

The Machine

Lecture 1

- **Programming** is the act of transforming a procedure to that which is understood by a computer.
- We first need to understand what a **computer** is and what motivation led to its creation.
- First, we will study the *history* and *physical nature* of the computer.

What are we learning?

“ You have to know the past to understand the present. ”

– *Dr. Carl Sagan*

Wisdom to Lead Us



Ancient Computers

- The **Antikythera mechanism** is historically one of the first examples of computation.

(100BC, Discovered 1902AD)

- It would be thousands of years before its sophistication would be matched.
- It calculated positions of astronomical objects given a date.

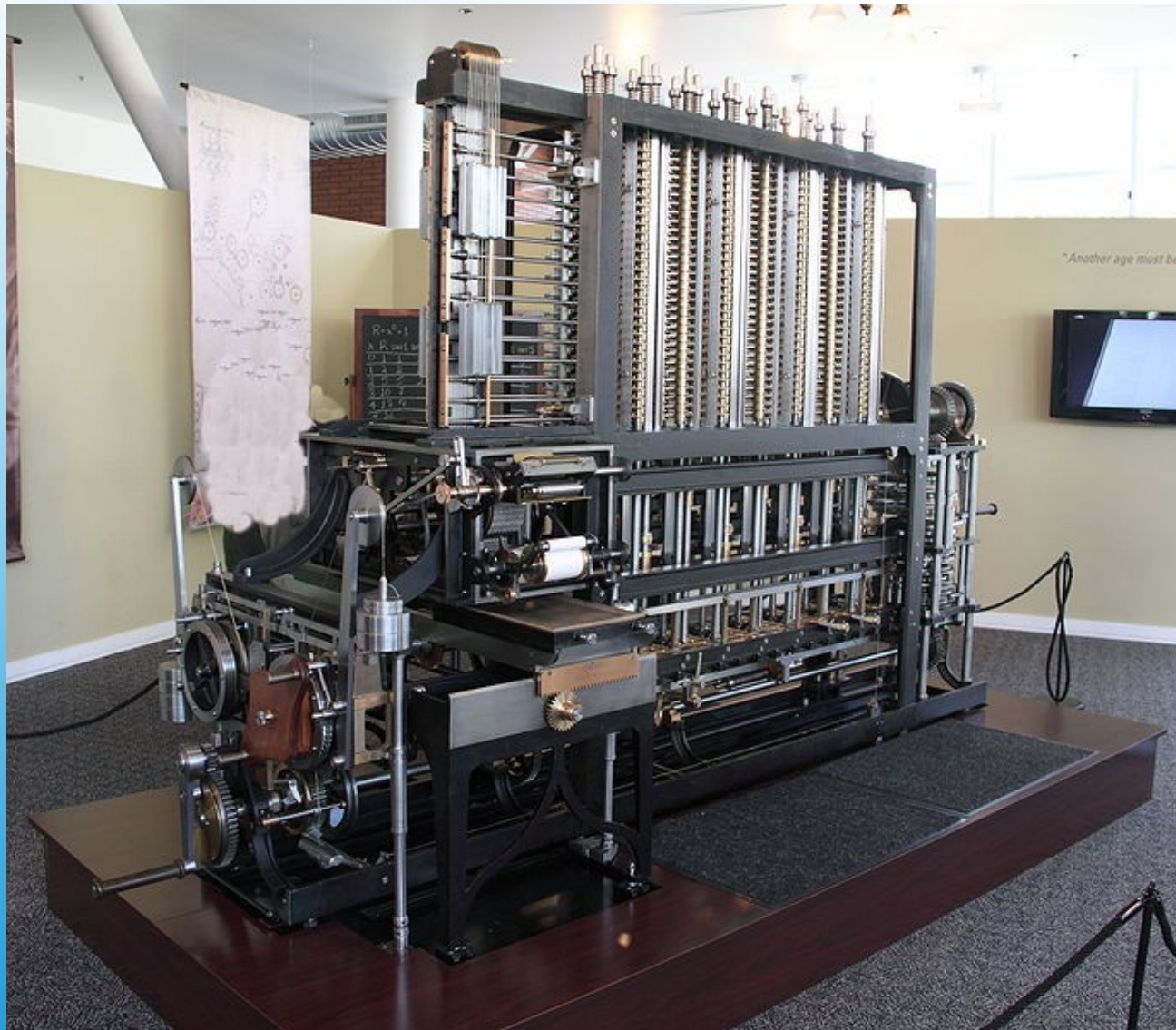


Antikythera Mechanism

- It is a **mechanical loom** (1801) invented by Joseph Jacquard.
- Produced textiles with complex patterns with ease.
- “Programmed” with the usage of small punch cards.



Jacquard Loom

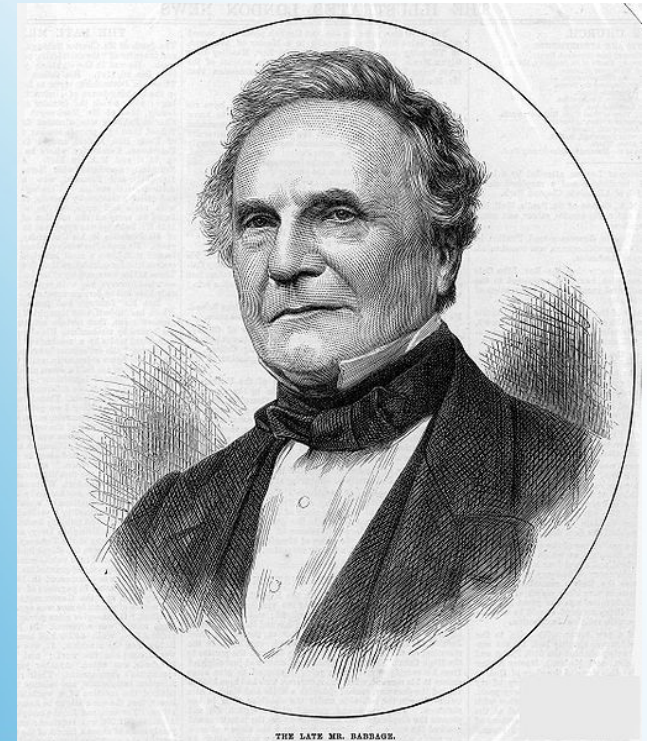


Difference Engine

- Computation of large formulas was necessary for many fields of science and engineering.
- Calculators existed, but were non-programmable. (They did one thing)
- The Difference engine was designed to provide this functionality.
 - **Multi-purpose calculator!**
- Initially conceived by the Hessian army (1786) and then designed by Charles Babbage (1849) and built by the London Science Museum (1989-1991)

The Difference Engine

- Charles Babbage (1791-1871)
- Mathematician and Mechanical Engineer
- Tried very hard to implement the difference engine, but never procured the finances.
- Surely, his next machine was easier and cheaper to implement???



**Charles Babbage,
Father of the Computer**

PHOTO DOES NOT EXIST
MACHINE NEVER BUILT

... oh

The Analytical Engine

- Charles Babbage went on to design a more **general purpose** machine.
- It did not simply calculate values, but performed computations (calculations based upon logic).
- This machine, designed in 1837, as described, was the first mechanical computer.
 - It is just as powerful as modern machines!
 - It was so complicated, it has **never** been built.

The Analytical Engine

- The Analytical engine was meant to be more **general purpose**.
- Proving that an arbitrary computation was possible on the machine was necessary to provide motivation.
- Babbage left this to mathematicians.
 - To date, these notes were the major contributions as the machine *was never built!*
 - Their notes became the basis of programming.

Describing the Analytical Engine

- One such mathematician was **Ada Lovelace**.



Describing the Analytical Engine

- **Augusta Ada King**
(née Byron), Countess of Lovelace (1815-1852)
- Considered the *first computer programmer*.
- Ada Lovelace Day is celebrated March 24th of every year.



**Ada Lovelace,
Enchantress of Numbers**

- She was tasked with translating a French paper describing the machine to English. (1843)
- She added an extensive collection of notes of her own.
- She devised a *mathematical language* to show the flexibility of the difference engine.
- With this language, she described how to compute various mathematical series.
- She inadvertently *created the first programming language!*

The First Programmer

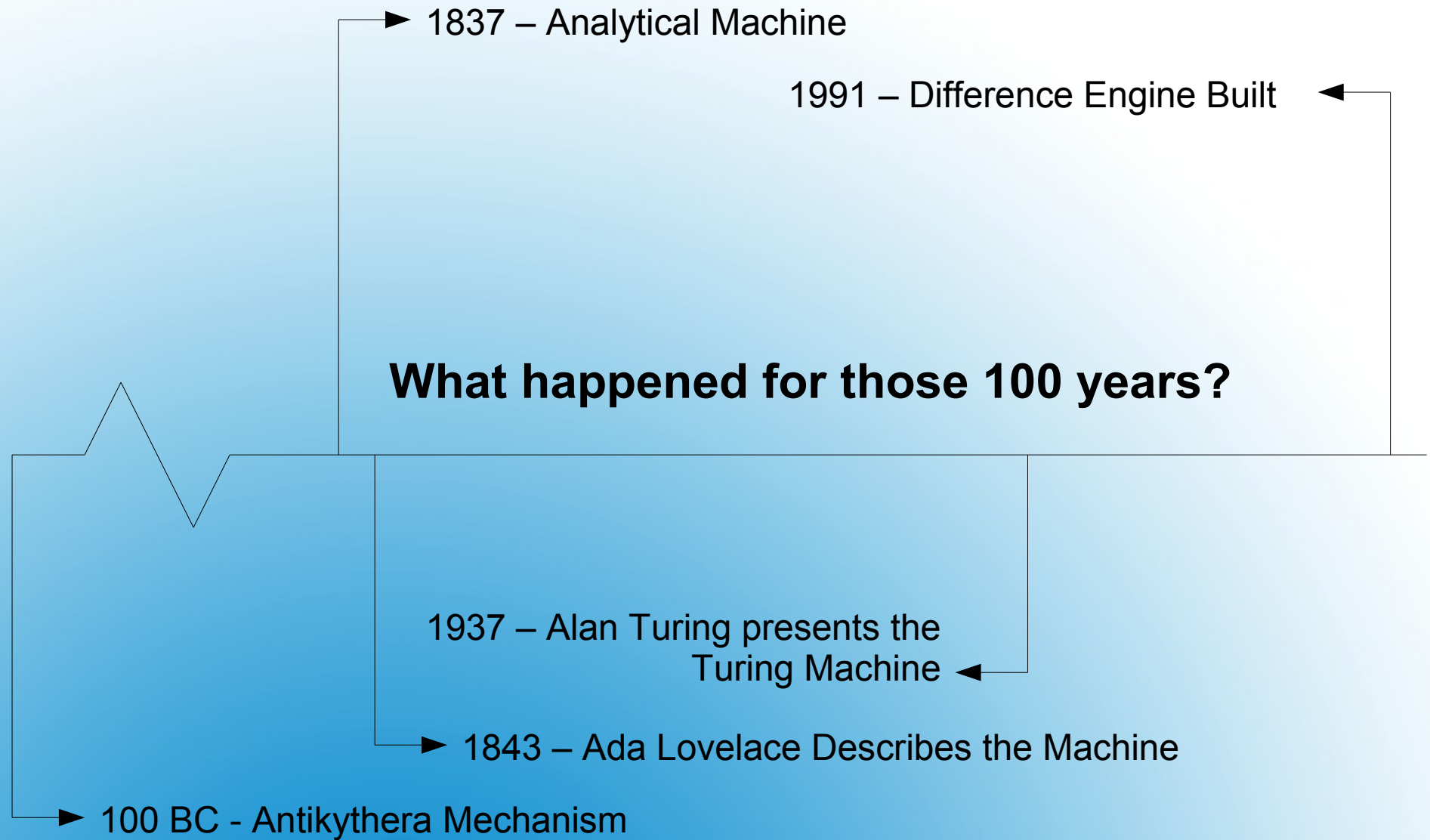
- Ada saw the usage of computers beyond that of engineers – even Babbage himself.

“ 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 Lovelace

Ada's Vision

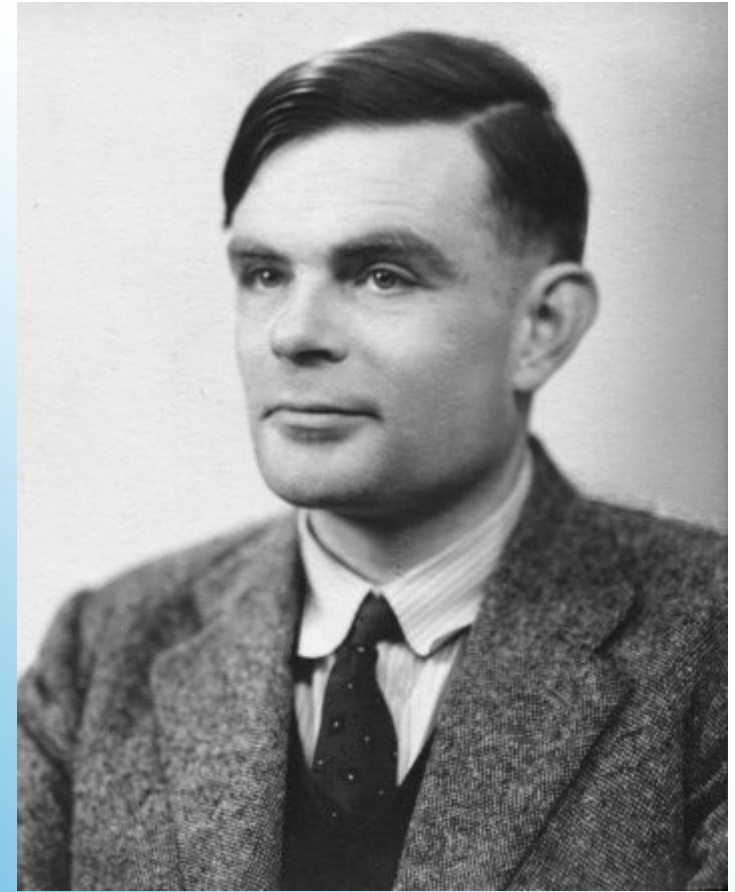


Timeline

- It wasn't until the **Church-Turing thesis** (1937-1939) that computers were formally defined.
- With this model, *the merits and limits of computation could be explored*. (what can be programmed and what can not)
- This exploration and its eventual application is called **computer science**.

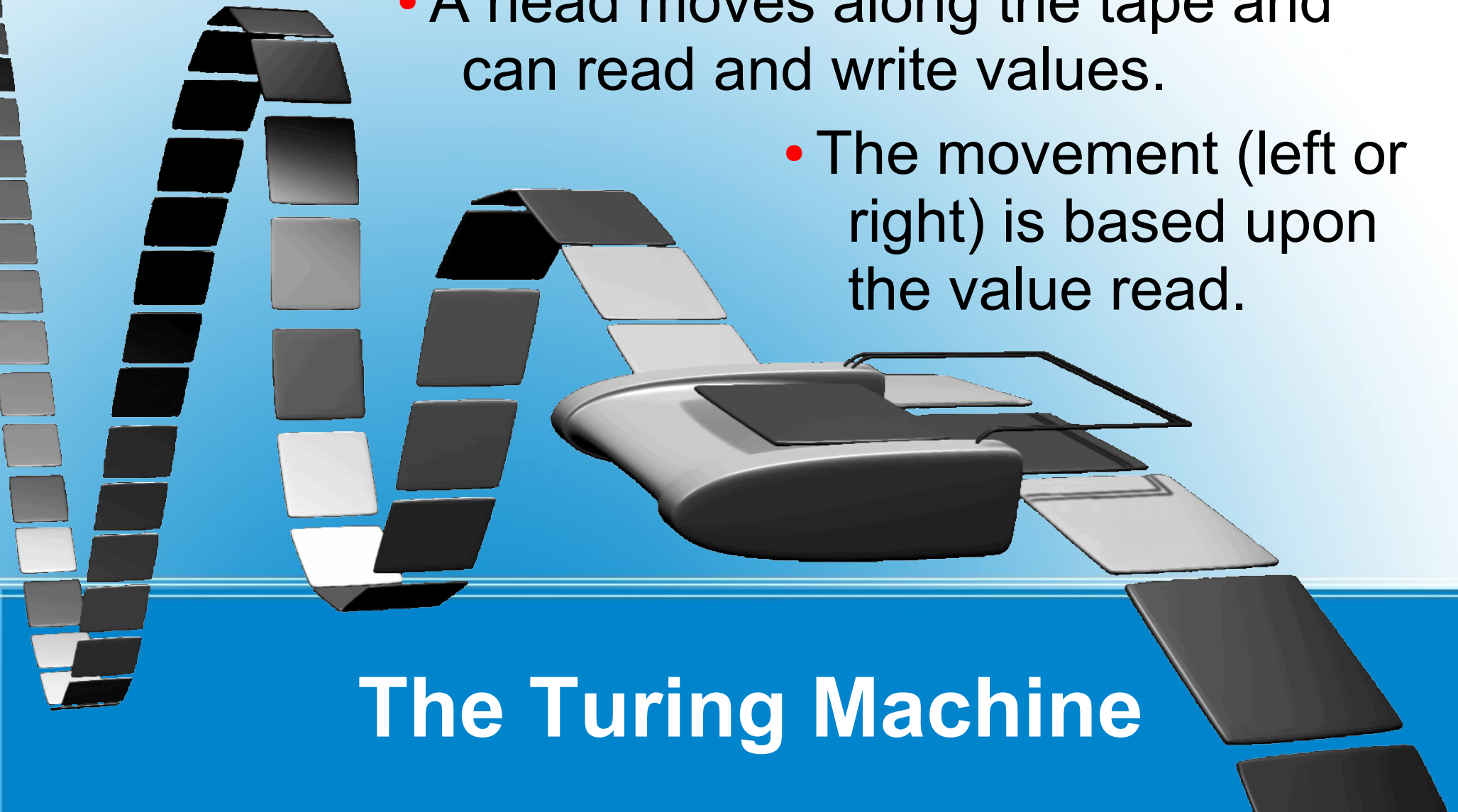
Founding Computer Science

- Alan Turing (1912-1954)
- Mathematician and cryptanalyst.
- Devised the scheme that broke the Enigma code in World War II. (Bombe)
- Published a thesis that provided a model of a computational machine, the **Turing Machine**, asserting the previous work of Kurt Gödel.



**Alan Turing,
Father of Computer Science**

- Has infinite memory represented by a single tape.
- A head moves along the tape and can read and write values.
- The movement (left or right) is based upon the value read.



The Turing Machine

- A general, formal description of a computer.
- Theoretical (and simple) but all physical machines live up to this formal description.
- Programming languages model the **theoretical machine not the physical machine**.
 - They assume infinite memory!
 - They assume infinite time!
 - The programmer, not the language, imposes and takes into account any extra limitations.

The Turing Machine

- Machines can be used to model a system, and uncomputability can be used to ascertain scientific feasibility.
 - If a problem cannot be computed via a Turing Machine, then no solution by any machine can solve it.
 - If something cannot be done via a Turing Machine, no physical machine can do it either.
 - This may apply to the human brain as well.
 - An open question is whether or not a machine is as capable as a human being.
 - Proof is a program that passes the **Turing Test**

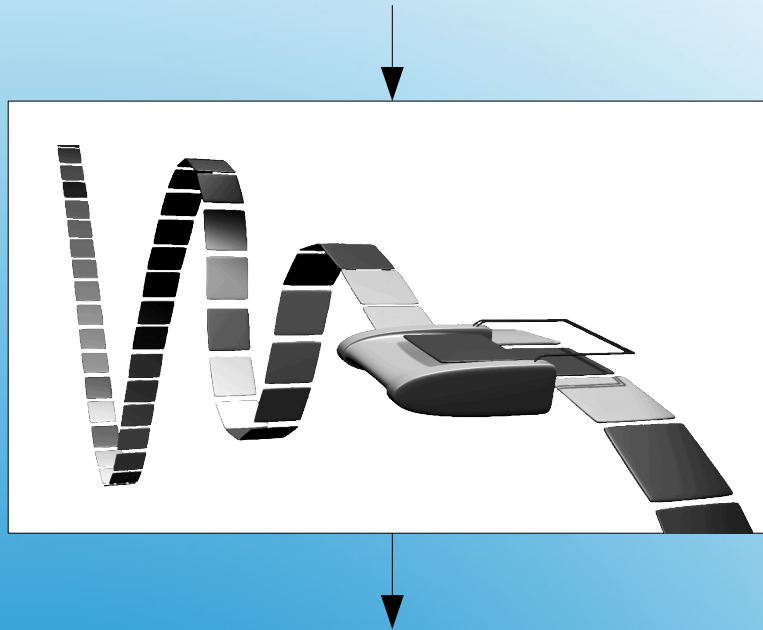
Turing's Vision

- We will discuss Turing's vision in more detail later.
 - What cannot be computed by a Turing machine? (which implies not computable by any supercomputer ever!)
 - What open questions about computability exist?
 - How do the answers affect us? Philosophically? Scientifically?

Future Discussion

- In our context, a computer is a Turing Machine.

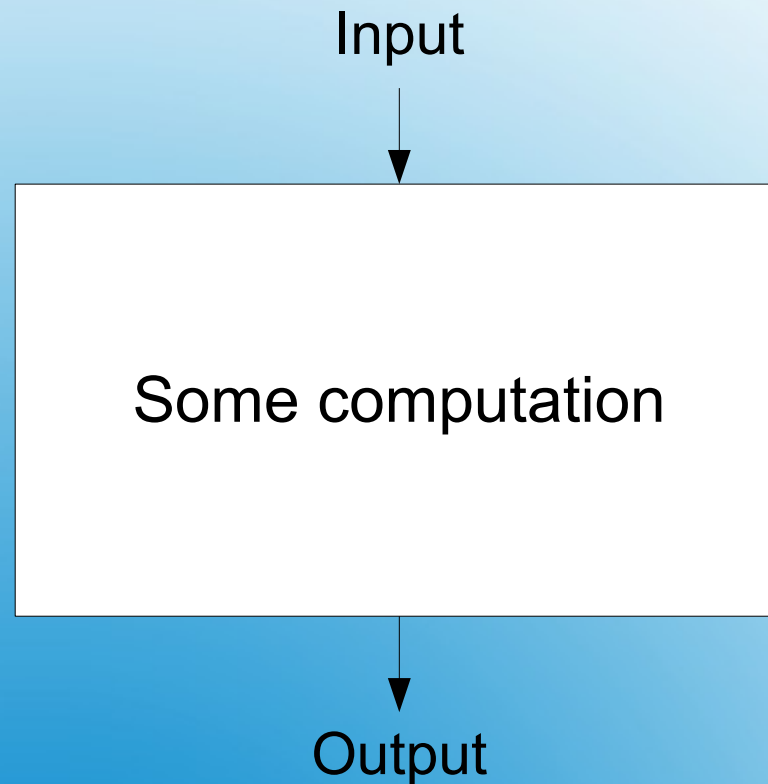
Input is the initial setting of the tape.



The output is the eventual setting of the tape.

What is a computer?

- We can think of it as a **black box**.

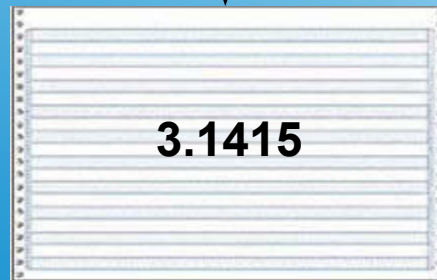


What is a computer?

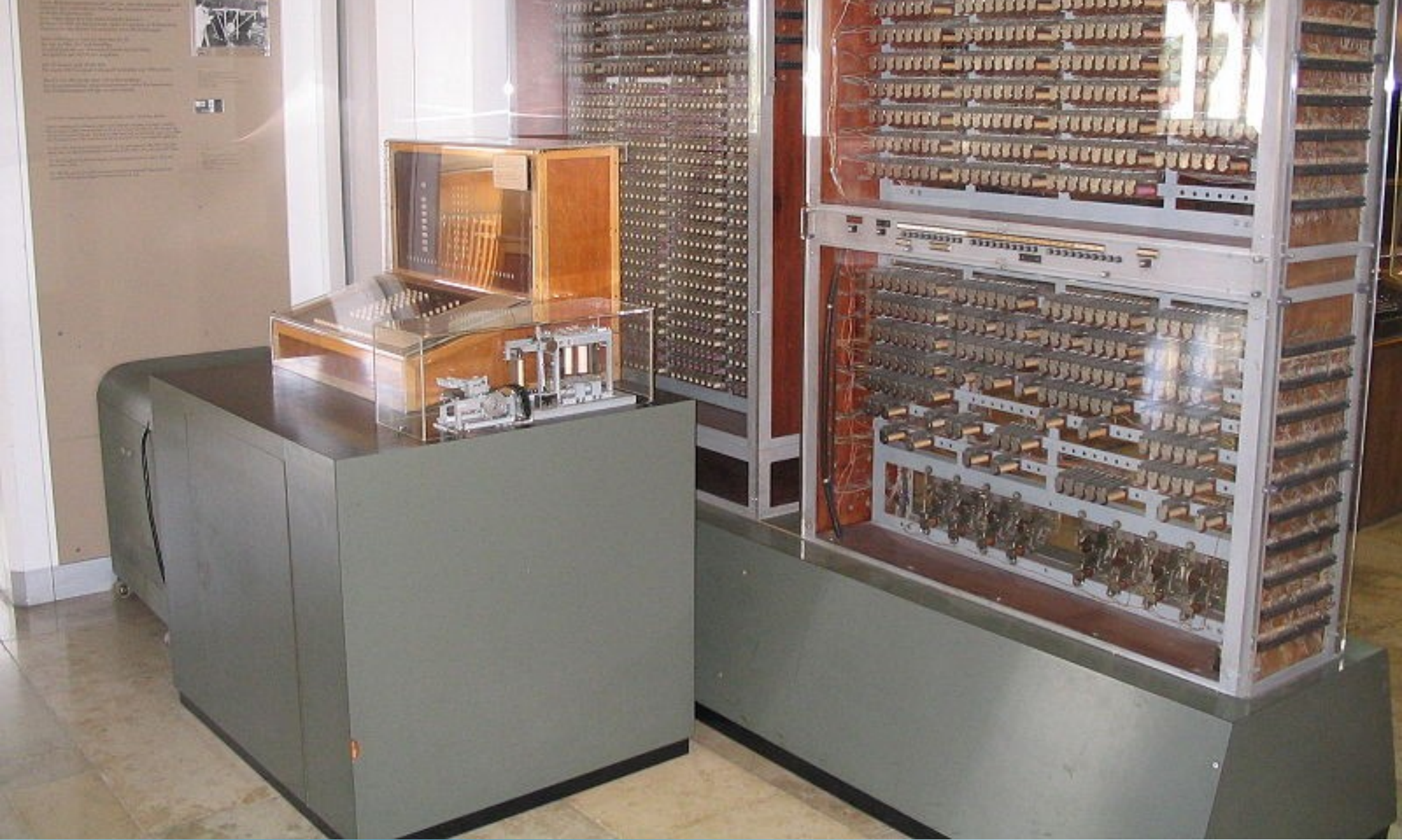
- “Modern” machines modeled this behavior.



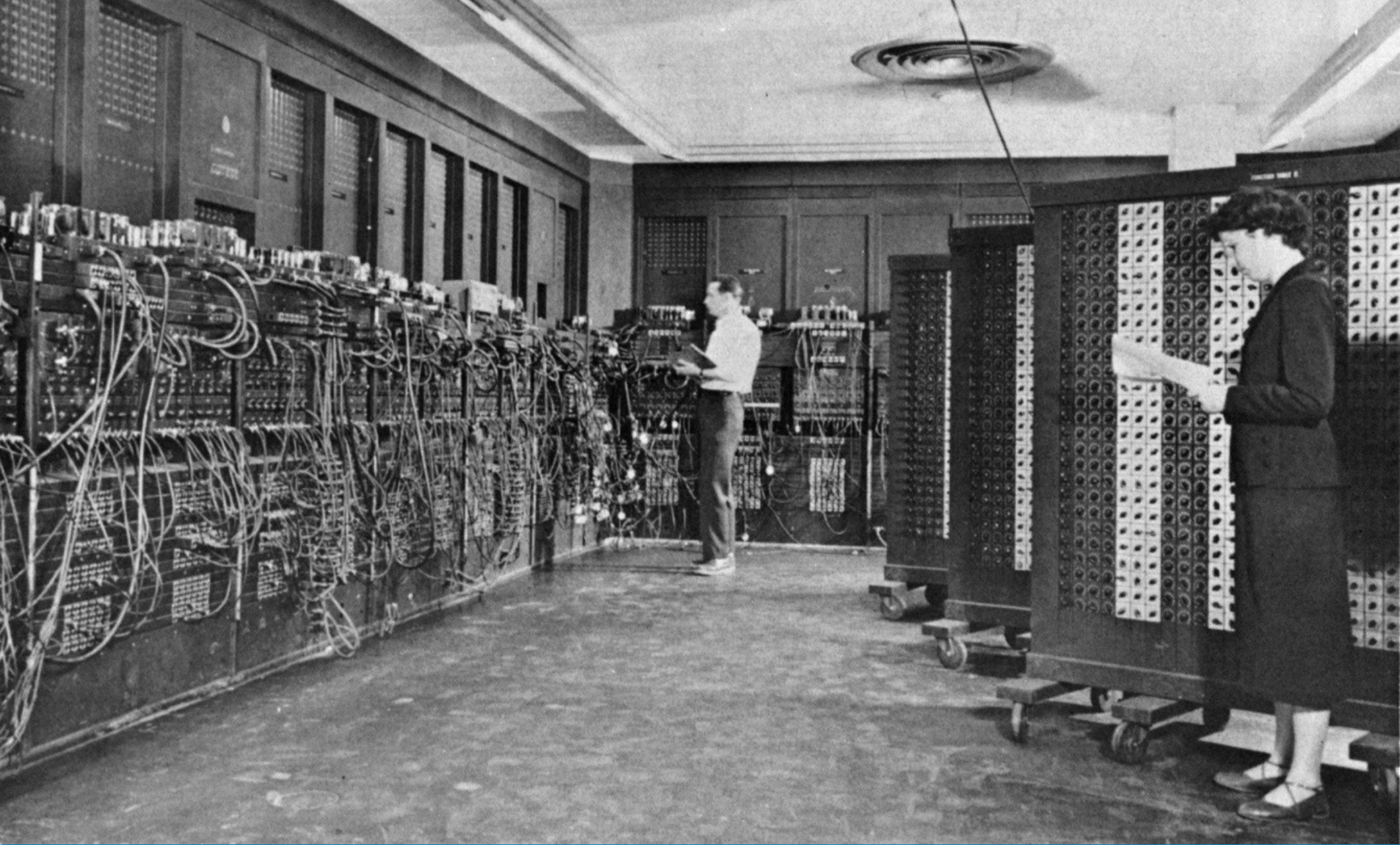
Some computation



What is a computer?



**Z3 – First Turing Complete
Computer (1941)**



ENIAC – First General Purpose Computer (1946)



University of Pittsburgh's Computation and Data Processing Center (1965)



DEC VT52 – Terminal (1975)



The Apple I – One of the first personal computers (1976)



The Apple II – First widely used personal computer (1977)



Epson HX-20 – First laptop (1981)



IBM Convertible – First “IBM Compatible” laptop (1986)



**Gateway Solo – First laptop with a
Pentium and CD Rom (1996)**



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