

## Science in History: From the Abacus to the Modern Computer Part 1: The Abacus



Even before humans could read or write, they needed to count. First they used their fingers, but when they had to deal with figures over ten, a counting device became necessary. Pebbles and bits of wood arranged on the ground were used to count goods and to figure prices. These were the predecessors of the abacus. The abacus has two distinct variations: the counting board and the bead frame abacus.

The earliest counting boards - possibly used as early as 3000 BC - probably involved pebbles and twigs and lines in the sand, so it is no wonder no such boards have ever been discovered. The oldest surviving counting board is the Salamis tablet, which was used as early as 300 BC in Babylon, and which was discovered on the island of Salamis in Greece. The Salamis tablet is a large flat slab of marble with sets of lines for different figures. Similar boards were also used in ancient Greece and Rome and in medieval Europe. These used 'counters' to keep track of figures. Greek and Roman 'counters' were usually small stones called *calculi* while Europeans used coin-like pieces of metal. The counting board may seem now like an outdated invention, but it was still being used in England as late as the 18<sup>th</sup> century.

The bead frame abacus as we know it today was probably invented by the Chinese sometime around the second century AD. It is usually made of a wooden frame with 13 vertical wires and 7 beads on each wire. The Japanese adopted and modified the Chinese abacus around the 17<sup>th</sup> century, reducing the number of beads on each wire to six and later on to five. A third form of the abacus is the Russian abacus which was probably brought to Russia from China and was modified for counting in rubles. Other ancient cultures, such as the ancient Egyptians and the Aztecs also used similar calculating devices. Without being influenced by the Chinese, the Aztec abacus evolved into a very similar device: it had exactly the same number of 'beads' and 'wires' - in this case, the beads were kernels of corn and the wires were strings.

The first counting devices were very simple. Neither a counting board nor an abacus performed any numerical operations on its own. The calculations were performed mentally by the person using the abacus, and both of these devices were only used for recording separate steps and keeping track of figures.

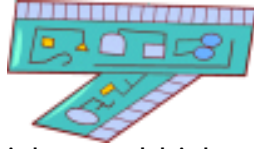
The abacus may seem obsolete in the world of modern computers, but in fact it is still in use in many countries around the world.

**Science in History:  
From the Abacus to the Modern Computer  
The Abacus: Questions**

Answer the following questions about the abacus:

1. The first counting device was .....
  - a. the Chinese abacus
  - b. the Salamis tablet
  - c. the human hand
  - d. the counting board
  
2. Why does the earliest counting board date only to 300 BC when counting boards were possibly being used in 3000 BC?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
  
3. What are *calculi*?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
  
4. Which two types of the abacus were directly derived from the Chinese abacus?
  - a. Aztec and Japanese
  - b. Japanese and Egyptian
  - c. Egyptian and Aztec
  - d. Russian and Japanese
  
5. The Japanese abacus .....
  - a. had a wooden frame and five or seven kernels on each string
  - b. was made of marble and required the use of 'counters'
  - c. was derived from the Chinese abacus in the second century AD
  - d. had a wooden frame and five or six beads on each wire
  
6. The basic function of the abacus is to:
  - a. help one in counting, in a passive way.
  - b. keep track of figures smaller than ten.
  - c. replace the calculator.
  - d. keep a record of past financial transactions
  
7. Match:
  - a. \_\_\_\_\_ abacus was invented in China
  - b. \_\_\_\_\_ abacus still used in England
  - c. \_\_\_\_\_ origin of Salamis tablet
  - d. \_\_\_\_\_ abacus still used in many countries
  1. 21<sup>st</sup> century
  2. 18<sup>th</sup> century
  3. 2<sup>nd</sup> century AD
  4. 300 BC

## Science in History: From the Abacus to the Modern Computer Part 2: The Era of Mechanical Computation



With the need to deal with higher and higher figures, a more sophisticated counting machine became necessary, but little progress was made beyond the abacus until the beginning of the seventeenth century, whose great minds gave birth to the first ideas concerning mechanical computation.

The first counting device - a mechanical "Calculating Clock" was invented by Wilhelm Schickard in 1624, but was forgotten for a time, so the man usually credited with inventing the first mechanical calculator is Blaise Pascal. Pascal, a French scientist and inventor, created a device in 1642 which, unlike the passive abacus, performed mathematical operations in an active manner. This calculator, called the 'Pascaline', could add and subtract numbers with up to eight digits, but was never used much because of its high cost and unreliability. German mathematician and philosopher Gottfried Wilhelm von Leibniz studied the Pascaline, and by means of an innovative gear system added a third function: multiplication, which was performed as a sequence of additions. The first mechanical calculator that could perform the four basic arithmetic functions was built by Frenchman Charles Xavier Thomas of Colmar more than a century later. Colmar's 'Arithometer' of 1820 was widely used until the beginning of the twentieth century.

The first step towards the creation of computers as we know them today was made by an English mathematics professor, Charles Babbage. Early on, he realized that all mathematical calculations can be broken up into simple operations which are then constantly repeated, and that these operations could be carried out by an automatic, rather than a mechanical, machine.

He started working on a 'Difference Engine', but after ten years he abandoned it for the 'Analytical Engine' - the real predecessor of the computer. The plans for the colossal steam-powered Analytical Engine made use of another great invention, punched cards, created in 1820 by Joseph-Marie Jacquard for use in looms. The cards were to function as programs. Sadly, Babbage never completed the machine, largely due to poor machining techniques of the time.

Punched cards were also used seventy years later by an American inventor, Herman Hollerith, who created a computing machine out of necessity. He was charged with the task of computing the U.S. Census, and so his machine used punched cards as a primitive form of memory to store data rather than as programs. Although still mostly mechanical, Hollerith's "computer" was the first machine to use electricity, thus bringing to a close the 'Mechanical Era' of computation.

**Science in History:  
From the Abacus to the Modern Computer  
The Era of Mechanical Computation: Questions**

Answer the following questions about early calculating devices:

1. Explain the most important difference between an abacus and early calculators.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
  
2. The first mechanical counting device was invented by ..... in .....
  - a. Blaise Pascal, 1820
  - b. William Schickard, 1624
  - c. Gottfried Wilhelm von Leibniz, 1642
  - d. Charles Xavier Thomas of Colmar, 1820
  
3. The first machine which could handle multiplication and division was...
  - a. the Pascaline
  - b. Leibniz's innovation of the Pascaline
  - c. the Arithometer
  - d. the Difference Engine
  
4. Which of these statements is true?
  - a. In 1820 Colmar's Arithometer was no longer in use.
  - b. The Pascaline could add and subtract ten-digit figures.
  - c. The Difference Engine was powered by electricity.
  - d. Babbage's Analytical Engine was never built.
  
5. The man who first planned his machine to deal with mathematical operations as sequences of simple repetitive tasks was \_\_\_\_\_.
  
6. Punched cards were .....
  - a. invented by Charles Babbage in 1820
  - b. used as programs by Herman Hollerith
  - c. first used in looms in 1820
  - d. used for storing data by Joseph-Marie Jacquard
  
7. Which of these was **not** a part of Herman Hollerith's computer?
  - a. punched cards used as programs
  - b. electrical power
  - c. punched cards used as memory
  - d. mechanical functions

## Science in History: From the Abacus to the Modern Computer Part 3: Early Computers

Babbage and Hollerith paved the way for further progress. In addition to Babbage's ideas of breaking complicated calculations down into small operations and the first attempt at programming, and Hollerith bridging the gap between the mechanical era and the new age of electronic computers, the work of mathematician George Boole was a key to further development. By means of determining that all mathematical calculations can be stated as either true or false, Boole defined the binary system - to be used by all future computers.

There are three machines which have claimed the title of being the first electronic computer ever. Instead of using electromechanical relays, they used fully electronic switches: vacuum tubes. These had one important advantage - they were about a thousand times faster than mechanical switches. They also had one disadvantage: vacuum tube computers were gigantic. This is the most important reason they were replaced by smaller transistors in the 1950s.

In 1941, J. V. Atanasoff, a professor at Iowa State University, and Clifford Berry, a graduate student, designed the first all-electronic computer using Boolean algebra. Although Atanasoff's machine used such advanced technology as vacuum tubes, it was still more like an electronic calculator than a computer.

It must be said that breakthroughs in the evolution of the computer were in many cases preceded by breakthroughs in the evolution of the calculator. Very sophisticated calculators were created in the 1930s by Konrad Zuse in Germany. Zuse, who also built computers for the German army in 1943, was one of the first to use Boole's binary system.

The Colossus, a computer designed by Englishman Alan Turing in 1943 exclusively for breaking German code messages during World War II was a second machine claiming the title of the first computer.

The third "first computer" was also originally created for military purposes: the ENIAC (Electronic Numerical Integrator and Computer), built by J. P. Eckert and J. V. Mauchly at the University of Pennsylvania, was to be used for calculating trajectory tables of newly developed weapons. However, the ENIAC was not completed until 1945. Shortly after the war it was used in developing the hydrogen bomb and later for weather prediction, etc. Although the ENIAC weighed some 80 tons and used about 1,800 square feet of floor space, it could store data and was crudely programmable - by wiring certain units of the machine in specific sequences.

Later the ABC (Atanasoff-Berry Computer) was ruled the first electronic computer, largely because it was the first to use vacuum tubes, even before the ENIAC. The inventors of the ENIAC went on to create the EDVAC, the first computer with a stored program. Since the computer was now capable of storing instructions as well as data, it could function more smoothly and was also faster.

As transistors replaced vacuum tubes in the 1950s, computers began to grow smaller and faster - a process that continues today.

**Science in History:  
From the Abacus to the Modern Computer  
Early Computers: Questions**

Answer the following questions about the first computers:

1. What number system was used by the first computers?
  - a. decimal system
  - b. duodecimal system
  - c. binary system
  - d. metric system
  
2. Name one advantage and one disadvantage of vacuum tubes:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
  
3. .... was the first all-electronic computer.
  - a. the EDVAC
  - b. Zuse's calculator
  - c. the ENIAC
  - d. the ABC
  
4. The ENIAC was the first programmable computer. How was the programming performed?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
  
5. Which of these computers were not created for military purposes?
  - a. the ABC
  - b. the ENIAC
  - c. the Colossus
  - d. Konrad Zuse's computers
  
6. Vacuum tubes .....
  - a. were first used in computers by J. V. Atanasoff
  - b. were replaced by mechanical switches
  - c. were invented by George Boole
  - d. were in use before World War I
  
7. The ENIAC was not used for .....
  - a. weather forecasting
  - b. breaking enemy code
  - c. calculating trajectories of weapons
  - d. developing the hydrogen bomb

## Science in History: From the Abacus to the Modern Computer Part 4: Computers Today



The invention of the transistor in 1947 was the beginning of a new era. Vacuum tube computers, which had taken up many rooms, now shrunk to bearable sizes. The transistor was also much faster and more reliable. As before, computers were now being used by specialized laboratories, but more often for peacetime science than for military purposes.

Early supercomputers, the Stretch by IBM and the LARC by Sperry-Rand, were built for atomic energy laboratories. These were the first machines to replace binary codes with programming codes consisting of a few letters. Additionally, they each had an operating system and a memory, and could store data on disk.

Transistors were definitely an improvement, but there was one drawback: they created heat, which tended to damage the heat-sensitive components. This problem was eliminated by the invention of the integrated circuit in 1958. The integrated circuit compressed several components onto one tiny quartz chip. The number of the components one chip could hold rose into the hundreds, later into the thousands, and then into the millions with ultra large scale integration (ULSI). In addition to the invention of the integrated circuit, another development of the 1960s was an operating system with a central program supervising other programs which could run simultaneously. Since computers were no longer so large, they also became cheaper. In the 1970s, computer manufacturers were ready to bring computers to consumers. These computers had user-friendly programs and offered the first word processors, spreadsheets, and even the first computer games!

In 1981, the first IBM PCs were introduced into homes, schools and offices. The Apple Macintosh was introduced three years later. These computers looked much like the ones we are used to today: they had a monitor, a mouse and a keyboard. The number of personal computers soared from 2 million in 1981 to almost 6 million in 1982, to 65 million in 1992.

As their potential grew, new ways of using computers were being developed. Computers could be linked together to form networks sharing software, memory space and information. The World Wide Web, which was started in 1989, links up computers worldwide to provide people with opportunities to share information and to enable communication via e-mail.

Today computers are an inseparable part of many people's lives and jobs and are likely to continue to be tools that we rely on.

**Science in History:  
From the Abacus to the Modern Computer  
Computers Today: Questions**

Answer the following questions about modern-day computers:

1. Computers using transistors were ..... than vacuum tube computers.
  
2. Early supercomputers .....
  - a. stored data on disk
  - b. had no operation system
  - c. used binary codes
  - d. had no memory yet
  
3. What disadvantage of the transistor did the integrated circuit eliminate?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
  
4. Which of these could not have been used by someone in the 1970s?
  - a. a spreadsheet
  - b. a computer game
  - c. a web-page
  - d. a word processor
  
5. The first personal computers (PCs) appeared in .....
  - a. 1989
  - b. 1981
  - c. 1958
  - d. 1947
  
6. Name at least one of the first manufacturers to supply the market with user-friendly computers:  
\_\_\_\_\_
  
7. Name at least three advantages computer networks create:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



## Science in History: From the Abacus to the Modern Computer Unit Review Questions

Answer the following questions:

1. Which of these devices did not perform numerical operations on its own (actively)?
  - a. Zuse's calculator
  - b. Greek counting boards
  - c. Babbage's Difference Engine
  - d. Apple Macintosh
  
2. Which of these used 'counters'?
  - a. Aztec abacus
  - b. The Colossus
  - c. Roman counting boards
  - d. Chinese abacus
  
3. Match the materials used with the devices/machines they were used in:

a. _____ corn kernels	1. Salamis tablet
b. _____ quartz	2. Japanese abacus
c. _____ wires	3. Aztec abacus
d. _____ marble	4. IBM PC
  
4. Which of these used beads to count?
  - a. calculator
  - b. supercomputer
  - c. counting board
  - d. abacus
  
5. Computers in the 19<sup>th</sup> century were generally ..... and ..... than computers in the second half of the 20<sup>th</sup> century.
  
6. Which of these was not mechanical?
  - a. The Pascaline
  - b. The Colossus
  - c. The Arithometer
  - d. The Difference Engine
  
7. Match the computers with the purposes they were used for:

a. _____ Hollerith's computer	1. weather prediction
b. _____ ENIAC	2. atomic energy research
c. _____ the Colossus	3. cracking code messages
d. _____ LARC	4. U.S. census

## Science in History: From the Abacus to the Modern Computer Unit Review Questions, Page 2

Answer the following questions:

8. Name at least two people who created their computers for military purposes around the time of World War II:

\_\_\_\_\_

\_\_\_\_\_

9. Arrange these components in chronological order:

- |                            |          |
|----------------------------|----------|
| a. transistor              | 1. _____ |
| b. integrated circuit      | 2. _____ |
| c. vacuum tube             | 3. _____ |
| d. electromechanical relay | 4. _____ |

10. Write the correct inventor on the line next to the inventions:

- |     |       |  |
|-----|-------|--|
| 1.  | _____ | Pascaline                                      |
| 2.  | _____ | punched cards                                  |
| 3.  | _____ | first all-electronic computer                  |
| 4.  | _____ | first device to perform 4 basic math functions |
| 5.  | _____ | first electromechanical computer               |
| 6.  | _____ | Calculator Clock                               |
| 7.  | _____ | binary system                                  |
| 8.  | _____ | Analytical Engine                              |
| 9.  | _____ | ENIAC  |
| 10. | _____ | vacuum tube calculators                        |

a. Wilhelm Schickard	b. Clifford Berry	c. Charles Babbage	d. J. P. Eckert	e. Herman Hollerith
f. Charles Xavier Thomas of Colmar	g. Konrad Zuse	h. Blaise Pascal	i. Joseph-Marie Jacquard	j. George Boole

11. Match the breakthroughs in computer development to the right dates:

- |   |         |
|---|---------|
| a. _____ Invention of the transistor            | 1. 1989 |
| b. _____ World Wide Web started                 | 2. 1958 |
| c. _____ First use of punched cards as programs | 3. 1947 |
| d. _____ Invention of the integrated circuit    | 4. 1820 |



## Science in History: From the Abacus to the Modern Computer Answer Sheet

### The Abacus

1. c
2. No counting boards dating to 3000 BC have been discovered because they were generally made of materials that do not last, e.g. twigs, pebbles, sand.
3. *Calculi* are ancient Greek and Roman counters, i.e. small round stones used on counting boards.
4. d
5. d
6. a
7. a - 3; b - 2; c - 4; d - 1

### The Era of Mechanical Computation

1. An abacus is a passive device, whereas early calculators could perform mathematical operations actively, without the user doing the operations mentally.
2. b
3. c
4. d
5. Charles Babbage
6. c
7. a

### Early Computers

1. c
2. Vacuum tubes were faster than mechanical switches used before, but used up a lot of space so vacuum tube computers were huge.
3. d
4. The ENIAC could be programmed by wiring its parts together in a certain sequence.
5. a
6. a
7. b

### Computers Today

1. faster, more reliable - any of these
2. a
3. The main disadvantage of the transistor was overheating. This is not a problem with the integrated circuit.
4. c
5. b
6. IBM, Apple
7. sharing software, sharing memory space, sharing information, communication, etc.

Name \_\_\_\_\_ Date \_\_\_\_\_

## Science in History: From the Abacus to the Modern Computer

### Review

1. b
2. c
3. a-3; b-4; c-2; d-1
4. d
5. larger, slower, more expensive, less common, less reliable etc.
6. b
7. a-4; b-1; c-3; d-2
8. Konrad Zuse, Alan Turing, J. P. Eckert, J. V. Mauchley - any two of these
9. 1-d; 2-c; 3-a; 4-b
10. a-6; b-3; c-8; d-9; e-5; f-4; g-10; h-1; i-2; j-7
11. a-3; b-1; c-4; d-2
12. c
13. c
14. a-4; b-3; c-2; d-1
15. answers will vary