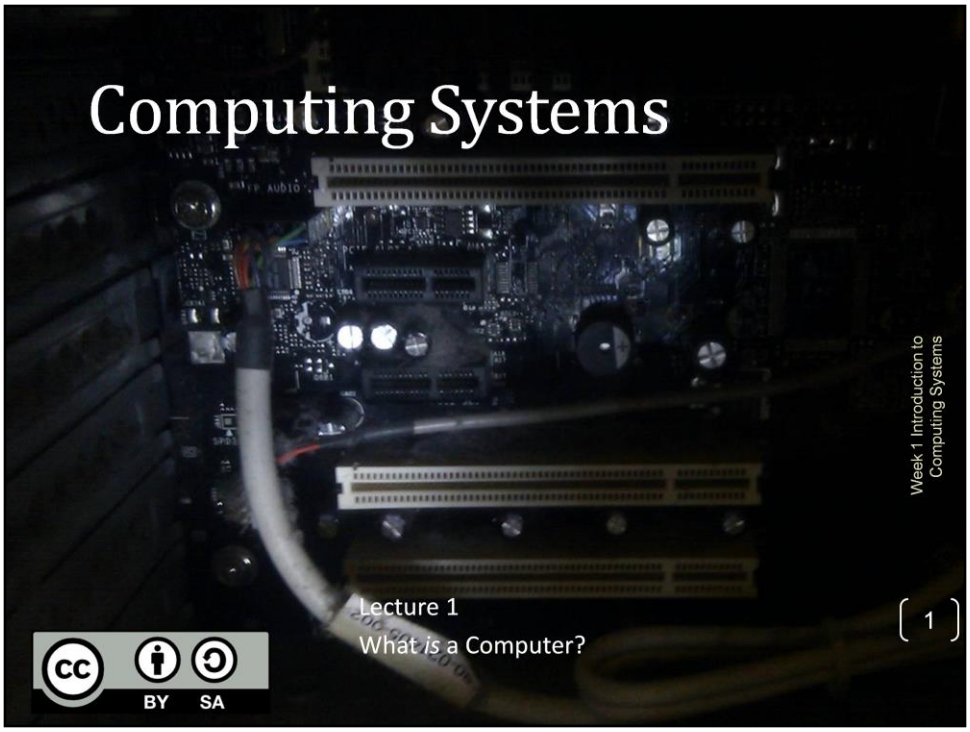
Computing Systems
Week 1 Introduction to Computing Systems
Lecture 1
What *is* a Computer?
1
BY SA

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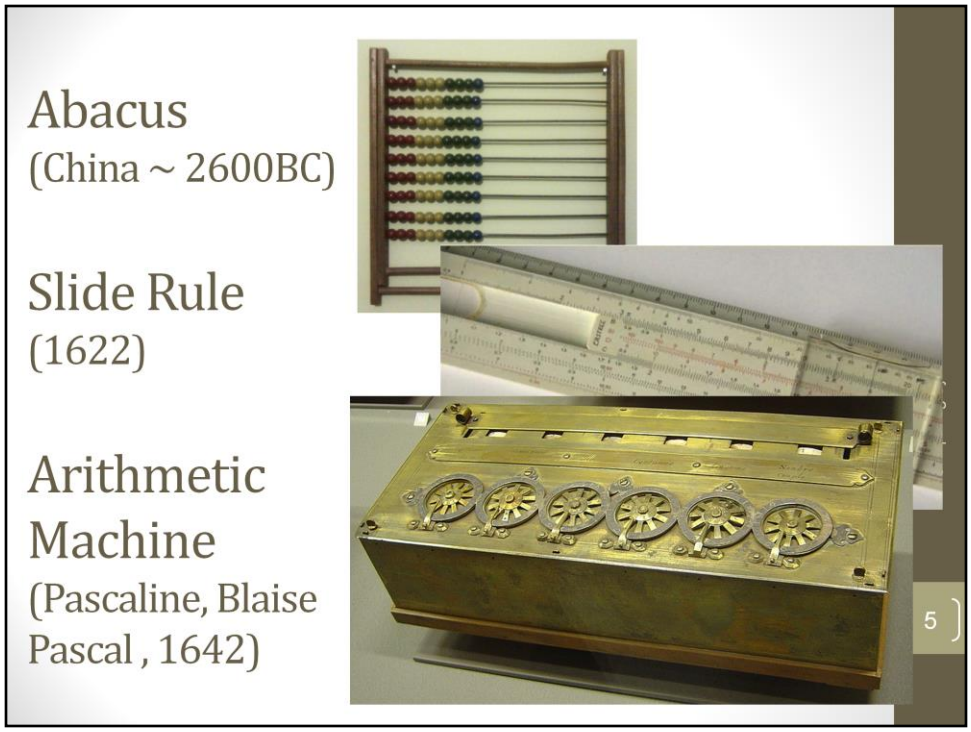
Mechanical Computing Systems

- Human attempts to create tools to manipulate data date back at least as far as 2600 B.C. when the Chinese came up with the abacus.
- Later on, Leonardo da Vinci created a mechanical calculator.
- When the slide rule was invented in 1621, it remained the mathematician's tool of choice until the electronic calculator took over in the early 1970s.

Mechanical Computing Systems

- All the early efforts to juggle numbers had *two things in common*: They were mechanical and they were on a human scale.
- They were machines made of parts big enough to assemble by hand.
- Blaise Pascal 's Arithmetic Machine used a system of gears turned by hand to do subtraction and addition.
  - It also used punch cards to store data, a method that's survived well into the 20th century.



Early Calculating Devices:

Abacus: over 3,000 years old. Exist in different forms, used to do calculations, Western form. Person performs the calculations by moving the beads, e.g. addition

Slide Rule: Based on Napiers Logarithms, could perform very large calculations, was very popular, used for over 350 years when pocket calculators took over.

Arithmetic Machine: Use the dials to enter different number, then shift things to calculations, could do quit difficult calculations.

Jacquard Loom
-
punch cards for weaving patterns (1801)

Week 1 Introduction to Computing Systems

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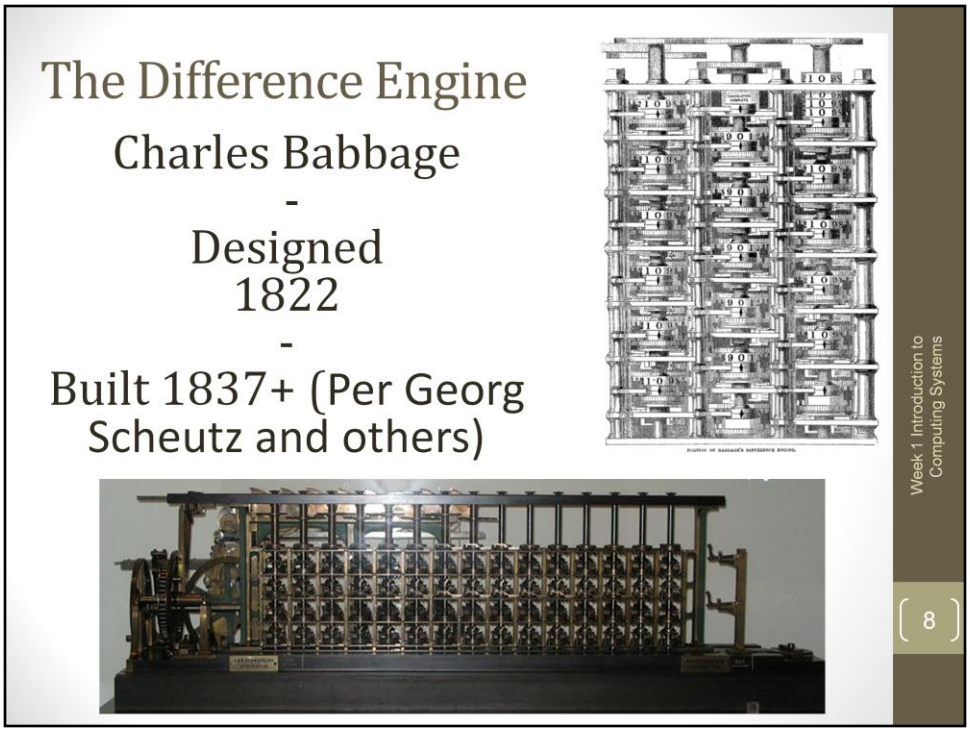
Jacquard Loom: used for making cloth and fabric, used punch cards which contain the pattern.
This automates the weaving of fabric, using the cards.
You can change the program by putting in another card, therefore is a programmable device. Not a computer but is a loom.
It probably makes less mistakes than a human.
It does have **Input/Process/Output,** but is **not** a computer.

Antikythera Mechanism

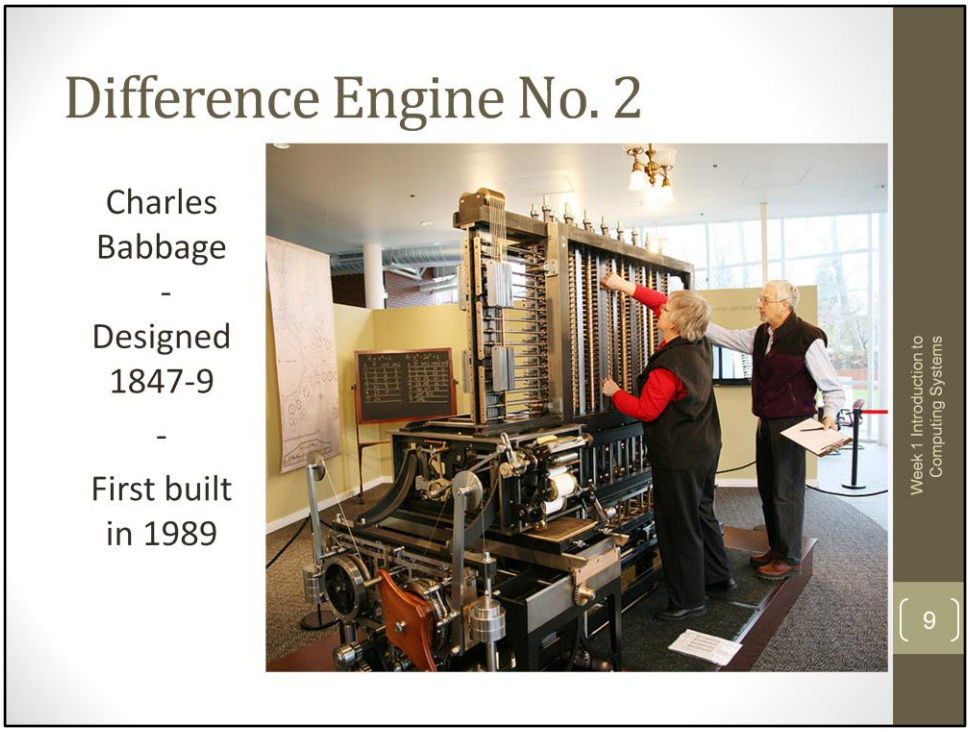
Ancient Greek astronomical clock ~150 BC

Contemporary accounts of other similar devices by e.g. Archimedes. None survive.

Antikythera Mechanism: piece of original on the left. Found in 1901 in a sunken ship. Reproduction on the right.
It is programmable, to work out the different positions of planetary bodies in the sky. Has a lot of interworking gears and mechanisms and it does execute a program of sorts. Program is hard coded in the gears and how they are set and positioned determines the program. Non survive and were considered legends until the Antikythera Mechanism turned up

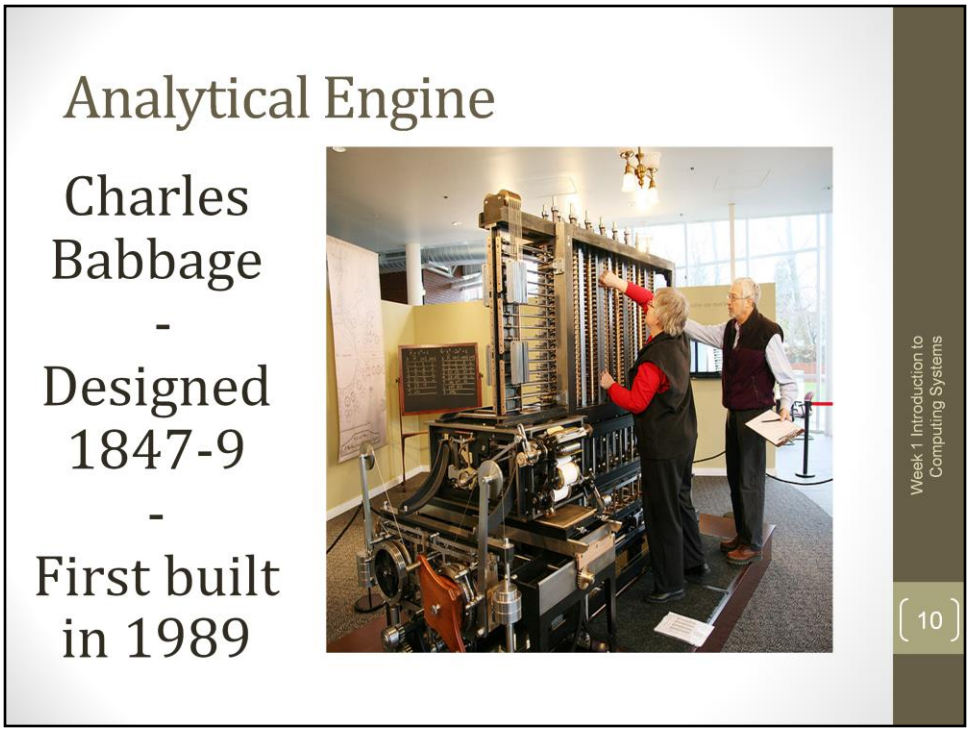


The Difference Engine:
First one built in 1837.
Could be used to perform huge numbers of calculations and is all mechanical.
Turn levers and dials and the whole thing rotates and you can see what is going on as it calculates.



Difference Engine No. 2:

Designed in the 1840s by Babbage but wasn't built till 1989 as he could persuade anyone to give him the money to build it. It was pushing the engineering capabilities of the time. Could produce huge amount of calculations and is comparable in power to some of the early electronic devices. Used for scientific, business calculations. He was a bit far ahead of his time



The Analytical Engine: Babbage designed Never built BUT Never built .
Mechanical, made of cogs, gears and levers. Design of it if built would have been the first 'mechanical *digital programmable general purpose computer*'.

In 2010 John Graham Cumming started a campaign to raise money to build the first Analytical Engine
As there is a belief if it had been built it would have worked with some very MINOR corrections in debugging

Analytical Engine

- In 1830, Charles Babbage invented-on paper-the Analytical Engine, which was different from its predecessors because, based on the results of its own computations, it could make decisions such as sequential control, branching, and looping.
- Babbage's machine was so complex that he died in 1871 without finishing it.

Analytical Engine

- It was built between 1989 and 1991 by dedicated members of the Science Museum in London.
- The physical size and complex mechanics of these mechanisms limited their usefulness; they were good for only a few tasks, and they were not something that could be mass produced.

Beginning of IBM

- Mechanical devices of all types flourished modestly during the first half of the 20th century.
- Herman Hollerith invented a mechanized system of paper cards with holes in them to tabulate the U.S. Census.
- In 1924, Hollerith's Computing Tabulating Recording Company changed its name to International Business Machines.

Diode Vacuum Tube

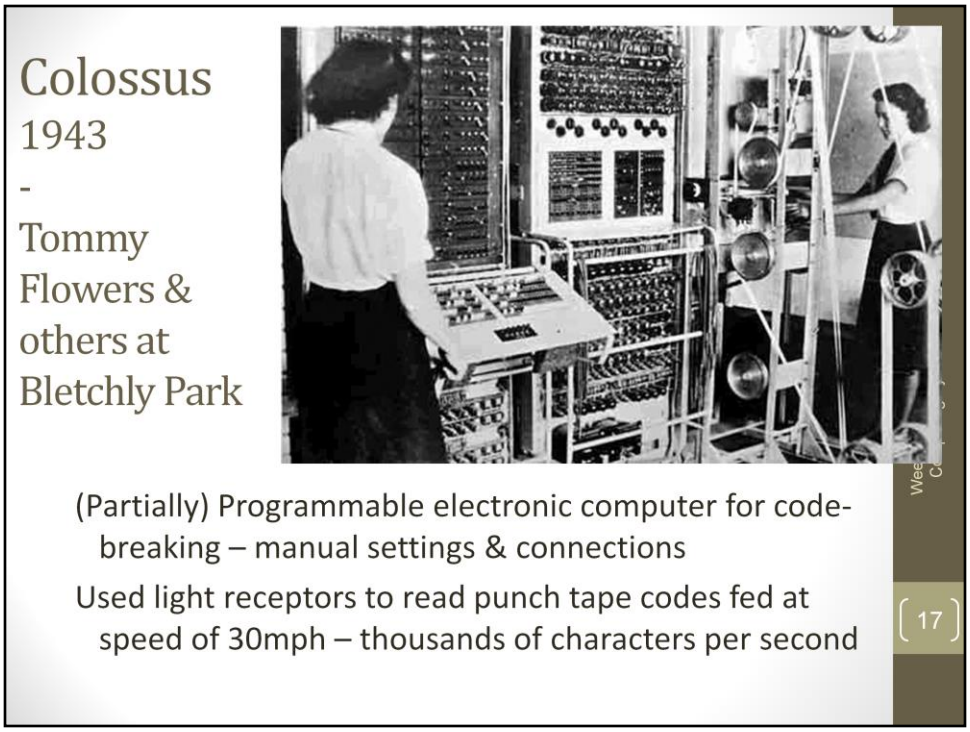
- Although no one could have known it at the time, the first breakthrough to the modern computer occurred in 1904 when John Ambrose Fleming created the first commercial diode vacuum tube, something Thomas Edison had discovered and discarded as worthless.
- The significance of the vacuum tube is that it was the first step beyond the human scale of machines.

Diode Vacuum Tube

- Until it came along, computations were made first by gears and then by switches.
- The vacuum tube could act as a switch turning on and off thousands of times faster than mechanical contraptions.
- Vacuum tubes were at the heart of Colossus, a computer created by the British during World War II to break the German Lorenz cipher.

Early Electronic Computers

- The Germans reportedly came up with a general-purpose computer --- one not limited to a specific task as Colossus was. But the German invention was lost or destroyed in the war.



Colossus:
First programmable **electronic** computer.
Not the first programmable computer.
There are other electrically powered computers from the 40s which are less well known.

(Partially) Programmable – did a set task it BROKE CODE. You could change jumper settings to change the code it would break.

It broke a code called 'lorenze' by Germans and 'fish' by the British. Only used by the German High Command, and was much harder to break than the Enigma. Allies never managed to capture one of the machines used for making the code until after the war. About a dozen were built to break code during the war.

The wheels have a tape on them which created a punched tape, which was fed through at a speed of 30 miles per hour, reading several thousand characters per seconds, processing vast amounts of data along time ago. Could work at 60 mph but the tape broke.

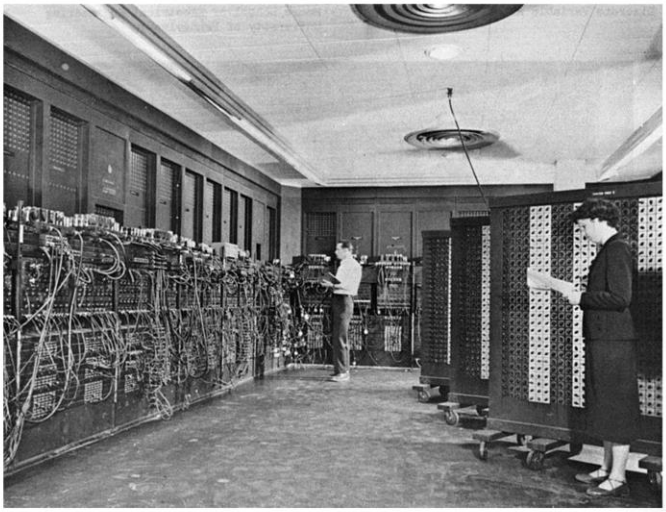
Went from a human driven process that took several months took break one message to breaking thousands of messages every day.

Enigma was a code broken by a different machine. Main code used by Germany in WW2 and before by Army and Navy. Allies never managed to capture one of the machines used for making the code until after the war.

ENIAC

- The war also gave birth to ENIAC (Electronic Numerical Integrator Analyser and Computer), built between 1943 and 1945 by the U.S. Army to produce missile trajectory tables.
- ENIAC performed 5,000 additions a second, although a problem that took two seconds to solve required two days to set up.
- ENIAC weighed 30 tons, contained 1,500 relays and 17,468 vacuum tubes.

ENIAC



Name	First operational	Numeral system	Computing mechanism	Programming	Turing complete
Zuse Z3 (Germany)	May 1941	Binary floating point	Electro-mechanical	Program-controlled by punched film stock (but no conditional branch)	Yes (1998)
Atanasoff–Berry Computer (US)	1942	Binary	Electronic	Not programmable—single purpose	No
Colossus Mark 1 (UK)	February 1944	Binary	Electronic	Program-controlled by patch cables and switches	No
Harvard Mark I – IBM ASCC (US)	May 1944	Decimal	Electro-mechanical	Program-controlled by 24-channel punched paper tape (but no conditional branch)	No
Colossus Mark 2 (UK)	June 1944	Binary	Electronic	Program-controlled by patch cables and switches	No
Zuse Z4 (Germany)	March 1945	Binary floating point	Electro-mechanical	Program-controlled by punched film stock	Yes
ENIAC (US)	July 1946	Decimal	Electronic	Program-controlled by patch cables and switches	Yes
Manchester Small-Scale Experimental Machine (Baby) (UK)	June 1948	Binary	Electronic	Stored-program in Williams cathode ray tube memory	Yes
Modified ENIAC (US)	September 1948	Decimal	Electronic	Program-controlled by patch cables and switches plus a primitive read-only stored programming mechanism using the Function Tables as program ROM	Yes
EDSAC (UK)	May 1949	Binary	Electronic	Stored-program in mercury delay line memory	Yes
Manchester Mark 1 (UK)	October 1949	Binary	Electronic	Stored-program in Williams cathode ray tube memory and magnetic drum memory	Yes
CSIRAC (Australia)	November 1949	Binary	Electronic	Stored-program in mercury delay line memory	Yes

Table from ‘Wikipedia’ showing early computers from the 40s, a good source.
Zuse not very well known, they were produced and destroyed during the war. It was only decades later information about them came out.
Colossus was also highly secret, until the 1970s, Bletchley Park and all the work there was secret till the 70s.
Because of this this US got the credit for all the early computers which were built.

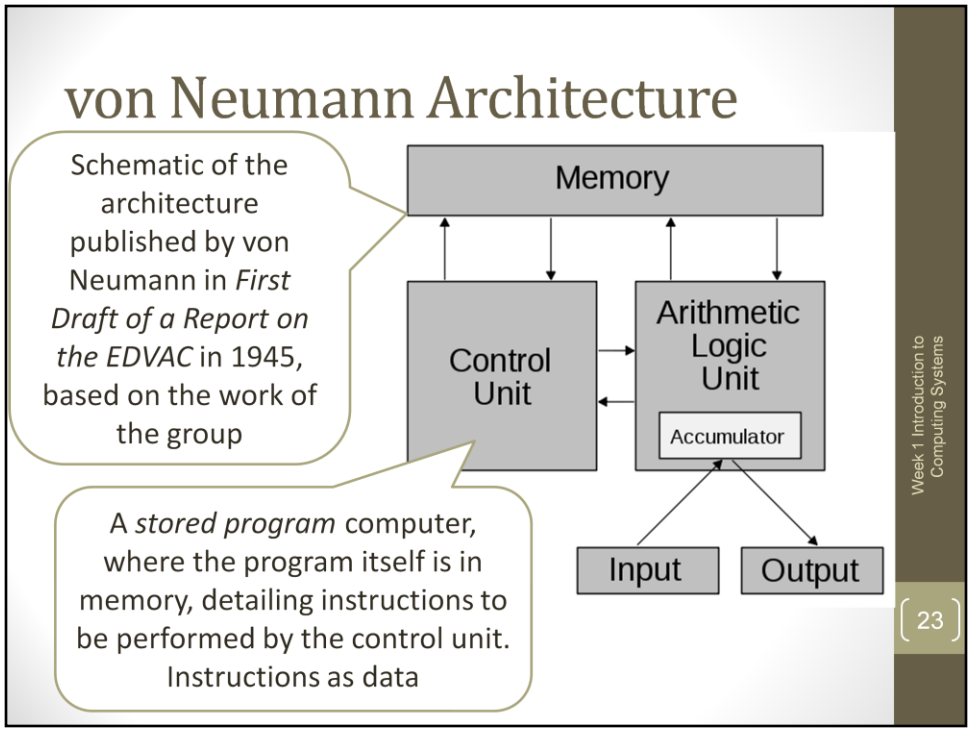
The column Turing Complete - is explained later in the course. Zuse Z3, is Turing Complete but was Electro-mechanical using Relays instead of Valves.

Vacuum Tube Problems

- Those same tubes that made ENIAC possible in the first place were also its Achilles' heel. Consuming 200 kilowatts of electricity each hour, the tubes turned the computer into an oven, constantly cooking its own components. Breakdowns were frequent. What was needed was something that did the job of the tubes without the heat, bulk, and fragility. And that something had been around since 1926.

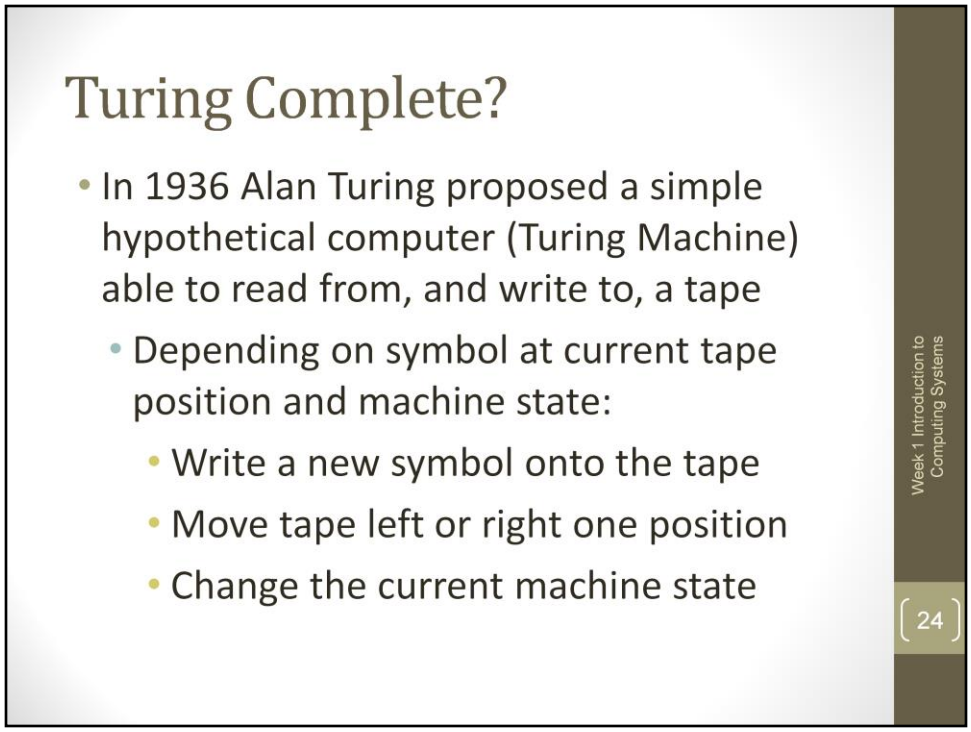
First Semiconductor Transistor

- In 1926, the first semiconductor transistor was invented, but it wasn't until 1947, when Bell Labs' William Shockley patented the modern solid state, reliable transistor, that a new era in computing dawned.
- The transistor did essentially the same thing a vacuum tube did-control the flow of electricity - but it was the size of a pea and generated little heat.



Prior to stored program... (from Wikipedia): "Reprogramming", when it was possible at all, was a laborious process, starting with flowcharts and paper notes, followed by detailed engineering designs, and then the often-arduous process of physically re-wiring and re-building the machine. It could take three weeks to set up a program on ENIAC and get it working.[1]

The idea of the stored-program computer changed all that: a computer that by design includes an instruction set and can store in memory a set of instructions (a program) that details the computation.

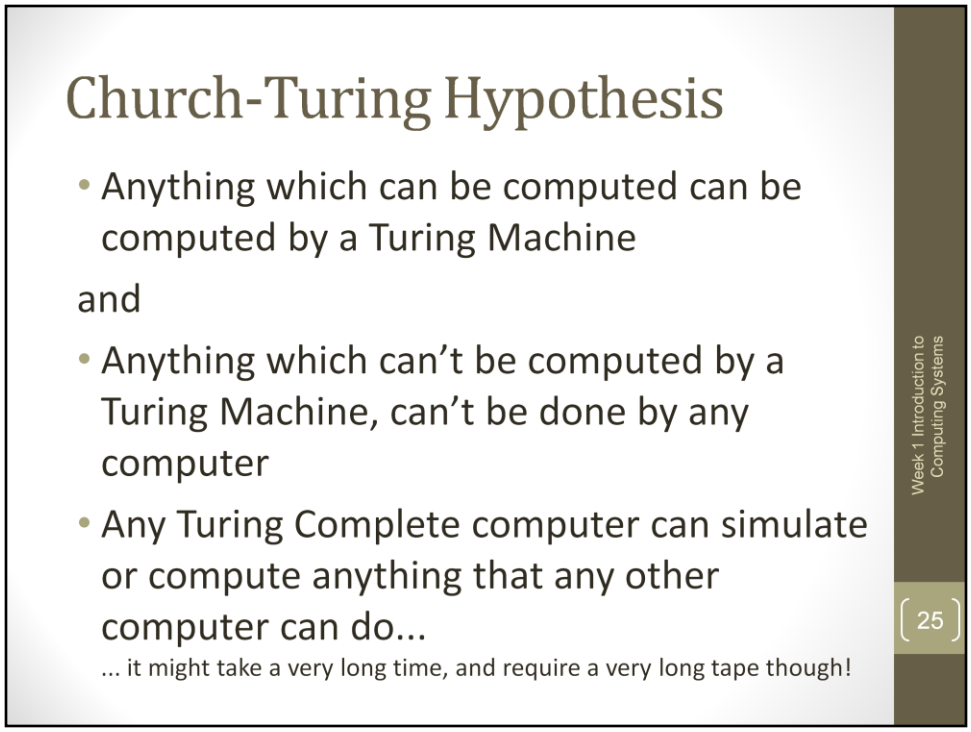


Worked in Bletchley Park but not on Colossus.

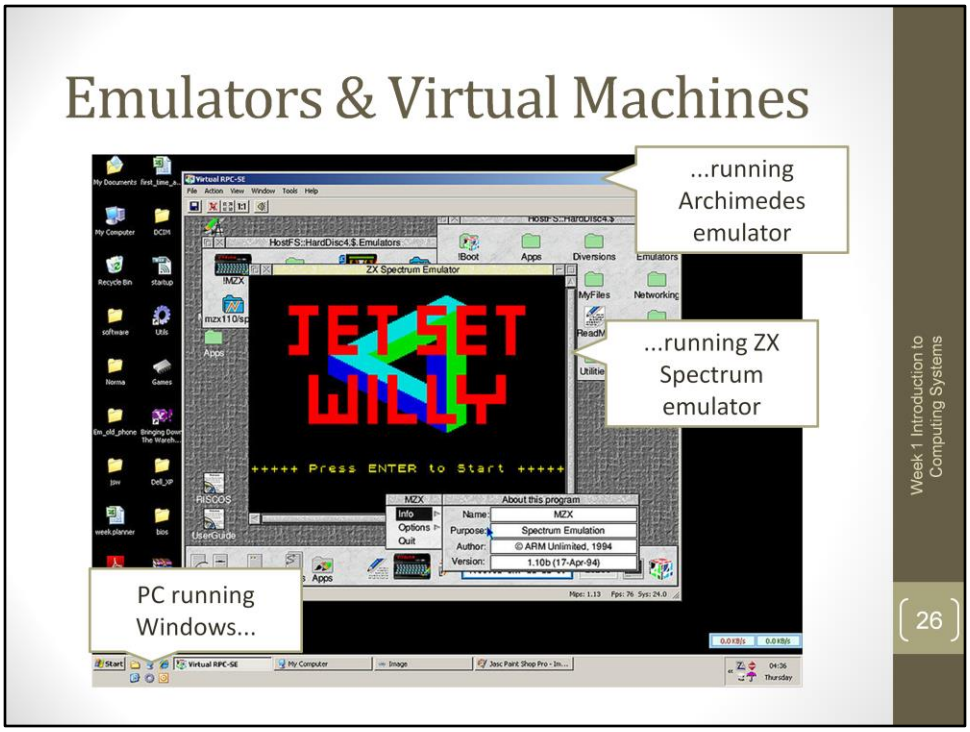
He DEVELOPED the machines that DECODED the ENIGMA MESSAGES, a different machine altogether.

Turing PROPOSED the Simple hypothetical computer (Turing Machine) – An IMAGINERY COMPUTER.

It can CHANGE the current STATE of a SYMBOL to different one, it can move the TAPE LEFT or RIGHT or change the STATE of the machine.



A Turing Machine with a tape that can be infinitely long, i.e. an imaginary computer with an imaginary infinitely long tape, therefore an infinite amount of memory then anything that can be computed can be computed by a Turing machine. i.e. any computation that is solvable can be done on a Turing machine. Also anything that cannot be done by a Turing machine cannot be done by any computer, i.e. non solvable problems. Any Turing Complete computer can simulate or compute anything that any other computer can do...



A consequence of this is that we have emulators and virtual machines. Here we have a PC running an Archimedes emulator which is running a ZX spectrum emulator (an early 80s home computer).

The Church Turing hypothesis says that in principle, though it would be incredibly slow, if we gave a ZX spectrum enough memory and enough time we could run an Acorn Archimedes emulator on a ZX spectrum and a PC emulator on the emulated Acorn Archimedes. It is theoretically possible but not practically possible because of time and memory requirements. Therefore a slower machine could emulate a faster machine, but it would take it a very long time and would require a lot of memory.

Any Turing Complete machine can run any program which can be computed. That is why it is important for understanding the capabilities of modern computers.

IBM introduces the 650

- Even with the transistor, the few computers built then still used tubes.
- It wasn't until 1954, when Texas Instruments created a way to produce silicon transistors commercially, that the modern computer took off.
- That same year IBM introduced the 650, the first mass-produced computer.
- Businesses and the government bought 120 of them the first year.

Altair 8800

- The computer grew increasingly smaller and more powerful, but its cost, complexity, and unswerving unfriendliness kept it the tool of the technological elite.
- It wasn't until 1975 that something resembling a personal computer appeared.
- The January issue of Popular Electronics featured on its cover something called the Altair 8800, made by Micro Instrumentation and Telemetry Systems (MITS).

Altair 8800

- For $397, customers got a kit that included an Intel 8080 microprocessor and 256 bytes of memory.
- There was no keyboard; programs and data were both entered by clicking switches on the front of the Altair.
- There was no monitor.
- Results were read by interpreting a pattern of small red lights. But it was a real computer cheap enough for anyone to afford.
- MITS received orders for 4,000 Altair systems within a few weeks.

Altair 8800

Apple

- The new computer was at first a toy for hobbyists and hackers.
- They devised clever ways to expand the Altair and similar microcomputers with keyboards, video displays, magnetic tape, and then diskette storage.
- Then two hackers-Stephen Jobs and Steve Wozniak---created a personal computer that came complete with display, built-in keyboard, and disk storage, and began hawking it at computer clubs in California.

Apple and IBM PC

- They called it the Apple, and it was the first personal computer that was powerful enough, and friendly enough, to be more than a toy.
- The development that finally broke the dam, unleashing microcomputers on a society that would forever after be different, was not a technical invention.
- It was a marketing decision IBM made when creating its first personal computer, the IBM PC.

IBM PC

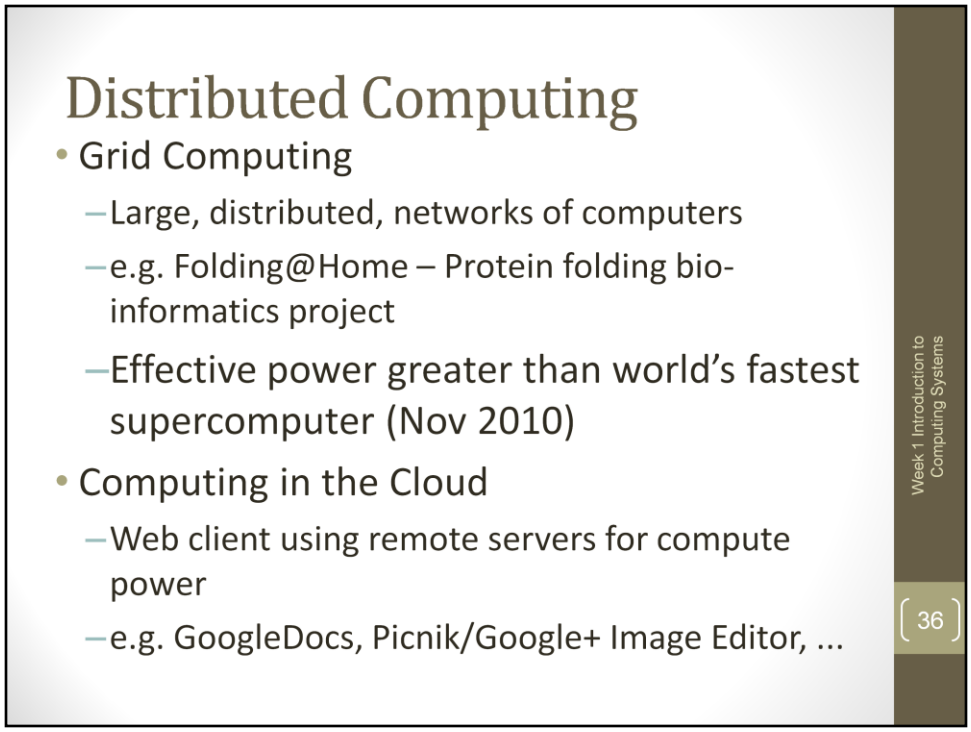
- IBM wanted to keep the price down, and so it decided to build the computer from components that were already available off the shelf from several suppliers.
- IBM also made the overall design of the PC freely available to competitors.

IBM PC

- The only part of the machine IBM copyrighted was the BIOS, the crucial basic input/output system, computer code residing in a single chip that defined how software was to interact with the PC's hardware.
- The competition could create their own PCs as long as they duplicated the operations of IBM's BIOS without directly copying it.

IBM PC vs Apple

- While Apple continued to keep its design proprietary, IBM's openness encouraged the creation of IBM clones that could use the same software and hardware add-ons the PC used. And the clones, while competing with IBM, at the same time helped establish the IBM architecture as the machine for which software and add-on hardware developers would design.



Seti@home - SETI@home is a scientific experiment that uses Internet-connected computers in the Search for Extraterrestrial Intelligence (SETI). You can participate by running a free program that downloads and analyzes radio telescope data.

Folding@home is a distributed computing project -- people from throughout the world download and run software to band together to make one of the largest supercomputers in the world. Every computer takes the project closer to our goals. Folding@home uses novel computational methods coupled to distributed computing, to simulate problems millions of times more challenging than previously achieved.

Protein folding is linked to disease, such as Alzheimer's, ALS, Huntington's, Parkinson's disease, and many Cancers.
Moreover, when proteins do not fold correctly (i.e. "misfold"), there can be serious consequences, including many well known diseases, such as Alzheimer's, Mad Cow (BSE), CJD, ALS, Huntington's, Parkinson's disease, and many Cancers and cancer-related syndromes.

Your PC becomes a small component of a much larger computer on the internet. Your computer sits computing away as part of a much bigger computer.

Grid computer is a computer made up from thousand of computers from all over the world, solving one problem.

Effect of all of these project is a computer which is more powerful than the most powerful supercomputer in the world. For a relatively modest cost these project get the power of a really powerful supercomputer.

PS3 Supercomputer - US Department of Defence part of the Air Force

Little over 2,000 PS3s. Because of the cost, processor used etc. it is very well suited to super computer tasks. It is much, much cheaper. Can no longer do this as the new playstations do not run Lynux. It cost a fraction of the cost of a supercomputer, it is one the cheapest super computers there is, it is on the top 500 list of the most powerful supercomputers in the world, it is very high performing.

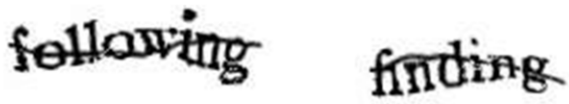
The Human Computer

- Until the mid 20th century, computer was a job title...
  - Not a machine
- Computers were employed to perform required calculations for commercial, industrial and scientific needs
- Might use mechanical or electrical calculators, slide rules and books of mathematical tables

NACA High Speed Flight Station "Computer Room"
Early "computers" at work, summer 1949. In the terminology of that period, computers were employees--typically female--who performed the arduous task of transcribing raw data from rolls of celluloid film and strips of oscillograph paper and then, using slide rules and electric calculators, reducing it to standard engineering units. Note mechanical calculator with Friden cover at left.
Seen here, left side, front to back, Mary (Tut) Hedgepeth, John Mayer and Emily Stephens. Right side, front to back, Lilly Ann Bajus, Roxanah Yancey, Gertrude (Trudy) Valentine (behind Roxanah), and Ilene Alexander.

Human Computers Today

- CAPTCHA: Completely Automated Public Turing test to tell Computers and Humans Apart



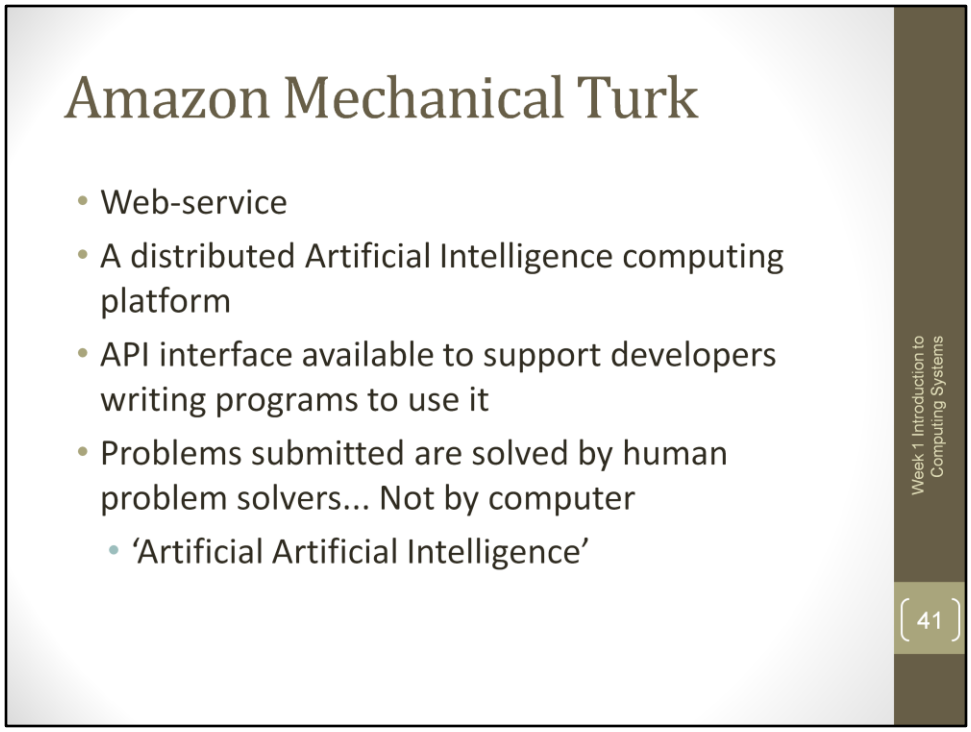
- reCAPTCHA: One of many CAPTCHA applications
  - presents one known and one word scanned from a document
  - Uses human response to recognise hard to scan words in books
  - People as elements in a computer program

CAPTCHA , - the Turing test is used to tell a person apart from a machine. Not a traditional test.

reCAPTCHA – Uses two words, one word is used to see if you can identify the word (are you human?)

The second one is used by some people who are trying to digitize large collections of books so that they will be available on the internet at some point in the future. The first word is testing if you are human, the second the computer is using you to solve it's problem, you are telling it what the words is by typing it in. You can't mess it up by typing the wrong answer to the second one as they are given in a random order therefore you don't know which one is which. You could guess but you cannot tell. Also the same word is sent to multiple users, therefore it verifies the answer from multiple responses.

It is using humans as elements in a computer program.



Amazon are a web company, they do very advanced web hosting as a Cloud based service, run Amazon Compute Cloud, to run very large programs. Offer web hosting to store very large files.

An application programming interface (API) is a source code based specification intended to be used as an interface by software components to communicate with each other. An API may include specifications for routines, data structures, object classes, and variables.

Amazon Mechanical Turk – You have a challenging task for a computer to do which you submit to Amazon. You post how much you are willing to pay to get it solved, then people do the solving not the computer.

Computer History Year/Enter	Computer History Inventors/Inventions	Computer History Description of Event
1936	**Konrad Zuse** - ***Z1 Computer***	First freely programmable computer.
1942	**John Atanasoff** & **Clifford Berry** **ABC Computer**	Who was first in the computing biz is not always as easy as ABC.
1944	**Howard Aiken** & **Grace Hopper** **Harvard Mark I Computer**	The Harvard Mark 1 computer.
1946	**John Presper Eckert** & **John** W. **Mauchly** **ENIAC 1 Computer**	20,000 vacuum tubes later...
1948	**Frederic Williams** & **Tom Kilburn** **Manchester Baby Computer & The Williams Tube**	Baby and the Williams Tube turn on the memories.
1947/48	**John Bardeen**, **Walter Brattain** & **Wiliam Shockley** **The Transistor**	No, a transistor is not a computer, but this invention greatly affected the history of computers.

http://inventors.about.com/library/blcoindex.htm

Mary Bellis

Computer History Year/Enter	Computer History Inventors/Inventions	Computer History Description of Event
1951	**John Presper Eckert** & **John** W. **Mauchly** **UNIVAC Computer**	First commercial computer & able to pick presidential winners.
1953	**International Business Machines** **IBM 701 EDPM Computer**	IBM enters into 'The History of Computers'.
1954	**John Backus** & **IBM** **FORTRAN Computer Programming Language**	The first successful high level programming language.
1955 (In Use 1959)	**Stanford Research Institute**, **Bank of America**, and **General Electric** **ERMA and MICR**	The first bank industry computer - also MICR (magnetic ink character recognition) for reading checks.
1958	**Jack Kilby** & **Robert Noyce** **The Integrated Circuit**	Otherwise known as 'The Chip'
1962	**Steve Russell** & **MIT** **Spacewar Computer Game**	The first computer game invented.

Computer History Year/Enter	Computer History Inventors/Inventions	Computer History Description of Event
1978	Dan Bricklin & Bob Frankston VisiCalc Spreadsheet Software	Any product that pays for itself in two weeks is a surefire winner.
1979	Seymour Rubenstein & Rob Barnaby WordStar Software	Word Processors.
1981	IBM The IBM PC - Home Computer	From an "Acorn" grows a personal computer revolution
1981	Microsoft MS-DOS Computer Operating System	From "Quick And Dirty" comes the operating system of the century.
1983	Apple Lisa Computer	The first home computer with a GUI, graphical user interface.
1984	Apple Macintosh Computer	The more affordable home computer with a GUI.
1985	Microsoft Windows	Microsoft begins the friendly war with Apple.

So, what *is* a computer?

Noun **computer** (plural **computers**)

1. (computing) A programmable device that performs mathematical calculations and logical operations, especially one that can process, store and retrieve large amounts of data very quickly.
2. (dated) A person employed to perform computations.

[Source: http://en.wiktionary.org/wiki/computer]

About This Module

- Exam 60% - Coursework/Class Tests 40%
- Moodle Discussion forum
  - Shared across different degrees & campuses
- Textbooks:
  - ***REQUIRED:*** How Computers Work (9th Edition) by Ron White (Available for about £20 online)
  - Also recommended:

Principles of Computer Hardware (4th Edition) by Alan Clements

... Other books listed on course website

This Week's Reading

- Required Reading
  - HCW – Introduction to Part 1 (pp 4-9)
- Further Reading
  - Wikipedia: History of Computing & related articles
  - PCH – Chapter 1
  - Computer History channel on YouTube:
    http://www.youtube.com/user/ComputerHistory

Questions For Next Week

- What are the main components of a modern computer?
- What do the different components do?
- How do they interact?

Next Week

- ***Required*** *Reading*
  - HCW Chapters 1, 2, 5
  - Skip Writing & Reading from RAM &memory cards
- Further Reading
  - Wikipedia
    - Computer, Personal Computer (Hardware)
  - PCH Sections 1.6 to 2.1

Quick Quiz

- Download the 'Socrative' app from Google Play, App Store or the Windows Store.
- Join 'Room 642124'.
- When you are instructed to begin try the quiz.
- Watch your progress on the board.