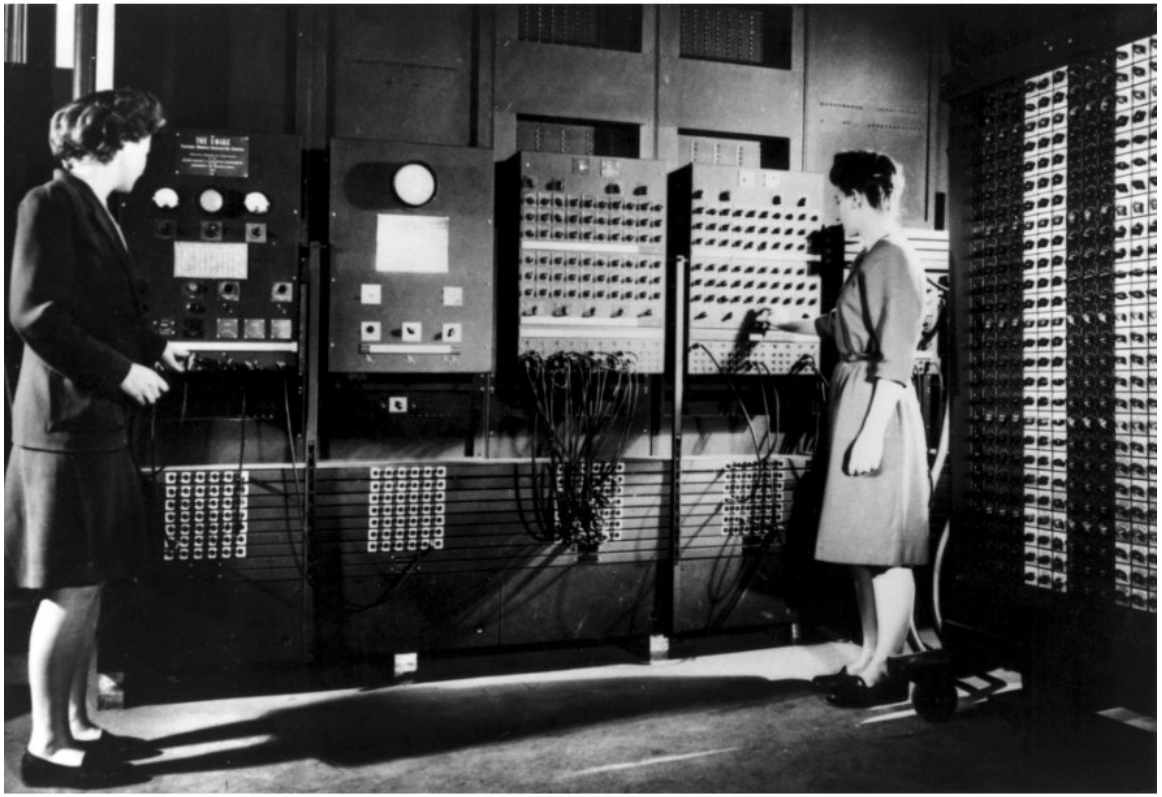
Colossus Mark 1 (UK,1944)

- The world's first electronic digital computer with programmability.



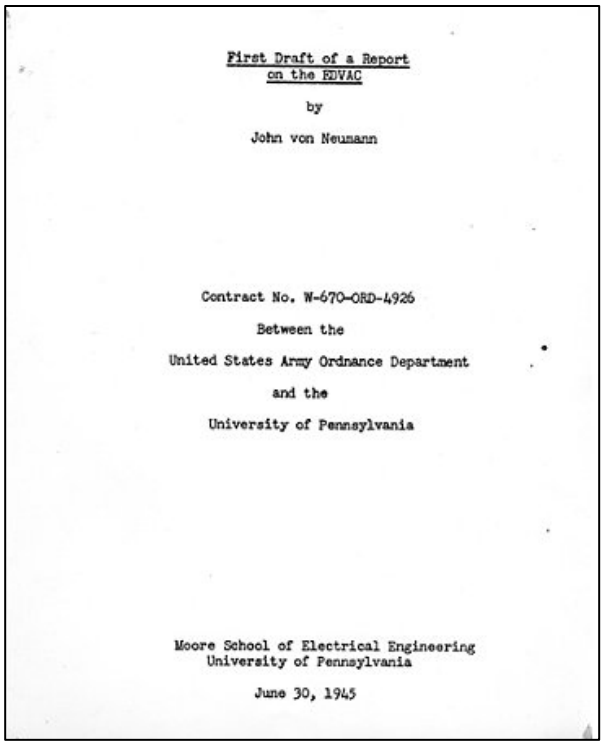
ENIAC (Mauchly and Eckert, USA, 1946)

- The first large-scale general-purpose electronic computer without any mechanical parts.
- Designed to calculate artillery firing tables for the United States Army's Ballistic Research Laboratory



EDVAC (von Neuman, USA, 1951)

- Unlike the ENIAC, it uses binary rather than decimal numbering system
- Instructions were stored in memory sequentially with their data
- Instructions were executed sequentially except where a conditional instruction would cause a jump to an instruction someplace other than the next instruction



First Draft of a Report
on the EDVAC

by

John von Neumann

Contract No. W-670-ORD-4926

Between the

United States Army Ordnance Department

and the

University of Pennsylvania

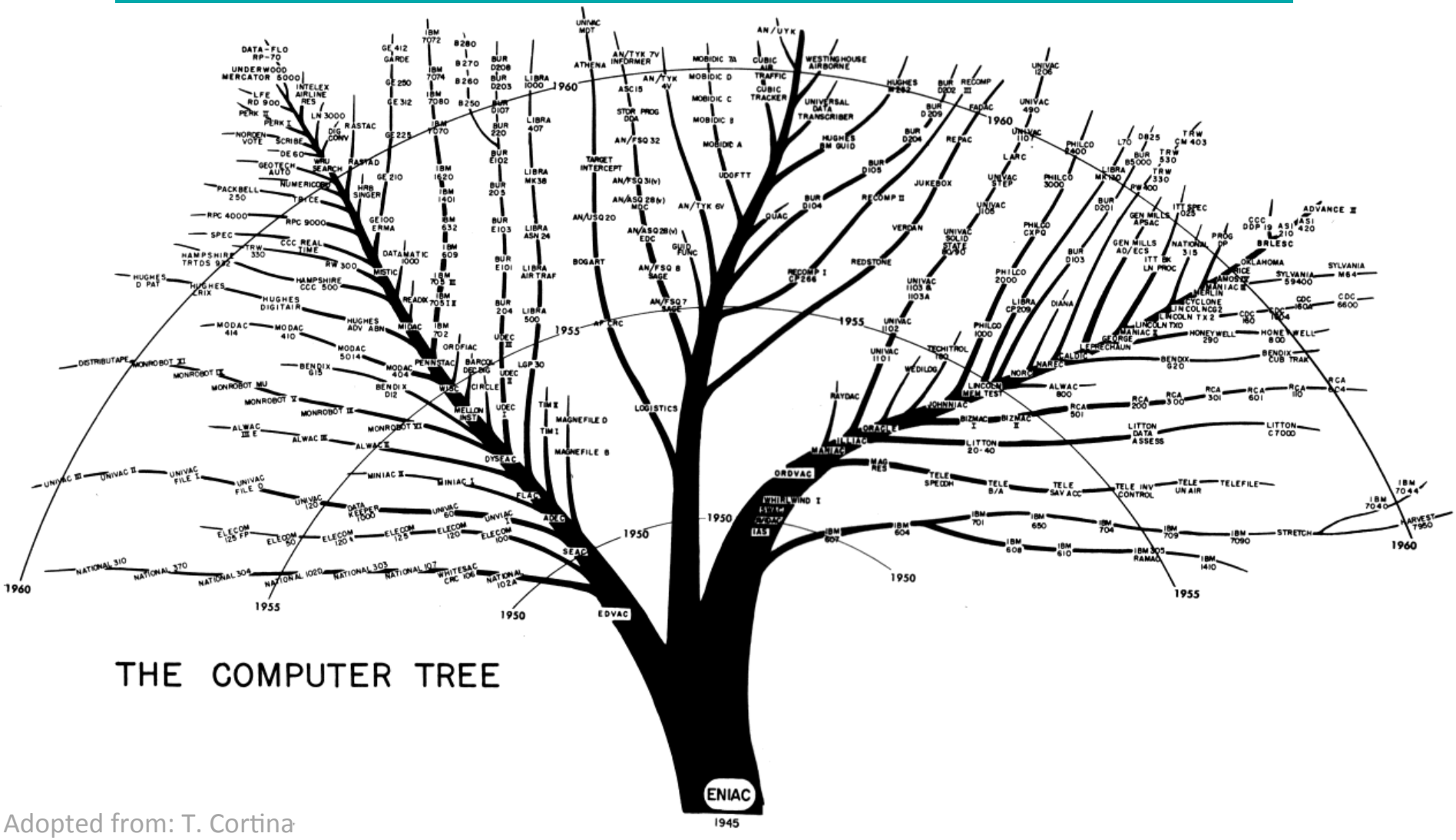
Moore School of Electrical Engineering
University of Pennsylvania

June 30, 1945

Adopted from G. Kesden

The Computer Tree

- http://ftp.arl.mil/~mike/comphist/61ordnance/chap7.html



Adopted from: T. Cortina

Summary

- **Introduction**
  - About the class
  - Organization of this course

- **What is computation?**
  - What is knowledge?
  - What is a computer?
  - What is a program?
  - History of computing

Next week

- More on stored program computers
  - Von Neumann architecture
  - Components of a computer
- Binary representations
- Abstraction
- Programming paradigms
  - Programming languages

The Birth of the Computer

- A TED talk given by George Dyson
  http://www.ted.com/talks/george_dyson_at_the_birth_of_the_computer.html