Computer Pre-History

AP Computer Science

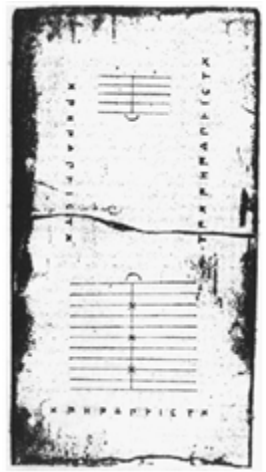
Module 9

Computer Pre-History

Counting Boards 300 B.C.E

The precise origins of the earliest calculating devices are literally lost in the sands of time. Initially, merchants probably simply drew a series of lines in the sand, placed pebbles between them, and moved them back and forth to keep track of inventories and conduct transactions. Keep in mind that this was actually prior to the adoption of the Arabic number system (0-9), so there was no way to actually write numbers. Affluent merchants used wooden tables with raised edges filled with blue or green sand in which lines were drawn thus making the first portable counting device!

Eventually counting boards made of wood or stone were developed with grooved lanes for the pebbles. The Salamis tablet, dating from 300 B.C.E in Babylonia (now Iraq) is the earliest surviving artifact of a counting board. It is a white marble slab (149 cm long, 75 cm wide and 4.5 cm thick) with a series of evenly spaced lines. At almost 5 feet in length, 2.5 feet wide, and 2 inches thick, such counting boards were lugable at best.



Salamis Tablet
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The word abacus, derived from the Greek abax, means counting board covered with dust. So, the earliest abaci (plural for abacus) were actually counting boards. This technology was used successfully for many centuries; however it suffered from a major flaw. If it crashed, the counting pebbles were dislodged from their data tracks!

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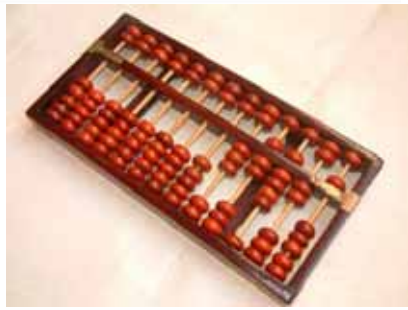
The Abacus 202 BCE – 1368 CE

The counting board was the precursor of the abacus that most of us readily recognize: a wooden frame divided into upper and lower sections. The position of beads on wires or rods within the frame indicate positional value. It's use predates the development of the Hindu-Arabic numeral system in the 9th century.



Chinese Abacus
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The abacus was invented independently by many different cultures around the world including the Chinese, Romans, Japanese, Russians, and Mesoamerican Indians.

Simulation

Japanese Abacus
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Russian Abacus
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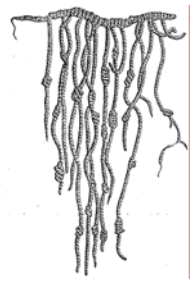

Aztec Abacus
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World's Smallest Abacus

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Napier's Bones 1617

John Napier was a Scottish Mathematician best known as the inventor of logarithms.

In 1617, Napier published Ragdologia in which he described a set of rods that could be used for multiplication and division by using addition.

John Napier
1550-1617
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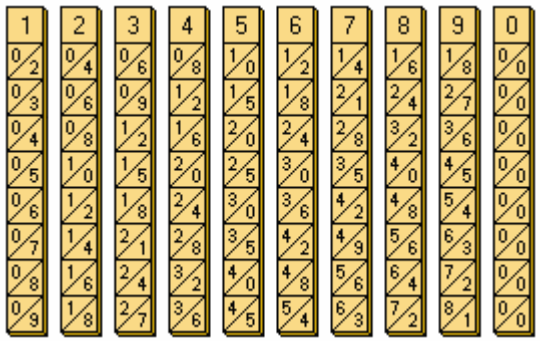
Simulation



Napier's Bones
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Slide Rule - 1625

William Oughtred invented the slide rule when he created a number line on which the positions of numbers were proportional to their logarithms.

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William Oughtred
1574-1660

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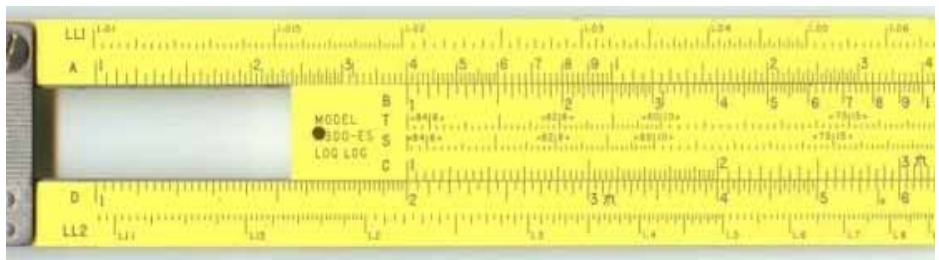
By placing two logarithmic scales side-by-side, multiplication could be carried out by sliding the number lines parallel to one another and reading of the product.

Simulation



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The Pascaline 1640

A French mathematician and philosopher, Blaise Pascal, invented the first operational mechanical digital calculator in 1640.

Known as the Pascaline, or the Arithmetic Machine, the device used a series of gears to perform addition and displayed cumulative sums when a handle was cranked.

Blaise Pascal
1623-1662
Public Domain

The Pascaline
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Computer Pre-History

The Stepped Reckoner 1670

Gotfried Liebniz was a German mathematician and philosopher best known today for inventing calculus independently of Isaac Newton. He is also credited with discovering the “modern” binary number system.

Leibiniz improved on the Pascaline and developed a mechanical calculating device that could not only add, but subtract, multiply, divide *and* evaluate square roots by a series of stepped additions.

The machine was never produced in any quantity due to the lack of manufacturing precision of the time period for making mechanical devices.

Gotfried Liebniz
1646-1716
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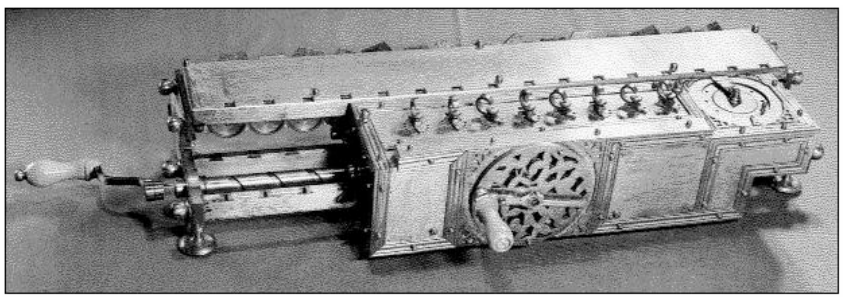

Stepped Reckoner
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"It is unworthy of excellent men to lose hours like slaves in the labor of calculation, which could be safely relegated to anyone else if machines were used.“

Gotfied Leibniz

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Jacquard's Loom 1801

As often happens in the history of technology, an unrelated invention provided the key to further advances in mechanical calculating machines.

In 1801, Joseph Marie Jacquard invented a mechanical loom that used holes punched in heavy cards to control textile designs.

Joseph Marie Jacquard
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Jacquard's Loom
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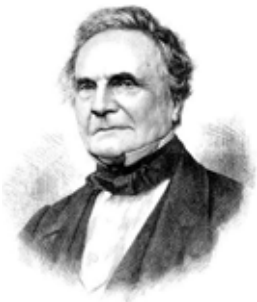
In effect, the loom could be "programmed" by changing the pattern of holes on the cards and a series of cards could be strung together to produce multi-threaded patterns. Jacquard's Punched Card Loom was important for the development of subsequent attempts to create large-scale, programmable mecahnical calculating devices.

Computer Pre-History

The Difference Engine 1822

Charles Babbage was an English mathematician and mechanical engineer who has been politely called an irascible genius. He was a rather disagreeable and odd individual who is reported to have baked himself in an oven at 265º F to see what would happen and was lowered into the Mount Vesuvius volcano so he could view molten lava.

He designed the Difference Engine, a steam driven special purpose mechanical calculator based on the decimal system to reliably calculate astronomical and mathematical tables. Funding problems and the inability of machinists of the era to manufacture parts to the necessary precision prevented him from actually building the device.



Charles Babbage
1791-1871
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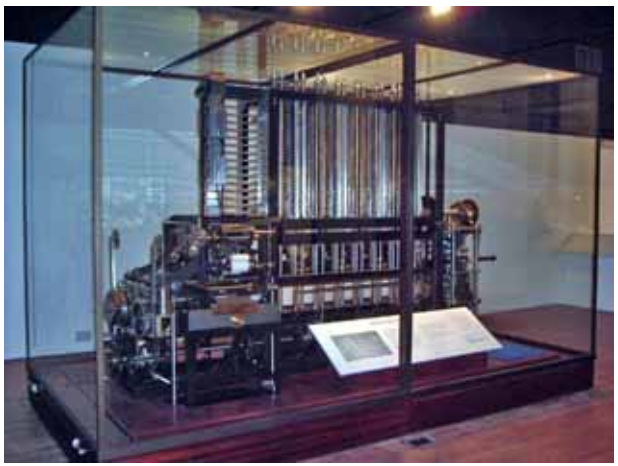

The Difference Engine
Public Domain

A full-scale replica built in 1991 worked reliably just as Babbage had intended. The basic design is similar to modern computers with I/O units and memory as well as the ability to store programs and make conditional branches. Consequently, Charles Babbage is regarded as the “father” of computing.

Another working model of the Difference Engine was recently constructed from Legos!

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The Analytical Engine 1837

Charles Babbage
1791-1871
Public Domain

Charles Babbage did not let his inability to actually construct the Difference Engine deter him. By the 1837 he had conceived of an even more ambitious general purpose calculating machine, the **Analytical Engine.** On paper at least, it would have been the first calculating machine programmed with punched cards, an idea borrowed from Jacquard's loom. Steam driven with 1000 axle rods and 50,000 geared wheels, it would have been almost 100 feet long and 30 feet wide!

The Analytical Engine (based on the decimal number system) had all of the features of modern computers including a CPU, memory, a printer, a curve plotter, and even a bell. It was designed to calculate and print 50-digit numbers. The programming language would have been recognizable as a precursor of assembly language used today. Unfortunately, this machine was once again simply beyond the technical *and* financial resources of the times to build.

Many descriptions of Babbage's proposal remain, but the following commentary by the Enchantress of Numbers herself foreshadows the concept of a thinking, reasoning machine.

> "*The bounds of arithmetic were, however, out stepped the moment the idea of applying cards had occurred; and the Analytical Engine does not occupy common ground with mere calculating machines. It holds a position wholly its own; and the consideration it suggests are most interesting in their nature. In enabling mechanism to combine together general symbols, in successions of unlimited variety and extent, a uniting link is established between the operations of matter and the abstract mental processes of the most abstract branch of mathematical science.*"
>
> *Ada Lovelace, 1837*

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Lady Ada, Countess of Lovelace 1843

Lady Ada
1815-1852
Public Domain

Augusta Ada Byron, daughter of the famous British poet Lord Byron, was raised by her mother to favor science and mathematics at a time when few women were encouraged to pursue those fields. Although not recognized for her contributions, she collaborated on several projects with many famous scientists of the era.

Lady Ada was known in scientific circles as the “Enchantress of Numbers” for her ability to understand scientific and mathematical concepts. That was considered a compliment in her day.

Today she is primarily recognized for writing a detailed method to calculate Bernoulli numbers with Charles Babbage’s Analytical Engine. Some historians consider her precise instructions as the first computer program, and Lady Ada as the first computer programmer. In 1980 the U.S. Department of Defense named a programming language Ada in recognition of her contributions. The language is stilled used today.

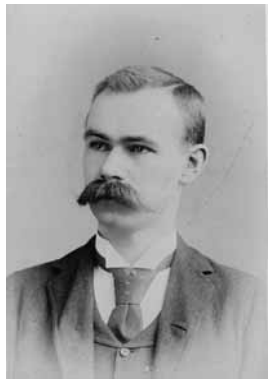
A fascinating account of her life can be found in *Bride of Science* by Benjamin Wooley or *Ada: Enchantress of Numbers* by Betty Toole.

Computer Pre-History

Herman Hollerith 1890

Tabulation of the 1880 census in the United States took seven years to complete. The population was growing so rapidly that the Census Bureau was worried the 1890 census would take even longer to tabulate, so it held a contest for the invention of a mechancial counting machine to handle the process.

A young mining engineer named Herman Hollerith, inspired by a train conductor punching passenger tickets built a tabulating machine that read punched cards. He won the contest and the 1890 census was completed in three years. Single handedly he had invented the data processing industry!



Herman Hollerith
1860-1929
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Movie

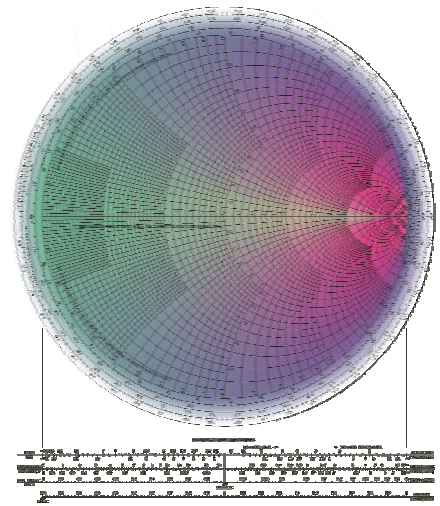
Hollerith eventually partnered with Thomas Watson and founded one of world's most successful companies: IBM.

Computer Pre-History

Analog Computers

Prior to World War II, several mechanical and electrical analog computers were constructed which used physical quantities such as voltages and currents and even water levels to represent numerical quantities. For example, the Water Integrator developed in the Soviet Union in 1936 manipulated water levels to solve differential equations.

Although analog computers were faster than early digital computers, they had to be manually re-programmed for each new problem. Results were often printed in diagrams to approximate numerical relationships.



Nomogram

Norden Bombsight

Analog computers, such as the Norden bombsight, were widely used during WWII for aiming weapons.

The most notable analog computer was the Differential Analyzer created by Vannevar Bush in 1930.

Computer Pre-History

The Differential Analyser - 1930

The Differential Anaylser was invented in 1876 by the brother of Lord Kelvin, James Thomson. It can be considered a mechanical analog computer which used a wheel-and-disk mechanism to perform integration and solve differential equations.

A more modern version was first constructed at MIT by Vannevar Bush in 1930. Among other tasks, the Differential Analyser was used to construct artillery firing tables.

Analog computers slowly fell into disuse as programmable digital computers improved.

Vannevar Bush
1890-1974
Public Domain

Differential Analyser
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It is interesting to note that many of the people pictured operating the earliest analog and digital computers were women.

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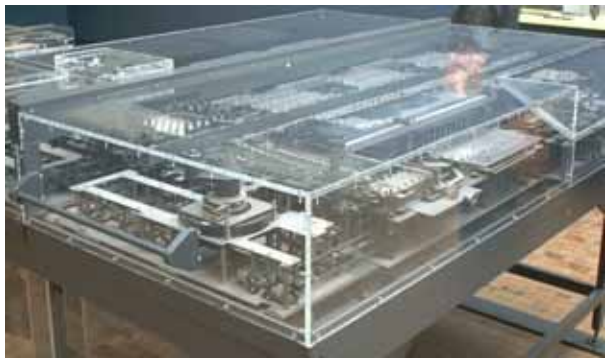
Z1 – 1936

The first electro-mechanical computer, Z1, was built by Konrad Zuse in his parent's living room in 1938. Zuse was not aware of developments The world did not know of his invention until after World War II.

Konrad Zuse
1910-1995
Public Domain

Unlike earlier calculating machines, the Z1 used the binary number system making it easier to construct and faster to use. The Z1 was programmed by a series of holes punched in film and fed through the machine like earlier devices that used card patterns.



Z1 Computer
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Computer Pre-History

Three periods of the pre-history of computers can be recognized: manual, mechanical, and electromechanical.

- The ancient Chinese, Egyptian, Babylonia, Greek, and Roman civilizations utilized manual methods of calculating, primarily the counting board and the abacus to facilitate commercial tranactions.
- Early mechanical devices to automate routine mathematical calculations appeared in the Middle Ages were followed by small geared calculating devices in the Renaissance to assist with scientific calculations.
- Attempts to construct large general purpose computing devices during the Industrial Age failed largely the inability to machine parts to the necessary precision.
- World War II provided the stimulus necessary to create a number of electromechanical and analog devices as well the programming concepts that served as the precursors to modern digital computers.