

## CSCI 2121

### Lecture 1: A Brief History of the Computing Machine

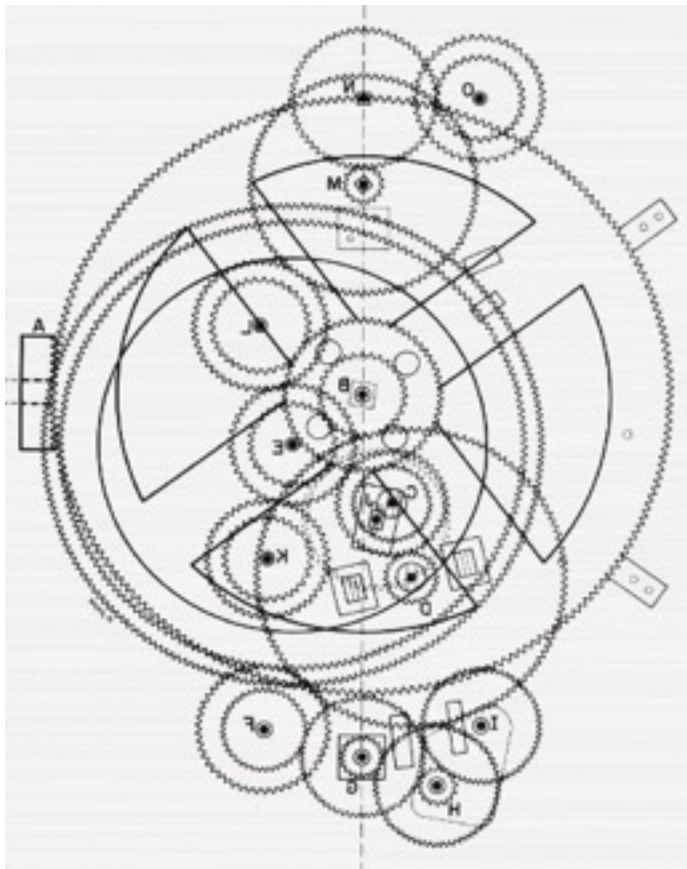
Humans have used computing devices for millennia. The first known computing device to appear, between 2700 BC and 2300 BC, was the Mesopotamian sexagesimal **abacus** (an interesting base-2 base-5 system). The abacus is not strictly a computing machine but more an aid to calculations.

<https://en.wikipedia.org/wiki/Abacus>

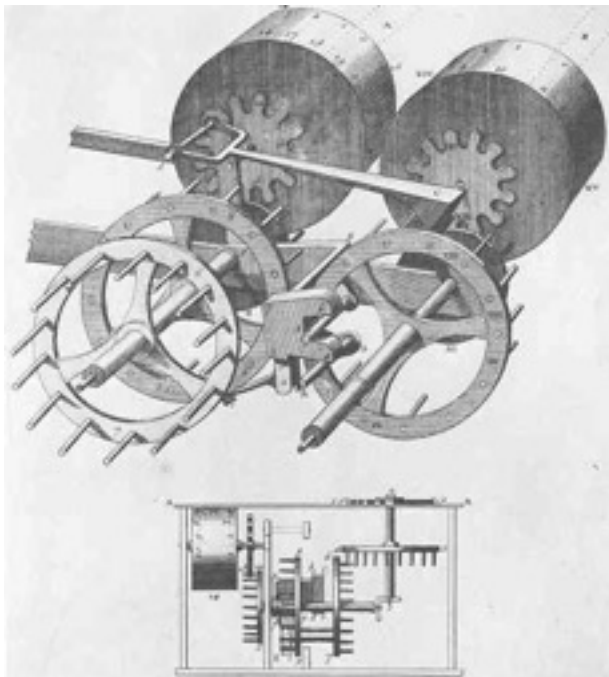
A device discovered in the wreck of an ancient Greek ship (circa 150 BC) in 1901 was recently discovered to be an orrery (think planetarium) called the [Antikythera](http://www.antikythera-mechanism.gr) – with a mechanism of at least 72 gears (the significance of this is the realization that the ancient Greeks used geared clockwork mechanisms – more than a 1000 years before they (re-)appeared). Here is a link to the research project

<http://www.antikythera-mechanism.gr>





The first truly mechanical computing machine appears in the 17<sup>th</sup> century – the device, the **Arithmetic Machine**, introduced by **Blaise Pascal** in 1642. The device could add and subtract. Subtraction was done using complements (like in a modern computer – more on this later). How could this machine be used to multiply? to divide? (Think how!).



The 17<sup>th</sup> century featured many attempts at a **mechanical computer**: The notes and letters of Leonardo Da Vinci (1500) contain evidence of and details for, building such devices - but no device appears. The oldest of such devices is the *Rechenuhr* built by Wilhelm Schickard (1625)

<http://www.computerhistory.org/revolution/calculators/1/47>

(A fun slide show is at: <http://www.computerhistory.org/revolution/>)

In 1670 Gottfried Leibnitz (1670) built the STEP RECKONER



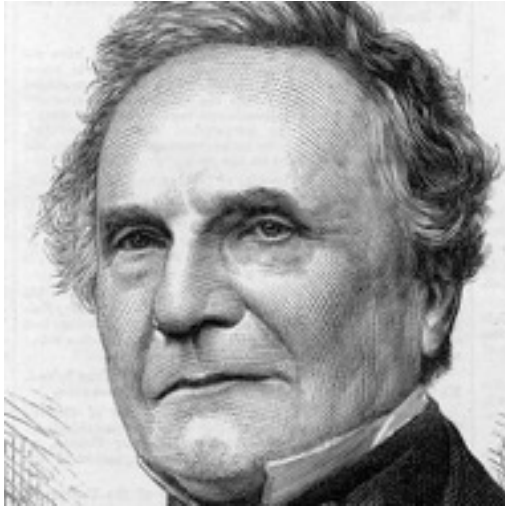
<http://www.computerhistory.org/revolution/calculators/1/49>

which could add, subtract, multiply and divide as well as take square roots (care to think how?). The problem with these devices was that they were delicate and unreliable and largely seen as curiosities. The output from Pascal's and Leibnitz's machine was obtained by observing the final gear positions.

The onset of the industrial revolution provided a great impetus to the drive to create a computing machine. It was the **age of quantification** (*everything was being reduced to a number*) and unprecedented engineering ambition. Bridges, railways, ships *etc.* were starting to be built on a commercial scale. The need for accurate and efficient calculations mushroomed. Computations were being done with the help of tables. Printed tables were being used for multiplications and a host of other regular arithmetic tasks. The problem is that the tables were riddled with errors. While this is a bad enough problem in many areas, it was catastrophic for navigational purposes. The sources of the errors were due to human fallibility. To construct the tables, (i) mathematicians devised formulae and then, over the range of values the tables were to cover, they calculated PIVOTAL VALUES at very large intervals. (ii) Next, the repeated mathematical calculations to fill-in the values between the pivotal were farmed out to 'computers' (low paid people who put up with the

drudgery). (iii) Each computation, performed by two independent computers, was assumed correct if the result was the same. (iv) The checked numbers were copied into lists, which were sent to the printers (v) where the manuscript was typeset. Each of the five steps above was fraught with error. Even the printing step could result in the type could be pulled out due to sticky ink, resulting in tables of uncertain accuracy.

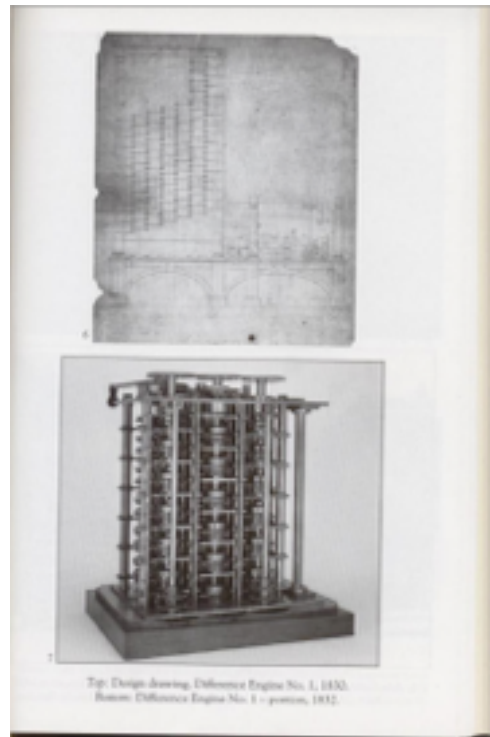
In 1821, Charles Babbage, finding error upon error in tables he was using, exclaimed “ I wish to God these calculations had been executed by steam”. He was to spend the rest of



his life building a machine that could perform calculations and print them out on paper. Babbage’s machines were never finished, although working models were. He first built the DIFFERENCE ENGINE that could perform a various calculations with a few adjustments. Babbage soon realized the worth of separating the machine into a section where the numerical computations were performed: THE MILL and the part where the numbers were stored THE STORE. This separation of the CENTRAL

PROCESSOR from the MEMORY is a central feature of all modern computers. This is not the only innovation by Babbage that has survived to the present day.

(I recommend reading *The Difference Engine: Charles Babbage and the Quest to Build the First Computer* by Doron Swade )



<http://www.computerhistory.org/revolution/calculators/1/51/2205>

(Interesting video on Babbage’s work here).

In 1801 Joseph Jacquard developed a weaving loom, where the patterns of the weave was fed into the loom with cards punched with holes. The cards were “read” by metal rods that controlled the various coloured threads. The concept of SOFTWARE was born.



(Another great read *Jacquard's Web: How a Hand-Loom Led to the Birth of the Information Age* by James Essinger).

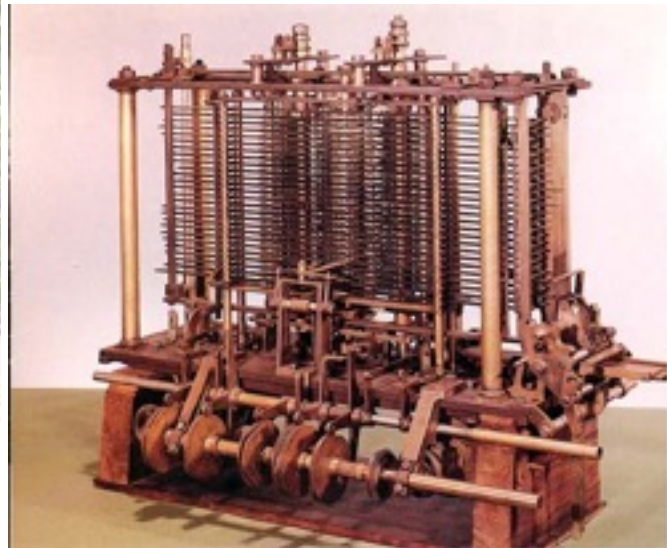
Babbage, inspired by the Jacquard loom, designed a general purpose computing machine to which the PROGRAM could be fed in by PUNCHED CARDS. By 1836, more than a hundred years before the appearance of a GENERAL PURPOSE (programmable) COMPUTER, Babbage had foreseen the idea.





Augusta Ada Byron – the Countess of Lovelace (the poet Lord Byron’s daughter – there is another book in this – for anyone with such ambitions) published a paper demonstrating how the ANALYTIC ENGINE could be programmed – making her the first computer scientist (although books often refer to her as the first programmer – she would have been livid! – as she was with Babbage – but that is another story) – a modern computing language ADA is named in her honour.

Lack of precision engineering prevented



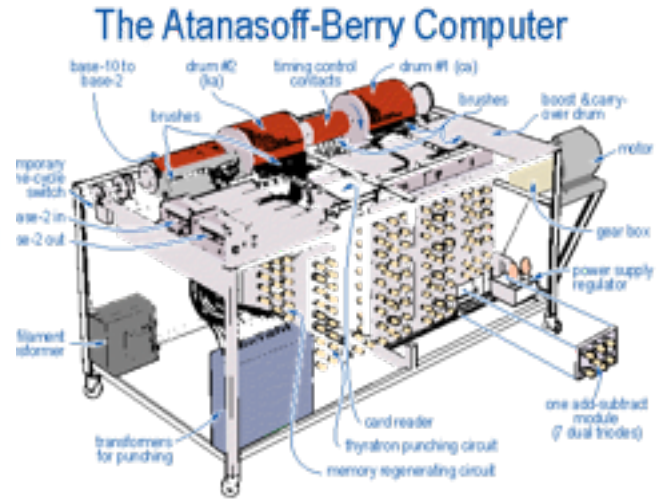
Babbage from creating a reliable and easily manufactured machine. These difficulties were overcome in the 20<sup>th</sup> century when the gears in the early machines were replaced. At first, with electrically controlled relays, a technology that existed because of the telegraph, then with vacuum tubes (diodes and triodes) and finally with the transistor.

In 1936 Alan Turing, publishes a paper, that becomes the foundation of modern computer science. In the paper he describes a Universal Machine that can decode and perform any set of instructions. [http://www.cs.virginia.edu/~robins/Turing\\_Paper\\_1936.pdf](http://www.cs.virginia.edu/~robins/Turing_Paper_1936.pdf)

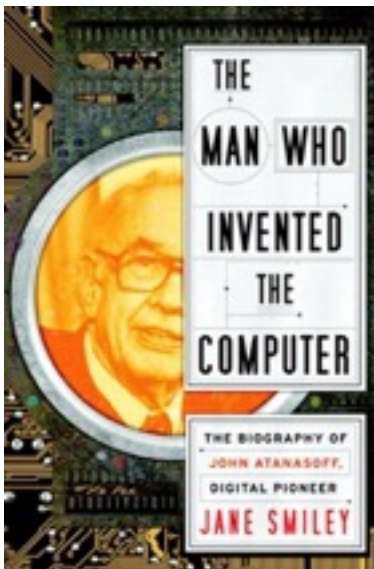
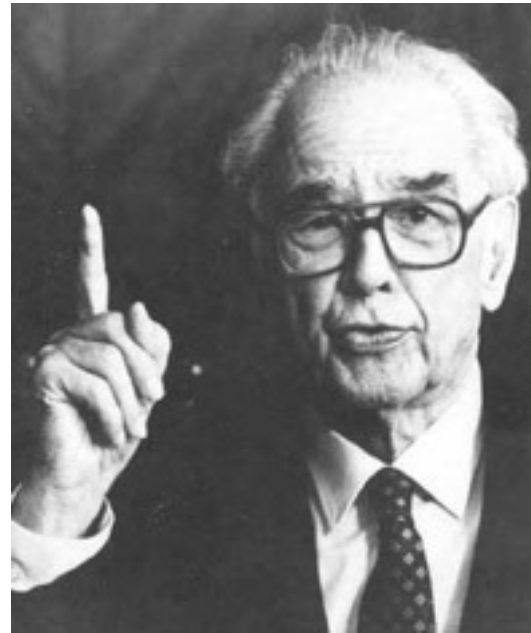
A simple tutorial on the Turing machine is here:

<https://www.cl.cam.ac.uk/projects/raspberrypi/tutorials/turing-machine/one.html>

In fact Turing comes up with a very simple way of translation instructions like ‘add’ and ‘subtract’ into a language the machine understands, by using a ‘paper tape’ with ‘1’s and ‘0’s that tell the machine how to behave. The genius of the idea is that to perform a different task, only the tape needs to be changed (*can you guess what the ‘paper tape’ is on your laptop?*)



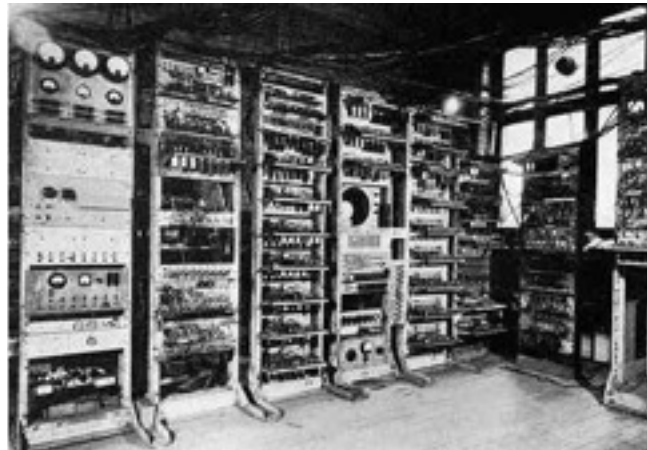
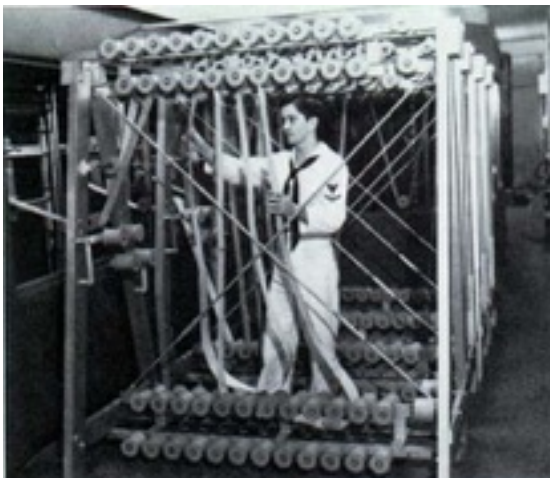
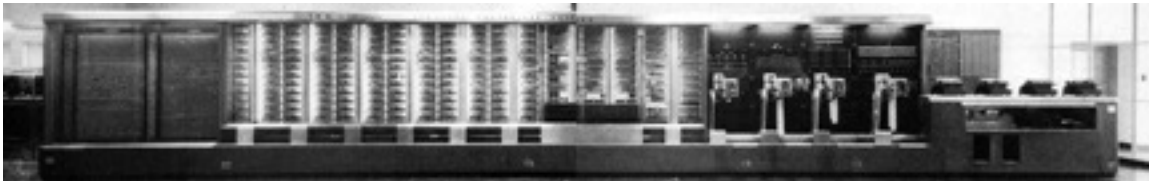
Possibly, the first digital computer was the [Atanasoff-Berry Computer](#) (ABC) were conceived by John Atanasoff (professor of physics at Iowa State College) in a flash of insight during the winter of 1937–1938 after a drive to Rock Island, Illinois. With a grant of \$650 received in September 1939 and the assistance of his graduate student [Clifford Berry](#), the ABC was prototyped by November of that year. The key ideas employed in the ABC included [binary](#) math and [Boolean logic](#).



After this, things moved fast!

- ✳ The MARK I, constructed in 1944 at Harvard by Howard Aiken and a group of IBM engineers, used relays ensuring that their computer became obsolete as soon as it was finished. Setting yet another precedent for the modern computer industry. However, the computer was used to design the first atomic bomb. More sophisticated versions were made with Mark II III IV

<http://www.computerhistory.org/revolution/birth-of-the-computer/4/86>



- ✳ In 1943, Alan Turing working on the Colossus project designed and used a computer, The bombe <http://www.turing.org.uk/scrapbook/ww2.html> to break the Enigma code (used by the Germans to communicate with U-Boats), considered unbreakable. *The Imitation Game* is a marvellous movie about Turing and the breaking of the Enigma code - **watch it as 'reading' for this lecture.**

The idea of the universal machine was foreign to the world of 1945.

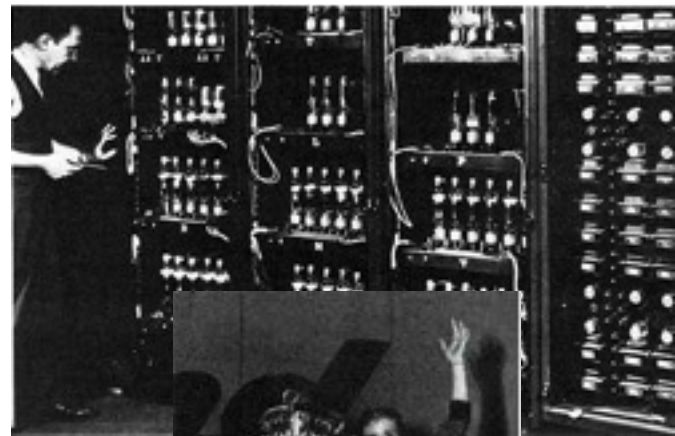
Even ten years later, in 1956, the big chief of the electromagnetic relay calculator at Harvard, Howard Aiken, could write:

*If it should turn out that the basic logics of a machine designed for the numerical solution of differential equations coincide with the logics of a machine intended to make bills for a department store, I would regard this as the most amazing coincidence that I have ever encountered.*

- ✱ Between 1936 and 1945 [Konrad Zuse](#), in Germany built a series of electro-mechanical computers of increasing sophistication: Z1 to Z4. The Z3 development was held up as the German government designated the project ‘strategically unimportant’. By the Z4, Zuse realized the difficulty of programming in machine language, so he developed a remarkably advanced language for expressing computations called [PLANKALKUL](#). Before (and for almost 15 years after this, programming meant coding in machine language or primitive assembly language) The details of Zuse’s work were only published in 1972.

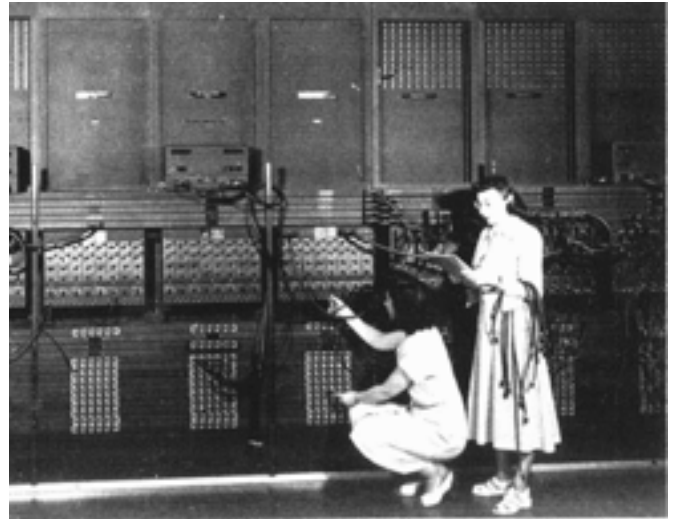


- ✱ Between 1943/46 J. Prosper Eckert and John Mauchly at Univ. of Pennsylvania built a truly modern GENERAL PURPOSE computer, the ENIAC (Electronic Numerical Integrator and Computer).
- ✱ The ENIAC was constructed to calculate artillery-firing tables and was ‘programmed’ by manually setting switches and connecting cables.



- ✱ The pair then went on to develop the EDVAC (Electronic Discrete Variable Automatic Computer) – where they discussed **STORING PROGRAMS AS NUMBERS**. Unfortunately for them, a brilliant (and very well-known) mathematician Johann von Neumann joined the ENIAC project. Von Neumann’s name is forever linked with this “new” idea of the **STORED PROGRAM COMPUTER**. Poor

Eckert and poor Mauchly – they were robbed! But then again, Mauchly may well have stolen the ideas and design details from Atanasoff (a lawsuit in 1971 said so). The sympathy for the two should be tempered – If you were to read: *The man who invented the computer* by Jane Smiley – it seems they actually ripped-off John Vincent Atanasoff!



✳ Von Neumann writes the famous *First Draft*

✳ <https://archive.org/details/firstdraftofrepo00vonn>

which outlined the logical design of a ‘stored-program computer’, known today as the von Neumann architecture. *Almost every modern computer follows the design von Neumann wrote in his now famous “[first draft](#)” (one of the most famous documents in modern computing history).*

✳ THE VON NEUMANN DESIGN FOR THE MODERN COMPUTER:

1. A MEMORY unit which would contain both the DATA and the INSTRUCTIONS for processing the data. Also, the instruction and data memory locations could be read in any order.
2. A CALCULATING UNIT capable of performing arithmetic and logic operations on the data (actually it could do so on the instructions as well).
3. A CONTROL UNIT, which could interpret the instructions (remember these were stored as numbers) retrieved from memory. The control unit could also select among several courses of actions depending upon the outcome of executing previous operations.

At this point the history of the computing machine is a sequence of technological advances:

✳ John Backus and a team at IBM (1954 - 57) built a commercial computer, which could use a HIGH-LEVEL programming language called FORTRAN (FORMula TRANslation). More of this in *PPL (CSCI 3136)*

(Read *Out of Their Minds* by Shasha Lazere)

✱ Ted Hoff invents the microprocessor in 1971/72. Intel appears on the scene with the [Intel 4004](#) in Nov 1971, designed by Frederico Fagin, It was a [4-bit CPU](#) (really look at this link!) that worked at 740KHz and had as much computing power as the ENIAC on a single chip! The first microprocessor commercially available. The Intel 8080 (an early ancestor of the PENTIUM/i7 – first sign of the revolution to come) appeared in 1974 .

✱ In 1976, Steve Jobs and Steve Wozniak start Apple Computer – to sell a commercially viable home computer. The year before, a small company called MICROSOFT was formed to sell software for the home hobbyist.

✱ In 1981, IBM released the IBM PC (with an open architecture) with underlying software developed by a small company called MICROSOFT.

✱ In 1989 Tim Berners-Lee working at CERN in Switzerland invented the WORLD WIDE WEB. The basic idea being to merge the technologies of PC's, computer networks and hypertext to create an automatic information sharing system.

The rest of the advances you have been around for .....

Advances in computing machines are spoken in terms of generations (by the sort who like to categorize these sort of things – I find it useless – and even a bit annoying due to its ignorance). Quantum Computing has appeared on the horizon – a fundamentally different paradigm of computing may already be underway – your kids may eventually ask you about it.....The course is **definitely** not about this

Gen.	Years	Technology	Product
1	1950-59	Vacuum tubes	Commercial Electronic Comp.
2	1960-68	Transistors	Cheaper Computer
3	1969-77	Integrated Circuits	Minicomputer
4	1978-?	VLSI	PCs and workstations
5	?	Biological? Quantum?	?

