History of Computing

Before 1930 or 1940 it is difficult to separate the histories of Computing and Mathematics. Even after that date their histories are closely intertwined, involving many of the same persons.

In pre-historic times people used a unary counting system, keeping tally sticks to count things. The Unary numbering system simply used one stroke (or notch, pebble, bone,..) to stand for the number 1. More strokes represents a bigger number, so for instance 12 = | | | | | | | | | | | | |

This is easy system in which to do addition, and perhaps subtraction.

The earliest known example is the Lemombo bone dated about 35,000 BC, which consists of 29 notches cut into a baboon's fibula. Below is the Ishongo bone, dated about 22,000 BC.

Abstraction is a recurring theme in all of Computer Science, i.e. representing one thing as another simpler thing in such a way that the representation retains the essential or interesting properties of the original.

The Rhind Papyrus is an Egyptian mathematical document dating to around 1650 BC. It gives instructions on how to solve geometric and algebraic problems.

The classical Greek period in Mathematics spans about 600 BC to 400 AD. Historians traditionally place the beginning of Greek mathematics proper to Thales of Miletus (624 - 548 BC). Another important figure in the development of Greek mathematics is Pythagoras of
Samos (580 - 500 BC). Euclid of Alexandria, active through about 300 BC, is often referred to as the "Father of Geometry".

Below is a figure depicting the Pythagorean Theorem: $c^2 = a^2 + b^2$.

The great contribution of this period was the realization of the importance of logic and rational thought. For the first time it was realized that "proof" was necessary in Mathematics. Below is a figure used in one of many proofs of the Pythagorean Theorem.

Musa al-Khwarizmi was a Persian mathematician who worked from around 780 to 850 AD. His name was Latinized to Algoritmi, from which we get the word Algorithm. His work "al-Jabar" also gives us the word Algebra.

The base-10 positional numbering system (i.e. the numbers we are used to) derived from both Hindu and Arabic numerals, and was introduced to Europe around 1200 AD, replacing the earlier Roman numerals. The impact on European science and engineering was enormous, forever changing the efficiency of arithmetic computation.
In 1624 John Napier invented logarithms to simplify difficult calculations. Logarithmic functions can transform problems of multiplication and division into addition and subtraction. They form the underlying idea behind the slide rule, a device in wide use even into the age of modern computers.

Various mechanical devices have been developed over the centuries to aid in computation. Blaise Pascal invented the Pascaline that could do addition and subtraction.

Gottfried Wilhelm Leibniz constructed a calculator called the Leibniz Wheel that could add, subtract, multiply, and divide.

These devices were marvels of their time, and while they did have memory, they were not programmable. The first device to include this feature was the Jacquard loom, created by Joseph Jacquard in 1801. It used punched cards to program a pattern into cloth.
Charles Babbage (1791-1871) invented two highly advanced computing devices. One, called the Difference Engine could do arithmetic to 6 significant digits.
Another called the Analytic Engine, which he could not construct, was programmable and was startlingly similar to a modern computer. It had an arithmetic-logic unit, memory, a processor, and the ability to do basic input-output operations using punched cards.

Ada Lovelace, the daughter of the poet Lord Byron, worked with Babbage on the Analytic Engine. The modern computer language Ada is named for her.

The period 1940 to 1950 is regarded as the birth of modern computers, and when the disciplines of Mathematics and Computer Science start to truly diverge. Below is a picture of the Mark I built by Howard Aiken at Harvard University for IBM and the US Navy. It was an electro-mechanical device using a mix of relays, magnets, gears, and vacuum tubes to process data. It is generally considered one of the first (if not the first) general purpose computer.
The ENIAC (Electronic Numerical Integrator and Calculator, 1946) was 100 feet long, 10 feet high, and contained 18,000 vacuum tubes. Unlike Mark I, it was fully electronic. It was also far less powerful than a pocket calculator you can buy for $25.00 today. Both the Mark I and ENIAC were binary computers, i.e. they used the electronic states on-off to signify the binary digits 0 and 1.

John von Neumann (1903-1957) was one of the most brilliant mathematicians in history. He did pioneering work in pure mathematics, economics, game theory, operations research, and computing. His invention was the stored program computer. Until then, all computers were programed externally using wires, connectors and plug boards. The memory unit stored only data, not instructions. For each different problem, users had to rewire virtually the entire computer. Von Neumann proposed that instructions be encoded in binary, and stored in the memory of the computer along with the data. To solve a new problem, instead of rewiring the machine, you could write a new sequence of instructions. This is computer programming as we know it today. One of his early machines, built in 1953 by the RAND corporation, was the UNIVAC I. His basic design is still the basis of all modern computers, and is called the Von Neumann Architecture.

The Prisoner's Dilemma is a famous example in game theory, to which von Neumann contributed. It is also the name of an excellent book by William Poundstone that gives a pretty good account of the example, and a good biography of John von Neumann.
The main elements of the von Neumann Architecture are the Control Unit, Arithmetic-Logic Unit, Memory, and Input-Output Devices.

Alan Turing (1912-1954) was another earlier contributor to the theory and practice of computing. He provided a formalization of the concept of "algorithm" and "computation" which is today called the Turing Machine.
A Turing Machine is not a physical computing device. Rather it is an abstract mathematical
definition of a computer. It can be used to prove theorems about the limits of computation.

Claude Shannon (1916-2001) is credited with founding Information Theory.

Shannon was among the first to understand the link between information and probability. Highly unlikely events carry more information than more likely ones. He defined the basic unit of information as the Bit (binary digit). Modern communication devices like cellphones, streaming video and audio all rely on this theory.
The period 1950-1957 is thought to be the first generation of computing in the modern era. These devices included the ENIAC, EDVAC, UNIVAC I (the first computer built for sale), and the IBM 701. These machines used vacuum tubes for processing and storage, were very large and difficult to maintain.

The second generation (1957-1965) saw the replacement of vacuum tubes by transistors, reducing size, reliability, and cost of computers.
The third generation (1965 to 1975) saw the advent of the integrated circuit, a single device that included thousands (and later millions) of transistors and other components. These individual components could now be photographically etched onto a single piece of silicon. The computers of this era were sometimes called "mini computers".

The fourth generation (1975-1985) was the beginning of the "microcomputer". Integrated circuit technology had advanced to the point that a complete computer system could be contained on a single circuit board. A desk-sized machine of a few years earlier now became a desktop machine. This era saw the emergence of computer networks, electronic mail, and graphical user interfaces. These machines sparked the beginning of the software industry as we know it today.

Atair 8800 Micro Computer
HP 85 Desktop Computer
The fifth generation (1985-present) is where we are today. Some of the major advances we have seen in this era are:

**Ultra large scale integrated circuits**

**Massively parallel processors capable of quadrillions \(10^{15}\) operations per second**

**Laptops and handheld devices**
Wireless networks

Cloud computing - the delivery of computing as a service rather than a product