Introduction to Computer Science

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COURSE INFO

› Course name: Introduction to Computer Science (計算機概論)
  - Credit hours: 3
  - Course ID: B57011RQ
  - Class hour: Mon 9:20AM~12:05PM
  - Course website: http://www.deepsea9.taipei/index.php/courses/introduction-to-computers/
  - Lecturer: William Hsu
  - Office hours: Monday 3:00PM~5:00PM
  - Lab location: CSE R405
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COURSE INFO

This course accompanies the main course.

› Course name: Laboratories for Introduction to Computer Science (計算機概論實習)
  - Credit hours: 1 (2 hours)
  - Course ID: B57011RR
  - Class hour: Mon 1:10PM~3:00PM
  - Course website: http://www.deepsea9.taipei/index.php/courses/introduction-to-computers/
  - Lecturer: William Hsu
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Introduction

The basics of computer science

Outline of Our Study

› Chapter 1: Data Storage

› Chapter 2: Data Manipulation

› Chapter 3: Operating Systems

› Chapter 4: Networks and the Internet

› Chapter 5: Algorithms

› Chapter 6: Programming Languages

› Chapter 7: Software Engineering

› Chapter 8: Data Abstractions

› Chapter 9: Database Systems

› Chapter 10: Computer Graphics

› Chapter 11: Artificial Intelligence

› Chapter 12: Theory of Computation

Resources

› Textbook: G. Brookshear and D. Brylow, Computer Science: An Overview (13th Edition), Pearson, 2014. (ISBN: 013487546X)
  – 滄海書局代理
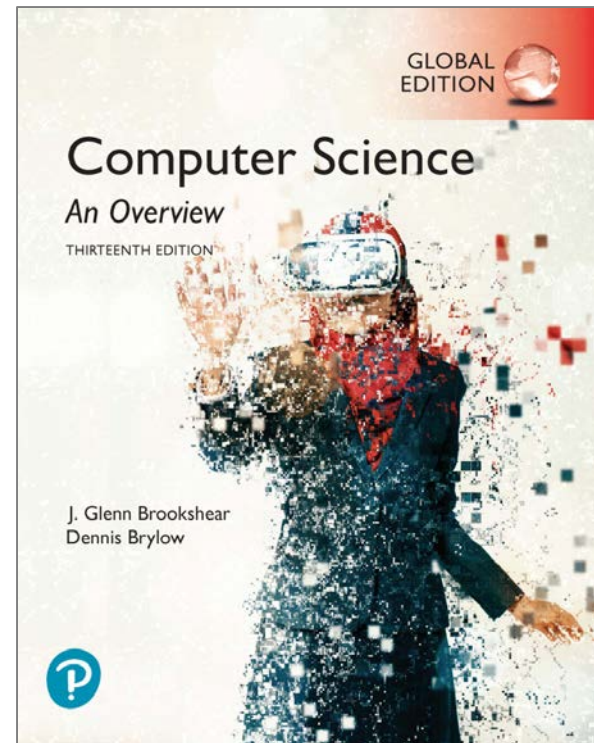
Tentative Policies

› Class policy:
  - Ask questions anytime!
  - You may leave anytime for WC without asking.
    › It's human rights.
  - Refrain from using any messaging devices.
  - Phones to vibration.
  - Eating and drinking is **ALLOW**ed, however…
    › If anyone leaves trash behind, this policy will be canceled. Penalty will be applied from this point on.
  - Name calling will not be conducted. It is your duty to make up yourself if you skip classes.
    › No need to ask for leave.
    › However, no make up exams will be given! (Unless you have a good reason)
  - Refrain from sleeping in classes.
    › Get sleep in your bed for maximum quality.
    › If it happens too much, I will start to deduct point adjustments of final scores.
  - Refrain from chatting too loud of personal matters.
    › I will remove you from the classroom because you are interfering with the class.

Tentative Policies

› Grading:
  – 5~10% Oral report bonus (weekly, by appointments).
    › Technology or CS related interesting topics.
  – 30% Quizzes (4-6 of them)
    › This year, laboratory contents will be included.
  – 10% Pop quizzes
  – 30% Midterm exam
  – 30% Final exam
  – The university ethics code must be complied.

Tentative Policies

› Grading – Extra credits:
  - Extra credit policy for attending public contests:
    › ITSA (ITSA程式能力線上自我評量): 1% ＋ 0.5% per solved problem.
    › 其他學校辦的公開賽, 如中區程式設計大賽, 靜宜盃, 東華盃區大賽等: 1% + 1% per solved problem.
    › CPE: 2% ＋ 1% per solved problem
    › ICPC-TOPC: 2% + 2% per solved problem
    › NCPC (教育部大專程式設計競賽, ICPC前導賽): 3% ＋ 2% per solved problem (預賽也算)
    › ICPC Regionals: 5% ＋ 2% per solved problem
    › ICPC World finals: 再說吧~

Computer Science

› The science of algorithms

› Draws from other subjects, including
- Mathematics
- Engineering
- Psychology
- Business Administration

Terminology

› **Algorithm:** A set of steps that defines how a task is performed

› **Program:** A representation of an algorithm

› **Programming:** The process of developing a program

› **Software:** Programs and algorithms

› **Hardware:** Equipment

Central Questions of Computer Science

› Which problems can be solved by algorithmic processes?

› How can algorithm discovery be made easier?

› How can techniques of representing and communicating algorithms be improved?

› How can characteristics of different algorithms be analyzed and compared?

Central Questions of Computer Science (continued)

› How can algorithms be used to manipulate information?

› How can algorithms be applied to produce intelligent behavior?

› How does the application of algorithms affect society?

The Overarching Themes of Computer Science

› Computing technology effects:

   – Governments, economics, scientific research, role of data, communication, …

› Seven "Big Ideas" that unite computer science:

   – Algorithms, Abstraction, Creativity, Data, Programing, Internet and Impact

The Central Role of Algorithms in Computer Science
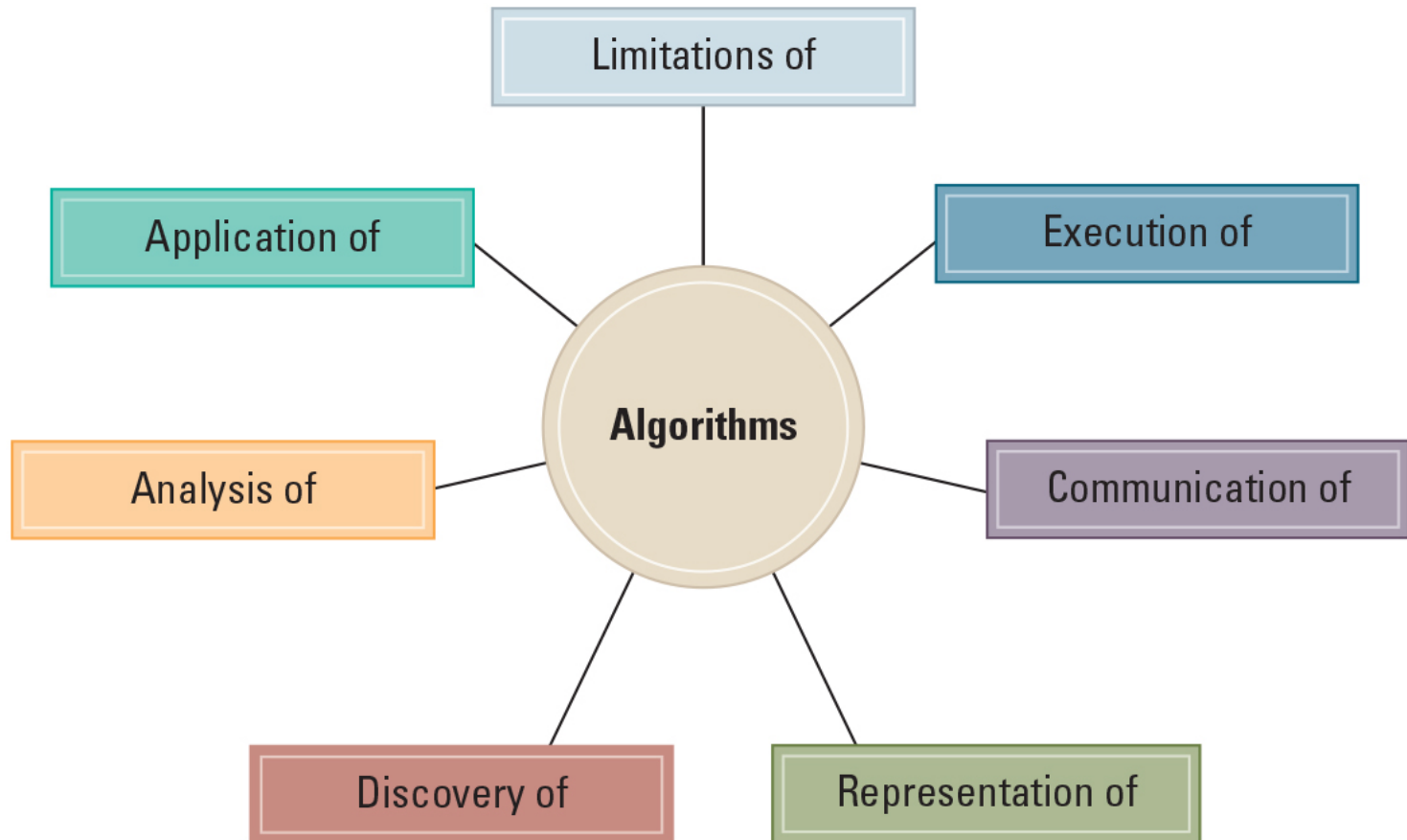
Abstraction

› **Abstraction:** The distinction between the external properties of an entity and the details of the entity's internal composition.

› **Abstract tool:** A "component" that can be used without concern for the component's internal properties.

Creativity

› Computer science is inherently creative

  − Discovering and applying algorithms is a human activity

  − Extends existing forms of expression

  − Enables new modes of digital expression

› Creating large software systems is like conceiving a grand new sculpture

Data

› Computers can represent any information that can be discretized and digitized

› Algorithms process and transform data
  − Search for patterns
  − Create simulations
  − Generate knowledge and insight

› Data is driving modern discovery
  − Mass storage
  − High speed networks

Questions about Data

› How do computers store data about common digital artifacts?

  – Numbers, text, images, sounds, and video.

› How do computers approximate data about analog artifacts in the real world?

› How do computers detect and prevent errors in data?

› What are the ramifications or an ever-growing and interconnected universe of digital data?

Programming

› **Programming** is broadly referred to as:
  − Translating human intentions into executable algorithms.

› Computer hardware is capable of only simple algorithmic steps.

› Abstractions in a **programming language** allow humans to reason and encode solutions to complex problems.

Questions about Programming

› How are programs built?

› What kind of errors can occur in programs?

› How are errors in programs found and repaired?

› What are the effects of errors in modern programs?

› How are programs documented and evaluated?

Internet

› Profound impact in the way information is:

– Stored

– Retrieved

– Shared

› Privacy

› Security

Social Repercussions

› Advances in computer science raise new questions
  − In law: Questions of rights and liabilities
  − In government: Questions of regulation
  − In the work place: Questions of professionalism
  − In society: Questions of social behavior

Impact

› Social, ethical, legal impacts including:
  – Security concerns
  – Issues of software ownership and liabilities
  – Social impact of database technology
  – Consequences of artificial intelligence

› No "Correct" answers, instead increase awareness of:
  – Various stakeholders
  – Alternatives
  – Short term and long term consequences

› Character-based ethics
  – "Good Behavior" is a consequence of "Good Character"

Ethical Theories

› Consequence based:

－ What leads to the greatest benefit?

› Duty based:

－ What are my intrinsic obligations?

› Contract based:

－ What contracts must I honor?

› Character based:

－ Who do I want to be?

History of Algorithms

› The study of algorithms was originally a subject in mathematics.

› Early examples of algorithms
  − Long division algorithm
  − Euclidean Algorithm

› **Gödel's Incompleteness Theorem**: Some problems cannot be solved by algorithms.

The Euclidean Algorithm

Description: This algorithm assumes that its input consists of two positive integers and proceeds to compute the greatest common divisor of these two values.

Procedure:

Step 1. Assign M and N the value of the larger and smaller of the two input values, respectively.

Step 2. Divide M by N, and call the remainder R.

Step 3. If R is not 0, then assign M the value of N, assign N the value of R, and return to step 2; otherwise, the greatest common divisor is the value currently assigned to N.

History of Computing

› Early computing devices
  – Abacus: positions of beads represent numbers
  – Gear-based machines (1600s-1800s)
    › Positions of gears represent numbers
    › Blaise Pascal, Wilhelm Leibniz, Charles Babbage
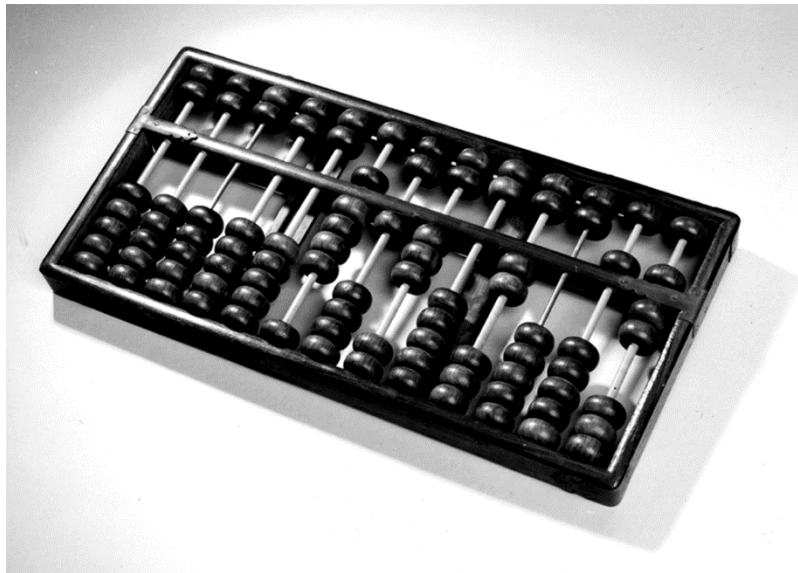
Early Data Storage

› Punched cards
- − First used in Jacquard Loom (1801) to store patterns for weaving cloth
- − Storage of programs in Babbage's Analytical Engine
- − Popular through the 1970's

› Gear positions
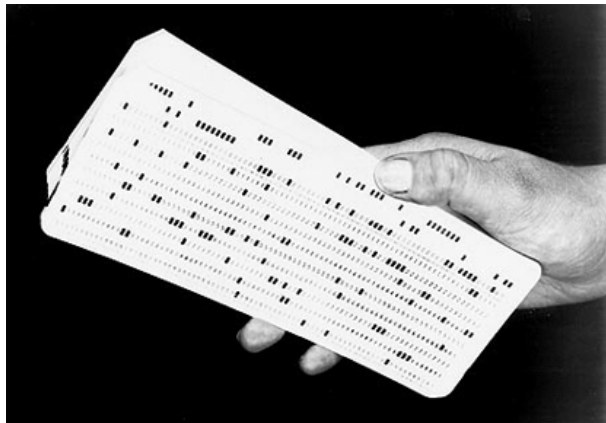
Early Computers

› Based on mechanical relays
  - 1940: Stibitz at Bell Laboratories
  - 1944: Mark I: Howard Aiken and IBM at Harvard

› Based on vacuum tubes
  - 1937-1941: Atanasoff-Berry at Iowa State
  - 1940s: Colossus: secret German code-breaker
  - 1940s: ENIAC: Mauchly & Eckert at U. of Penn.

Abacus

› The ***abacus*** was an early aid for mathematical computations.

› Its only value is that it aids the memory of the human performing the calculation.

› A skilled abacus operator can work on addition and subtraction problems at the speed of a person equipped with a hand calculator (multiplication and division are slower).
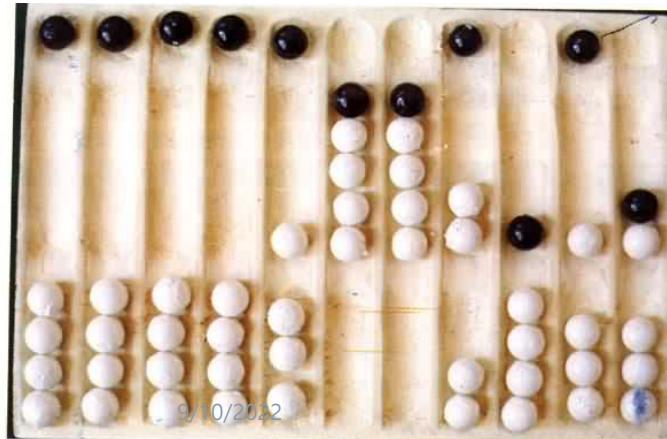
Abacus

› The abacus is often wrongly attributed to China.

› In fact, the oldest surviving abacus was used in 300 B.C. by the Babylonians.

› The abacus is still in use today, principally in the far east.

John Napier

› In 1617 an eccentric (some say mad) Scotsman named John Napier invented ***logarithms***, which are a technology that allows multiplication to be performed via addition

$$\log_2 x = 5$$

Napier's Bones

› The magic ingredient is the logarithm of each operand, which was originally obtained from a printed table.

› Napier also invented an alternative to tables, where the logarithm values were carved on ivory sticks which are now called *Napier's Bones*.
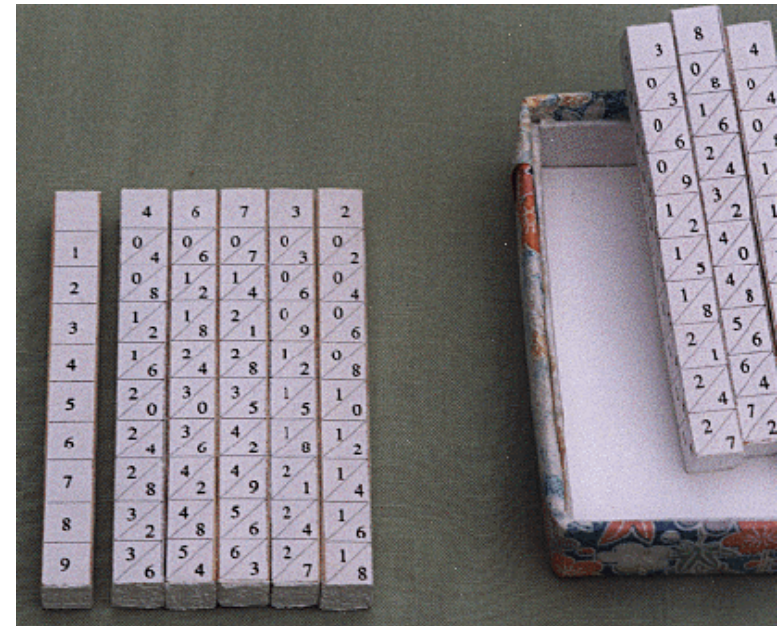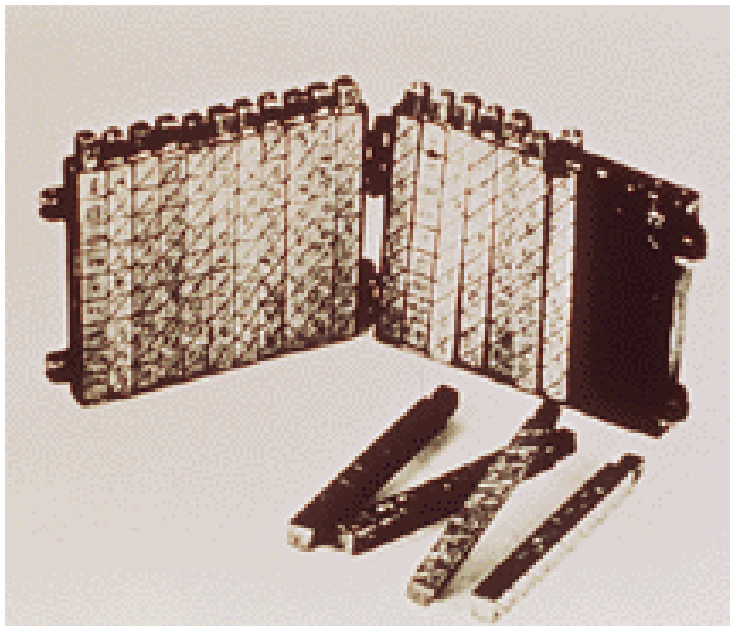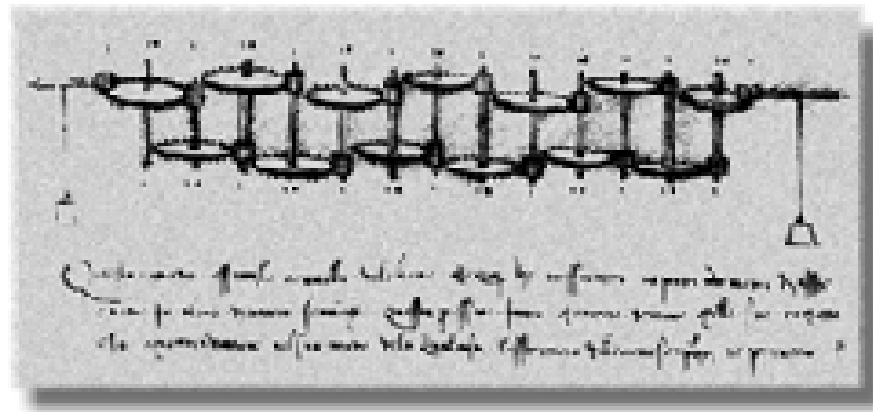
Slide Rule

› Napier's invention led directly to the ***slide rule***, first built in England in 1632 and still in use in the 1960's by the NASA engineers of the Mercury, Gemini, and Apollo programs which landed men on the moon.
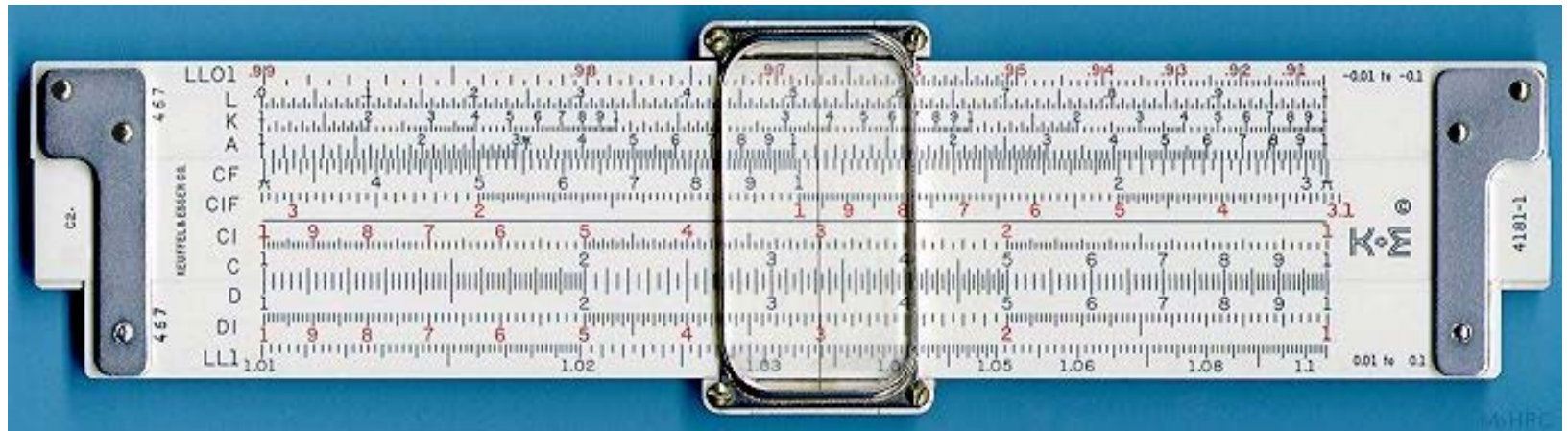
Leonardo da Vinci

› Leonardo da Vinci (1452-1519) made drawings of gear-driven calculating machines but apparently never built any.

Calculating Clock

› The first gear-driven calculating machine to actually be built was probably the ***calculating clock***, so named by its inventor, the German professor Wilhelm Schickard in 1623.

› This device got little publicity because Schickard died soon afterward in the bubonic plague.
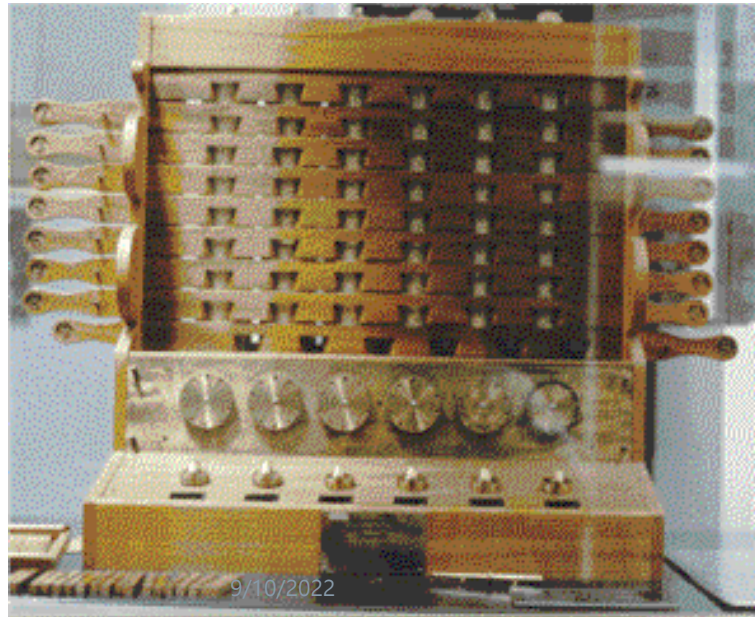
Blaise Pascal

› In 1642 Blaise Pascal, at age 19, invented the ***Pascaline*** as an aid for his father who was a tax collector.

  – Pascal built 50 of this gear-driven one-function calculator (it could only add) but couldn't sell many because of their exorbitant cost and because they really weren't that accurate (at that time it was not possible to fabricate gears with the required precision).

› Up until the present age when car dashboards went digital, the odometer portion of a car's speedometer used the very same mechanism as the Pascaline to increment the next wheel after each full revolution of the prior wheel.

8-digit Pascaline
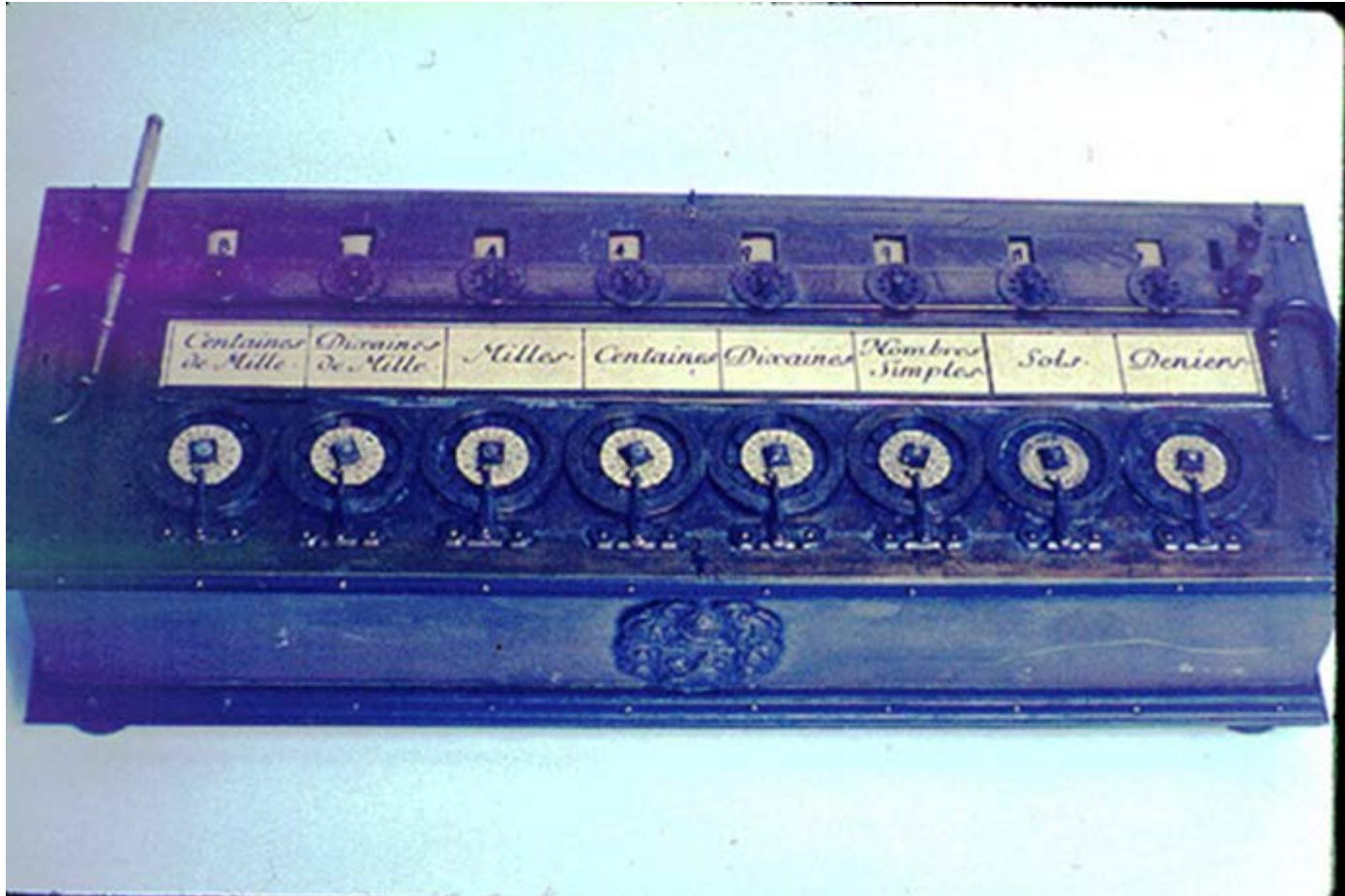
Pascaline Insides

Leibniz

› Just a few years after Pascal, the German Gottfried Wilhelm Leibniz (co-inventor with Newton of calculus) managed to build a four-function (addition, subtraction, multiplication, and division) calculator that he called the *stepped reckoner* because, instead of gears, it employed fluted drums having ten flutes arranged around their circumference in a stair-step fashion.

› Although the stepped reckoner employed the decimal number system (each drum had 10 flutes), Leibniz was the first to advocate use of the **binary number system** which is fundamental to the operation of modern computers.

› Leibniz is considered one of the greatest of the philosophers but he died poor and alone.

Stepped Reckoner
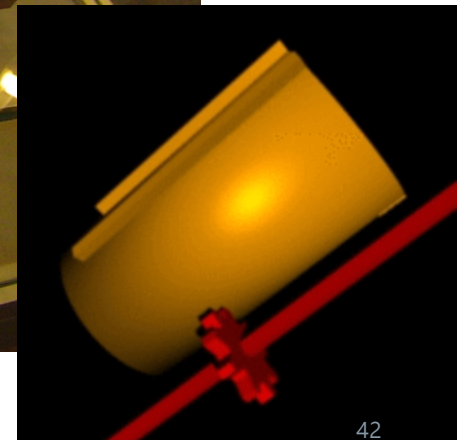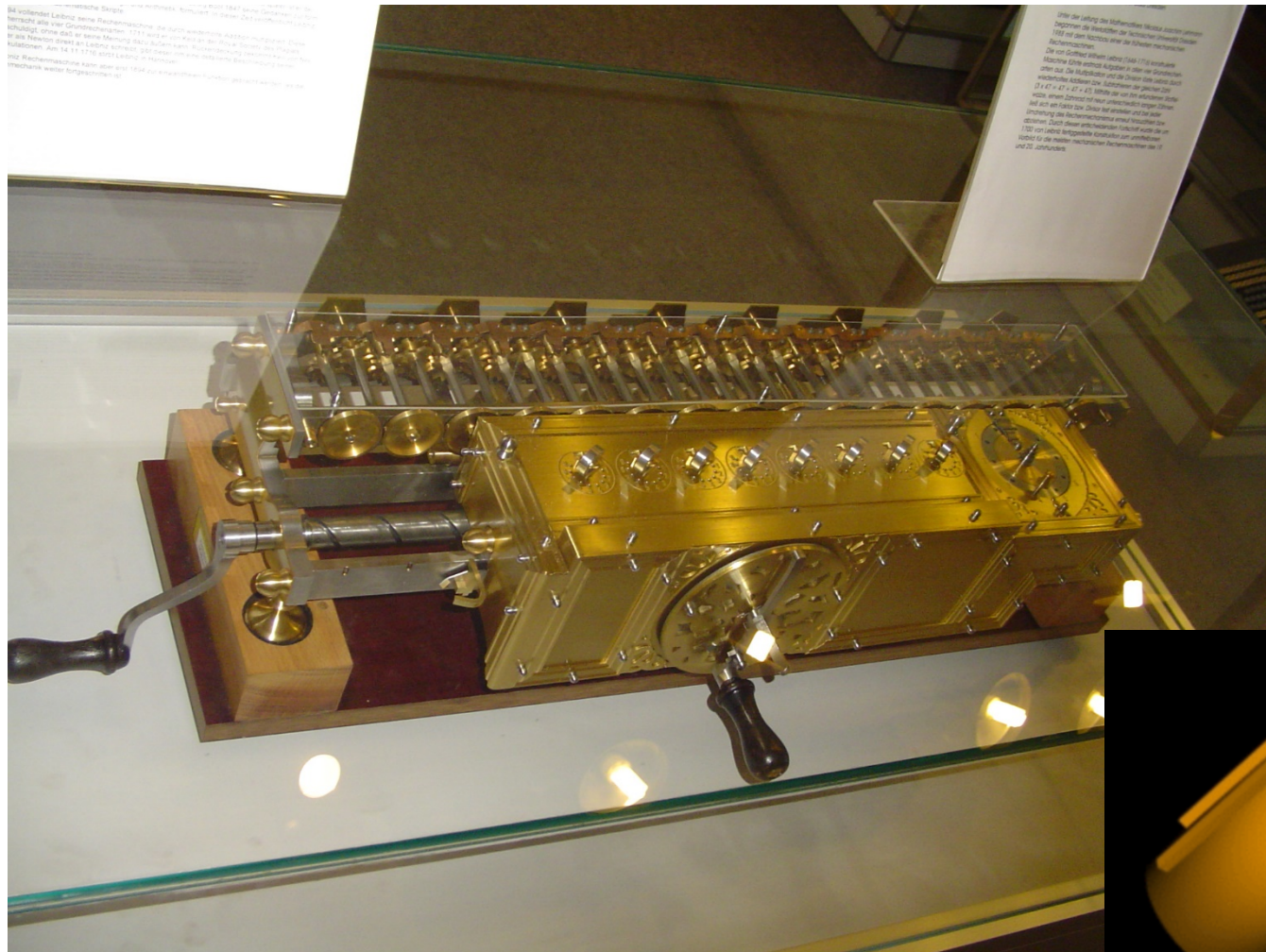
Jacquard

› In 1801 the Frenchman Joseph Marie Jacquard invented a power loom that could base its weave (and hence the design on the fabric) upon a pattern automatically read from punched wooden cards, held together in a long row by rope.

› Descendants of these *punched cards* have been in use ever since!

Power Loom

› By selecting particular cards for Jacquard's loom you defined the woven pattern.

[Jacquard-card Making.]

Close up of a Card

Technology -vs- Jobs

› Jacquard's technology was a real boon to mill owners, but put many loom operators out of work.

  – Angry mobs smashed Jacquard looms and once attacked Jacquard himself.

› History is full of examples of labor unrest following technological innovation yet most studies show that, overall, technology has actually increased the number of jobs.

Charle's Babbage

› By 1822 the English mathematician *Charles Babbage* was proposing a steam driven calculating machine the size of a room, which he called the *Difference Engine*.

Difference Engine

› This machine would be able to compute tables of numbers, such as logarithm tables.

› He obtained government funding for this project due to the importance of numeric tables in ocean navigation.

› Construction of Babbage's Difference Engine proved exceedingly difficult and the project soon became the most expensive government funded project up to that point in English history.

› Ten years later the device was still nowhere near complete, acrimony abounded between all involved, and funding dried up. **The device was never finished.**

Babbage-Analytic Engine

› Babbage was not deterred, and by then was on to his next brainstorm, which he called the ***Analytic Engine***.

› This device, large as a house and powered by 6 steam engines.

› It was programmable, thanks to the punched card technology of Jacquard.

› Babbage saw that the pattern of holes in a punch card could be used to represent an abstract idea such as a problem statement or the raw data required for that problem's solution.

Babbage-Analytic Engine

› Babbage realized that punched paper could be employed as a storage mechanism, holding computed numbers for future reference.

› Because of the connection to the Jacquard loom, Babbage called the two main parts of his Analytic Engine the "Store" and the "Mill", as both terms are used in the weaving industry.

› The Store was where numbers were held and the Mill was where they were "woven" into new results.

› In a modern computer these same parts are called the *memory unit* and the *central processing unit* (CPU).

Babbage-Analytic Engine

› The Analytic Engine also had a key function that distinguishes computers from calculators: the conditional statement.

› A conditional statement allows a program to achieve different results each time it is run.

› Based on the conditional statement, the path of the program can be determined based upon a situation that is detected at the very moment the program is running.

Ada Byron

› Babbage befriended *Ada Byron*, the daughter of the famous poet Lord Byron.

› Though she was only 19, she was fascinated by Babbage's ideas.

› She began fashioning programs for the Analytic Engine, although still unbuilt.

› The Analytic Engine remained unbuilt (the British government refused to get involved with this one) but Ada earned her spot in history as the first computer programmer.

› Ada invented the subroutine and was the first to recognize the importance of looping.

US Census

› The next breakthrough occurred in America. The U.S. Constitution states that a census should be taken of all U.S. citizens every 10 years in order to determine the representation of the states in Congress.

› While the very first census of 1790 had only required 9 months, by 1880 the U.S. population had grown so much that the count for the 1880 census took 7.5 years.

– Automation was clearly needed for the next census.

› The census bureau offered a prize for an inventor to help with the 1890 census and this prize was won by Herman Hollerith.

Hollerith Desk

› The *Hollerith desk*, consisted of:

  – A card reader which sensed the holes in the cards,

  – A gear driven mechanism which could count (similar to Pascal's)

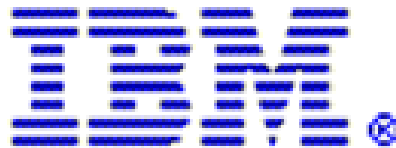 – A large wall of dial indicators to display the results of the count.

Hollerith Desk

› Hollerith's technique was successful and the 1890 census was completed in only 3 years at a savings of 5 million dollars.
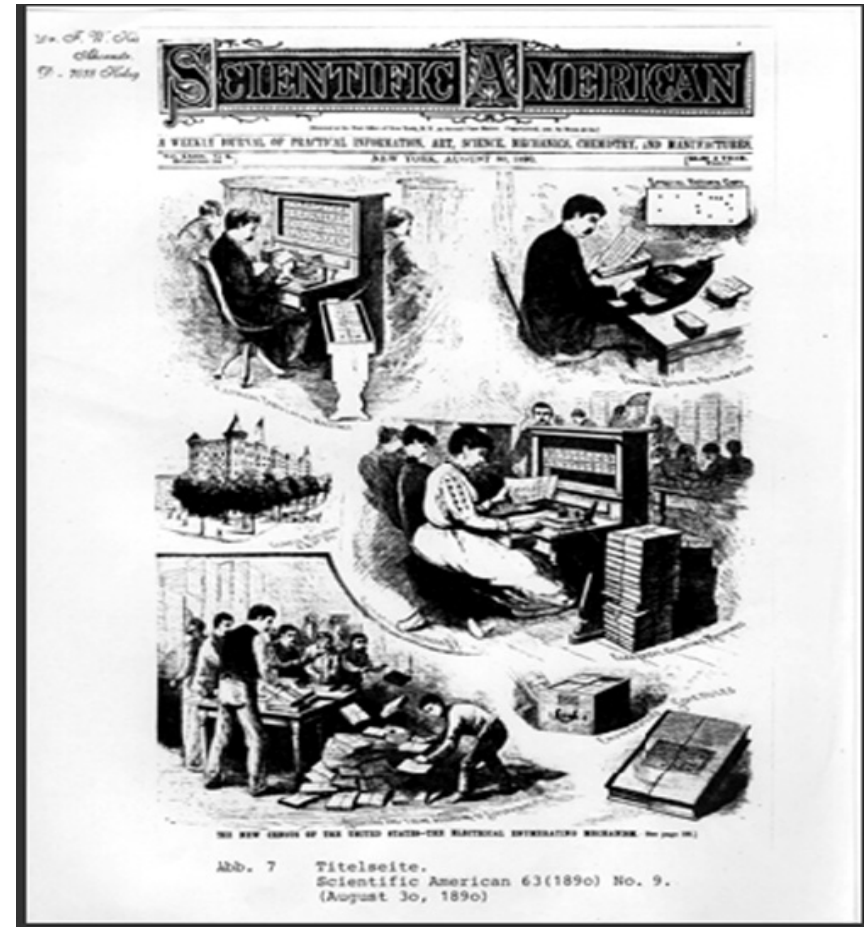
IBM

> Hollerith built a company, the Tabulating Machine Company which, after a few buyouts, eventually became International Business Machines, known today as ***IBM***.

sponsert
Frankfurt

Hollerith's innovation

› By using punch cards, Hollerith created a way to store and retrieve information.

› This was the first type of read and write technology.

US Military

› The U.S. military desired a mechanical calculator more optimized for scientific computation.

› By World War II the U.S. had battleships that could lob shells weighing as much as a small car over distances up to 25 miles.

› Physicists could write the equations that described how atmospheric drag, wind, gravity, muzzle velocity, etc. would determine the trajectory of the shell, but solving such equations was extremely laborious.

US Military

› Human computers would compute results of these equations and publish them in ballistic "firing tables".

› During World War II the U.S. military scoured the country looking for (generally female) math majors to hire for the job of computing these tables, but not enough humans could be found to keep up with the need for new tables.

› Sometimes artillery pieces had to be delivered to the battlefield without the necessary firing tables and this meant they were close to useless because they couldn't be aimed properly.

› Faced with this situation, the U.S. military was willing to invest in even hair-brained schemes to automate this type of computation.
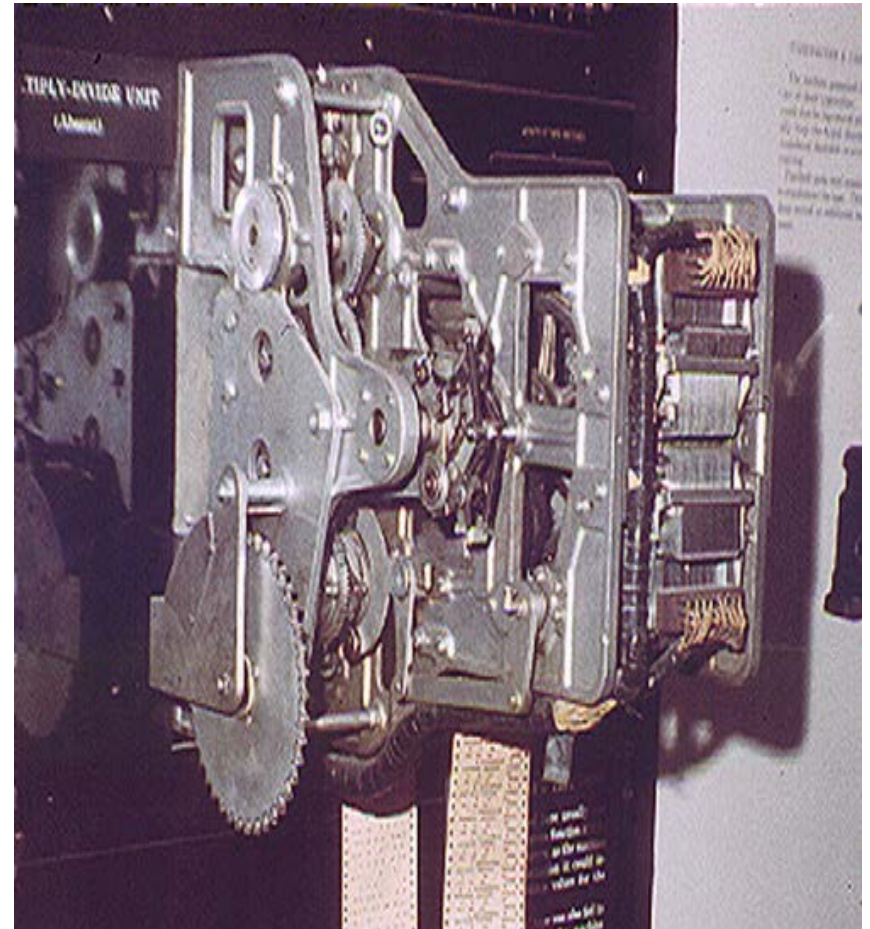
Mark I

› One early success was the Harvard *Mark I* computer which was built as a partnership between Harvard and IBM in 1944.

› This was the first programmable digital computer made in the U.S.

› But it was not a purely electronic computer. Instead the Mark I was constructed out of switches relays, rotating shafts, and clutches.
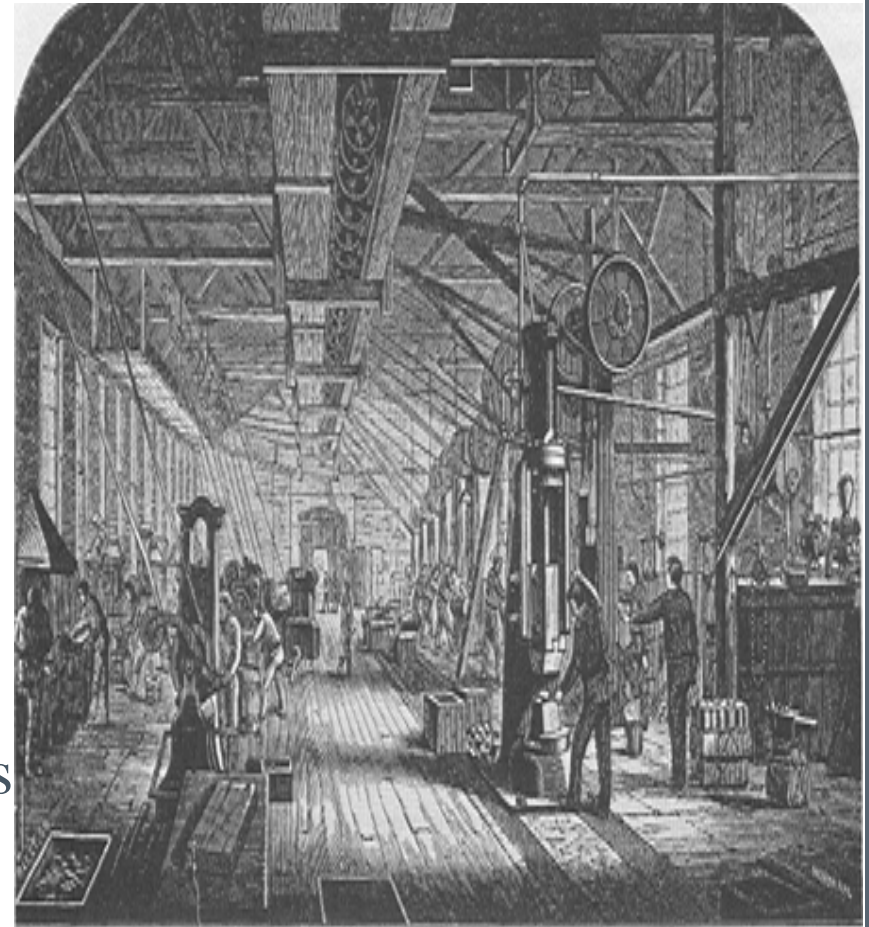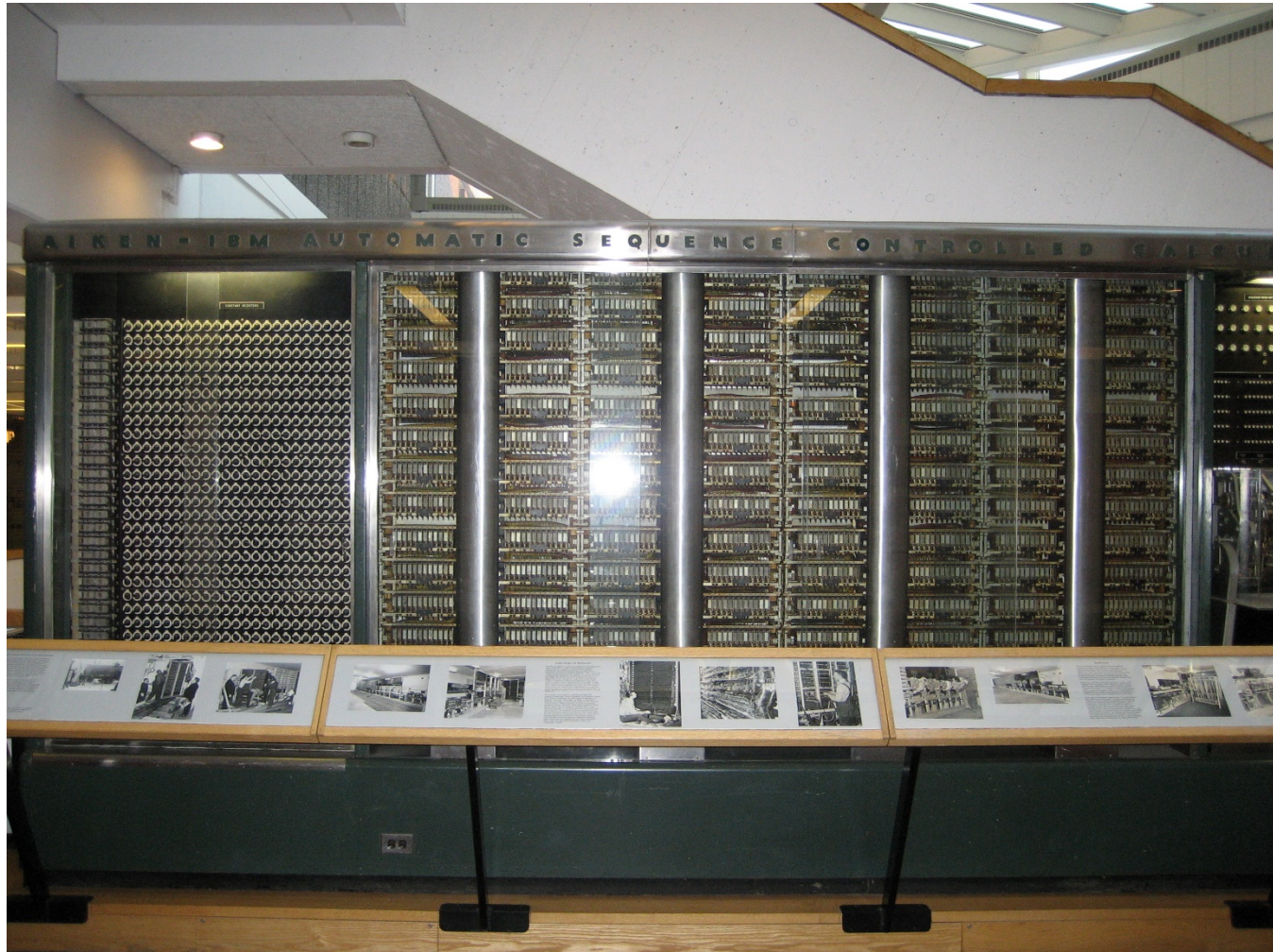
Mark I

› The machine weighed 5 tons, incorporated 500 miles of wire, was 8 feet tall and 51 feet long, and had a 50 ft rotating shaft running its length, turned by a 5 horsepower electric motor.

› The Mark I ran non-stop for 15 years, sounding like a roomful of ladies knitting.
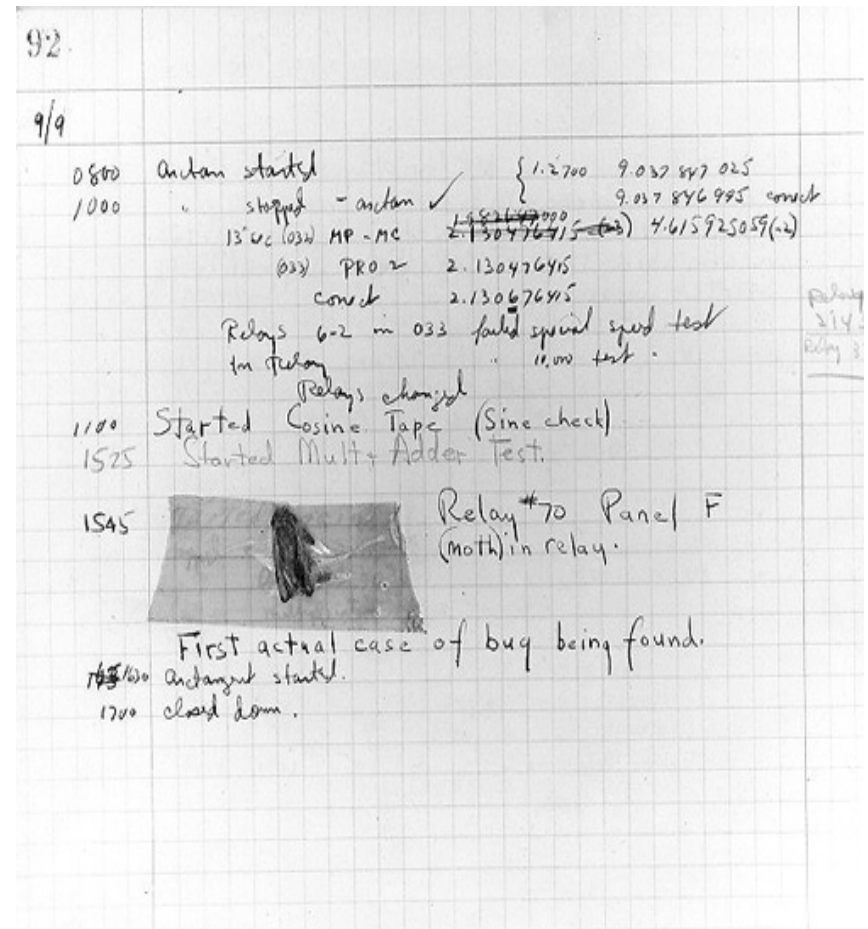
The Mark I computer

Mark I

The First Bug

› One of the primary programmers for the Mark I was a woman, *Grace Hopper*.

› Hopper found the first computer "bug": a dead moth that had gotten into the Mark I.

› The word "bug" had been used to describe a defect since at least 1889 but Hopper is credited with coining the word "debugging" to describe the work to eliminate program faults.

Humor

› On a humorous note, the principal designer of the Mark I, **_Howard Aiken_** of Harvard, estimated in 1947 that six electronic digital computers would be sufficient to satisfy the computing needs of the entire United States.

The Future of Computers?

› IBM had commissioned this study to determine whether it should bother developing this new invention into one of its standard products (up until then computers were one-of-a-kind items built by special arrangement).

› Aiken's prediction wasn't actually so bad as there were very few institutions (principally, the government and military) that could afford the cost of what was called a computer in 1947.

› He just didn't foresee the micro-electronics revolution which would allow something like an *IBM Stretch* computer of 1959.

First Generation Computers

› The first electronic computer was designed at Iowa State between 1939-1942.

› The Atanasoff-Berry Computer used the binary system(1's and 0's).

› Contained vacuum tubes and stored numbers for calculations by burning holes in paper.

Atanasoff – Berry Computer

› One of the earliest attempts to build an all-electronic (that is, no gears, cams, belts, shafts, etc.) digital computer occurred in 1937 by *J. V. Atanasoff*.

› This machine was the first to store data as a charge on a capacitor, which is how today's computers store information in their main memory (*DRAM* or *dynamic RAM*). As far as its inventors were aware, it was also the first to employ binary arithmetic.
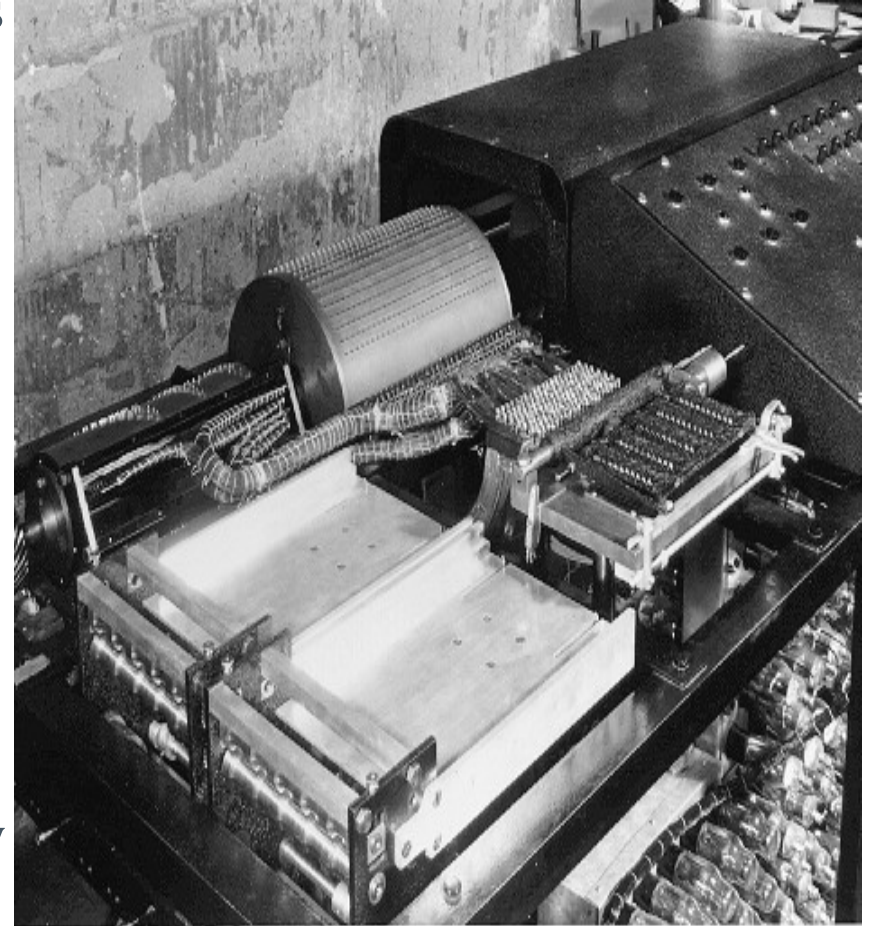
Colossus

› ***The Colossus***, built during World War II by Britain for the purpose of breaking the cryptographic codes used by Germany.

› Britain led the world in designing and building electronic machines dedicated to code breaking, and was routinely able to read coded Germany radio transmissions.

› Not a general purpose, reprogrammable machine.
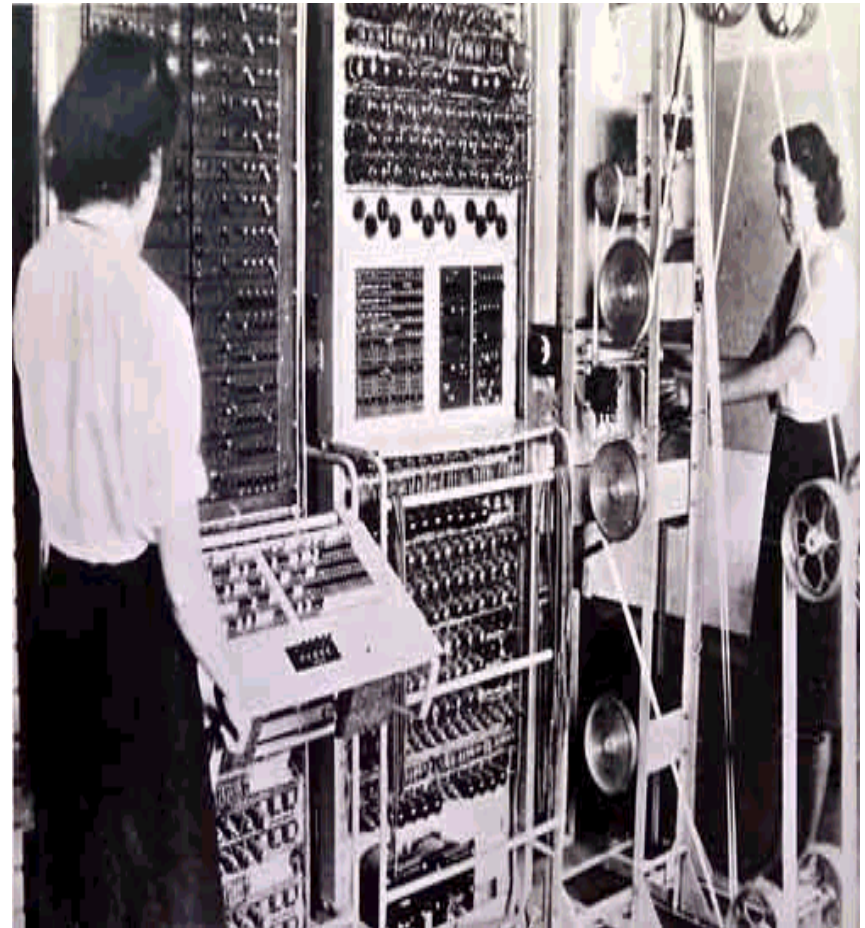
History of Microprocessors

› Most important advances in computer technology: 16-bit and 32-bit microprocessors (μp).

› Pioneered by Intel since 1970's and dominated by INTEL since 1980's
  − 4-bit 4004 in 1971.
  − 8-bit 8008 in 1972.
  − 8-bit 8080 and 8085 in 1974.
  − 16-bit 8088 and 8086, brains of famous IBM PC.
  − 32-bit 80286 (1982), 80386 (1985), 80486 (1989), Pentium.
  − (1993), Pentium II (1997), Celeron and Pentium III (1999)and Pentium 4 (2000).
  − 64-bit Itanium (2001).
  − 64-bit Pentium 4 and Xeon (2005).
  − Core iX series (2008-2010).

# The ENIAC – Electronic Numerical Integrator and Computer
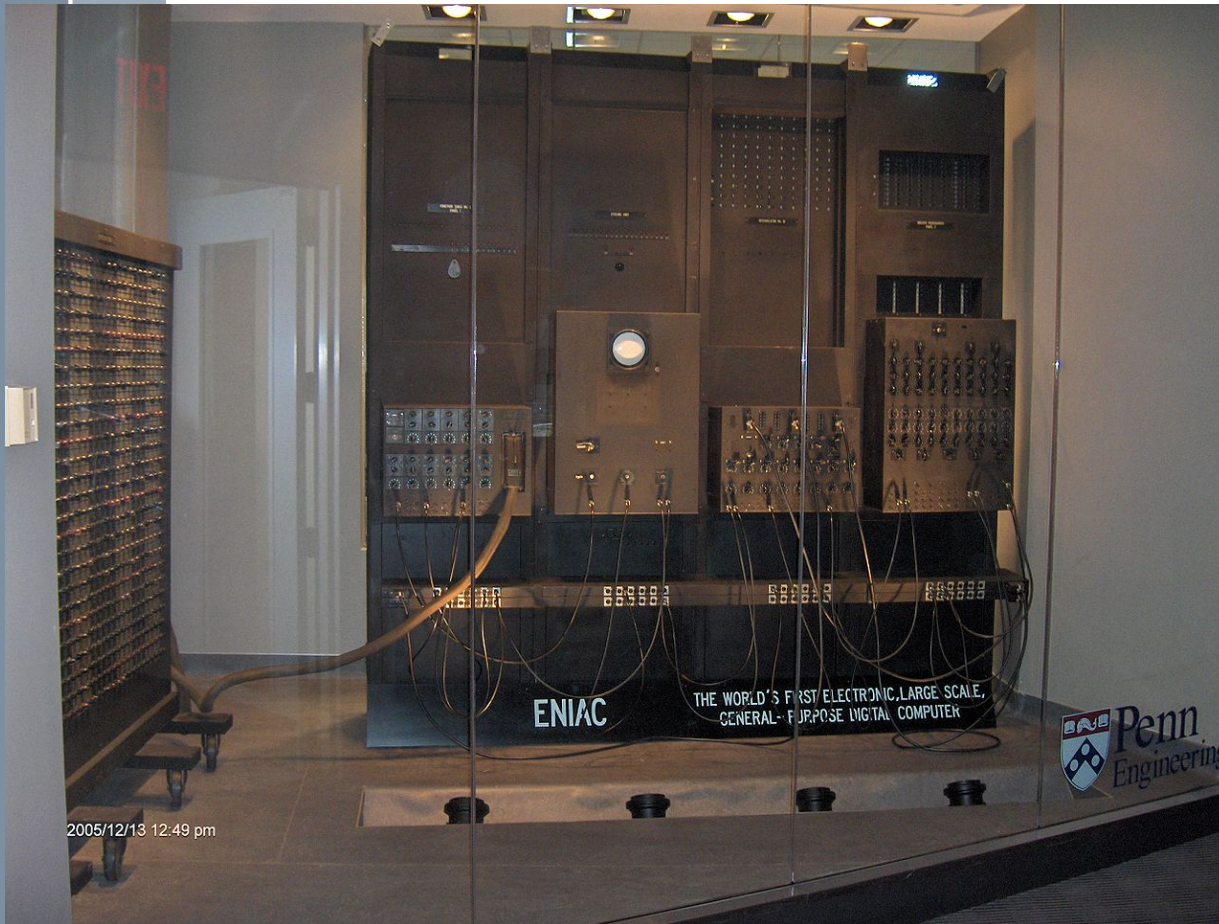
Vacuum tubes

ENIAC

› The title of forefather of today's all-electronic digital computers is usually awarded to ***ENIAC***, which stood for Electronic Numerical Integrator and Calculator.

› ENIAC was built at the University of Pennsylvania between 1943 and 1945 by two professors, ***John Mauchly*** and the 24 year old ***J. Presper Eckert***, who got funding from the war department after promising they could build a machine that would replace all the "computers"

› ENIAC filled a 20 by 40 foot room, weighed 30 tons, and used more than 18,000 vacuum tubes.

"Writing" Programs on the ENAIC
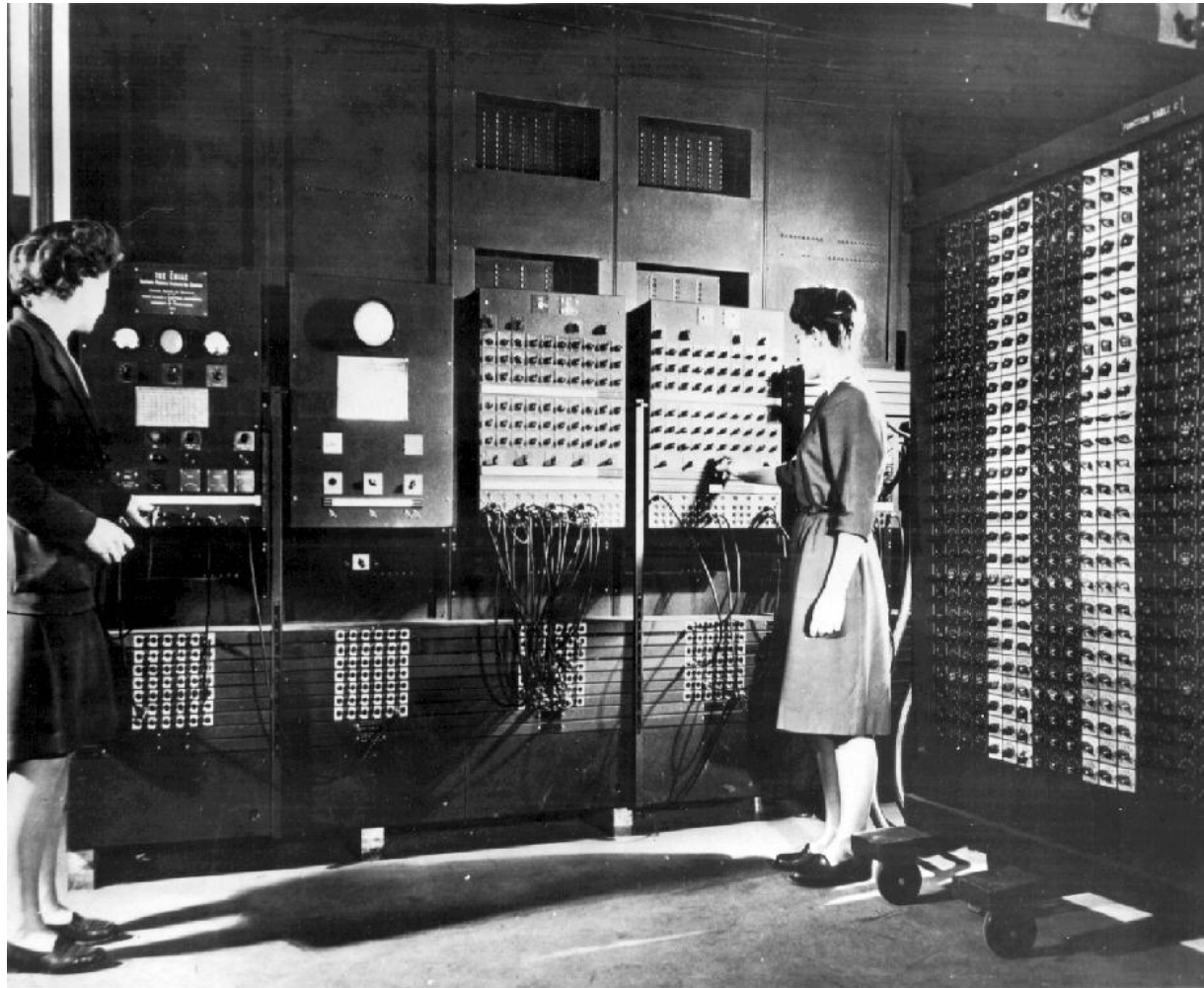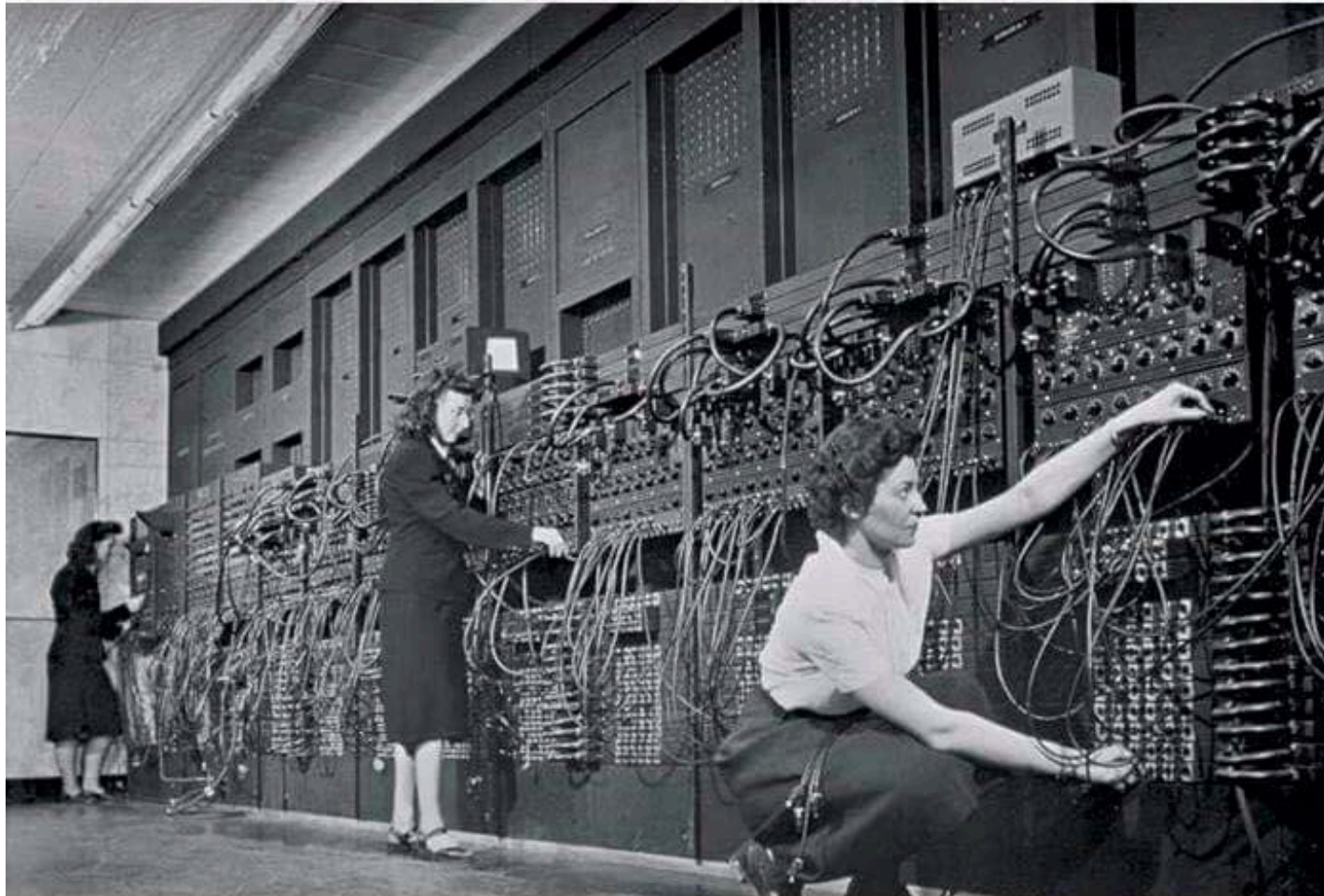
The first computer programmers were women

Programming the ENIAC

› To reprogram the ENIAC you had to rearrange the patch cords, and the settings of 3000 switches.

› To program a modern computer, you type out a program with statements like:

  Circumference = 3.14 * diameter

› To perform this computation on ENIAC you had to rearrange a large number of patch cords and then locate three particular knobs on that vast wall of knobs and set them to 3, 1, and 4.

Problems with the ENIAC

› The ENIAC used 18,000 vacuum tubes to hold a charge.

› Vacuum tubes were so notoriously unreliable that even twenty years later many neighborhood drug stores provided a "tube tester".
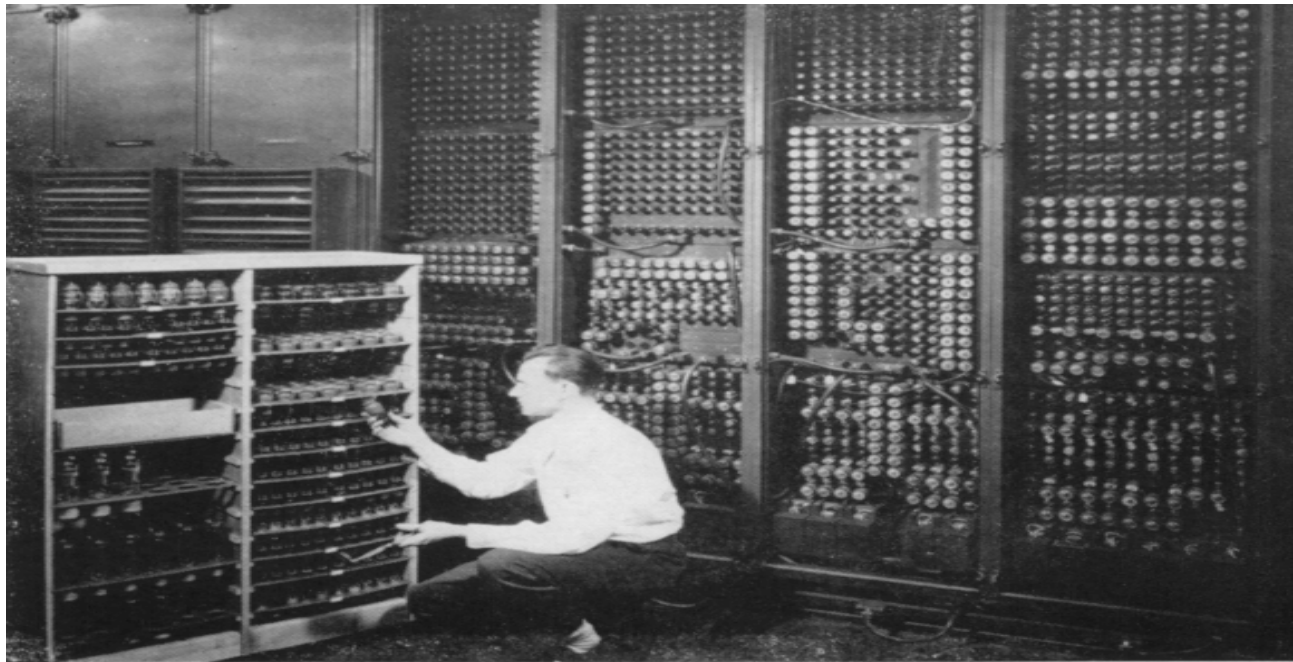
Replacing a bad tube meant checking among ENIAC's 19,000 possibilities.

Von Neumann Architecture

› John Von Neumann came up with the bright idea of using part of the computer's internal memory (called Primary Memory) to "store" the program inside the computer and have the computer go get the instructions from its own memory, just as we do with our human brain.
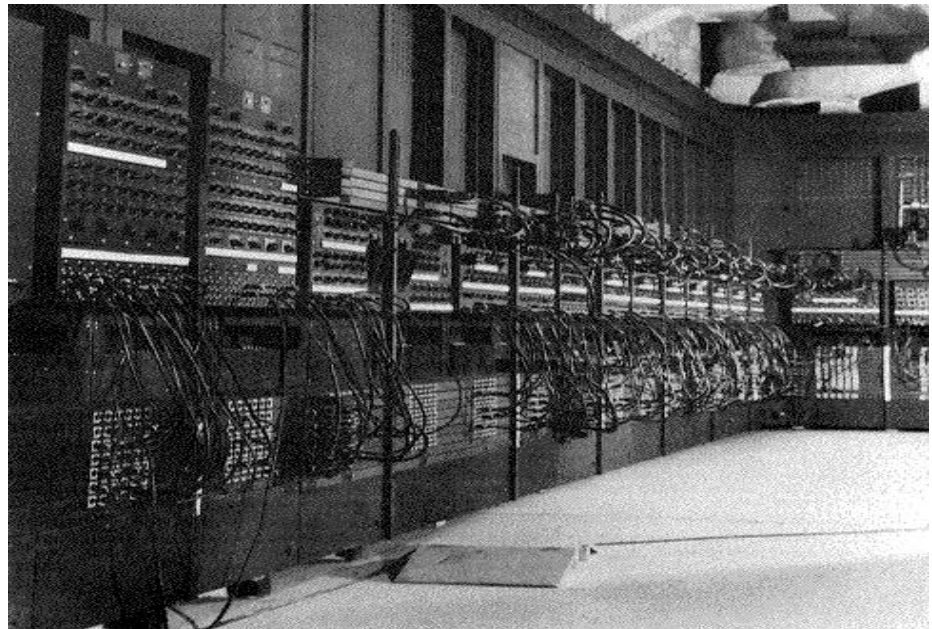
The Stored Program Computer

› In 1945 John von Neumann presented his idea of a computer that would store computer instructions in a CPU.

› The CPU(Central Processing Unit) consisted of elements that would control the computer electronically.

› The EDVAC, EDSAC and UNIVAC were the first computers to use the stored program concept.

› They used vacuum tubes so they were too expensive and too large for households to own and afford.

EDVAC

› It took days to change ENIAC's program.

› Eckert and Mauchly's next teamed up with the mathematician *John von Neumann* to design *EDVAC*, which pioneered the *stored program*.

› After **ENIAC** and **EDVAC** came other computers with humorous names such as **ILLIAC, JOHNNIAC**, and, of course, **MANIAC.**
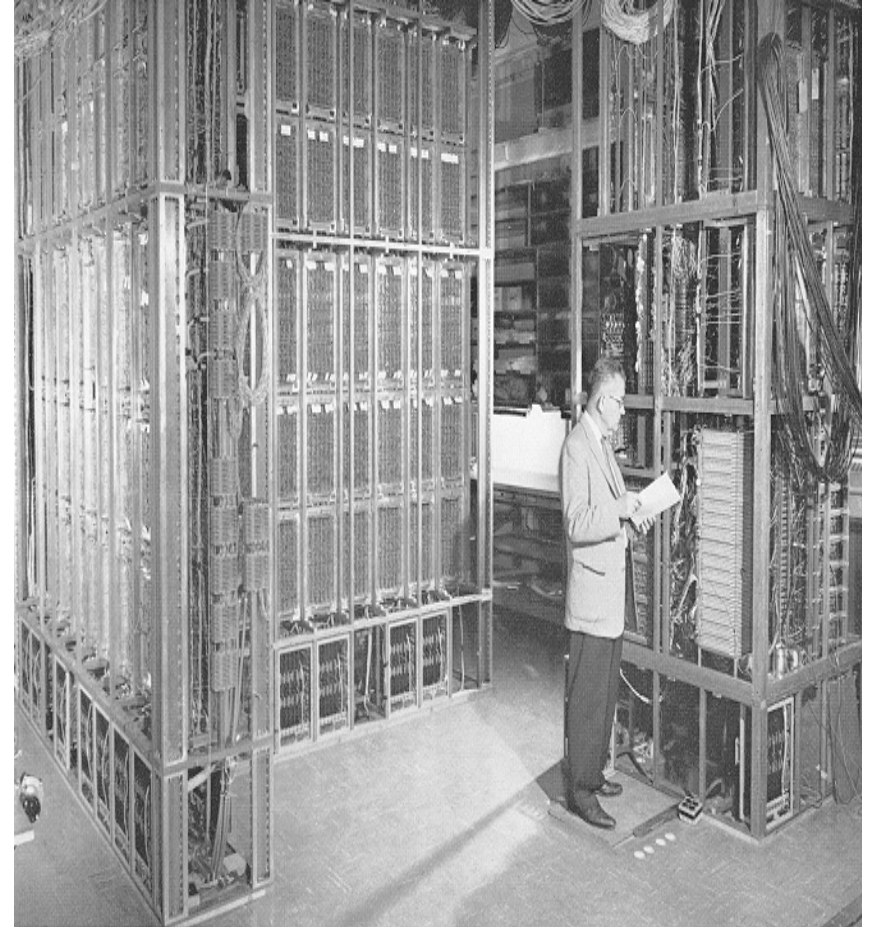
Prices in 1968

› Does not include maintenance and tech support!

Model	Description	Purchase Price	Installation Fee
3011-95	1108 CPU	$566,460	$2,200
7005-72	131 K word Core Memory	$823,500	$2,250
5009-00	FASTRAND^{tm} Controller	$41,680	$600
6010-00	FASTRAND II Storage Unit	$134,400	$1,080
5012-00	FH-432/FH-1782 Drum Controller	$67,360	$600
6016-00	FH-432 Drum (capacity 262,144 words)	$34,640	$480
6015-00	FH-1782 Drum (capacity 2,097,152 words)	$95,680	$540
4009-99	Console (TTY-35)	$29,365	$200

Second Generation Computers

› In 1947, the transistor was invented.

› The transistor made computers smaller, less expensive and increased calculating speeds.

› Second generation computers also saw a new way data was stored.

› Punch cards were replaced with magnetic tapes and reel to reel machines.

John Bardeen, William Shockley and Walter Brattain

UNIVAC

› The ***UNIVAC*** computer was the first commercial (mass produced) computer.

› In the 50's, UNIVAC (a contraction of "Universal Automatic Computer") was the household word for "computer" just as "Kleenex" is for "tissue".

› UNIVAC was also the first computer to employ magnetic tape.

Third Generation Computers

› Transistors were replaced by integrated circuits (IC).

› One IC could replace hundreds of transistors.

› This made computers even smaller and faster.
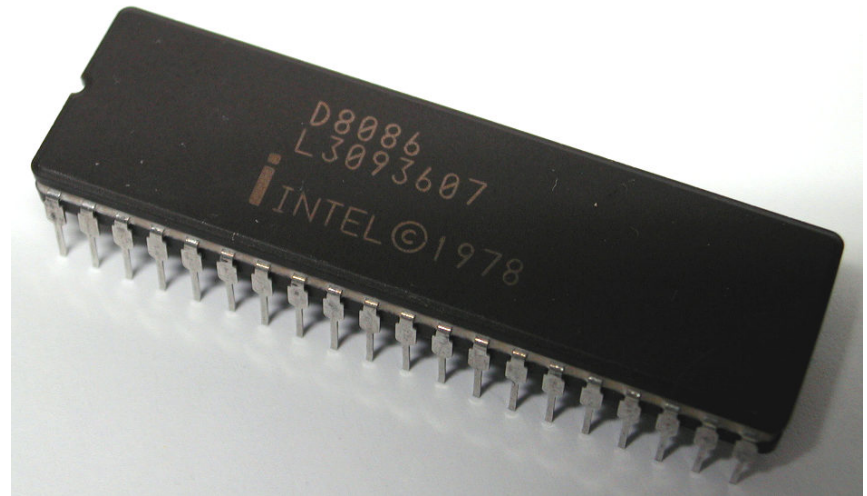
Fourth Generation Computers

› In 1970 the Intel Corporation invented the Microprocessor: an entire CPU on one chip.

› This led to microcomputers-computers on a desk.
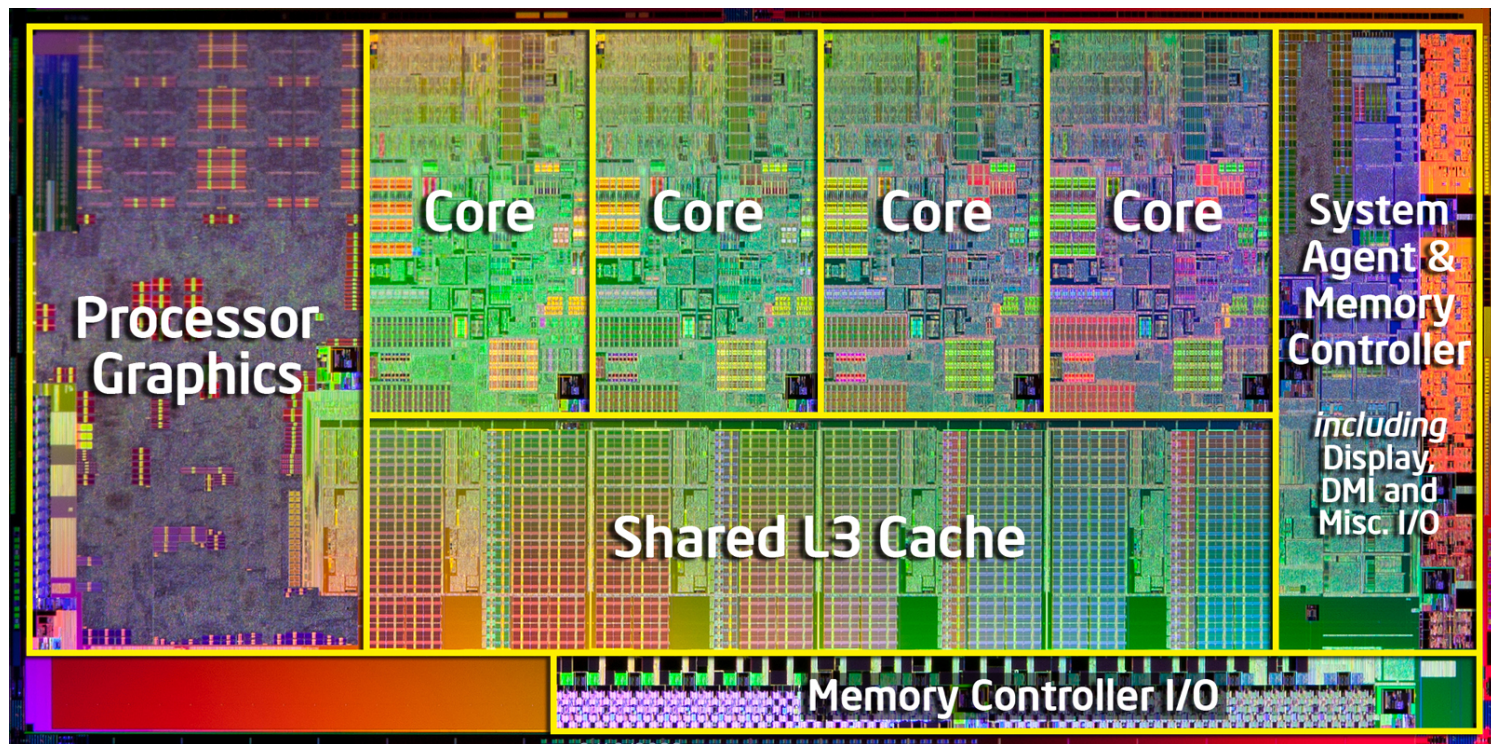
Personal Computers

› First used by hobbyists

› IBM introduced the PC in 1981.

- − Accepted by business
- − Became the standard hardware design for most desktop computers
- − Most PCs use software from Microsoft

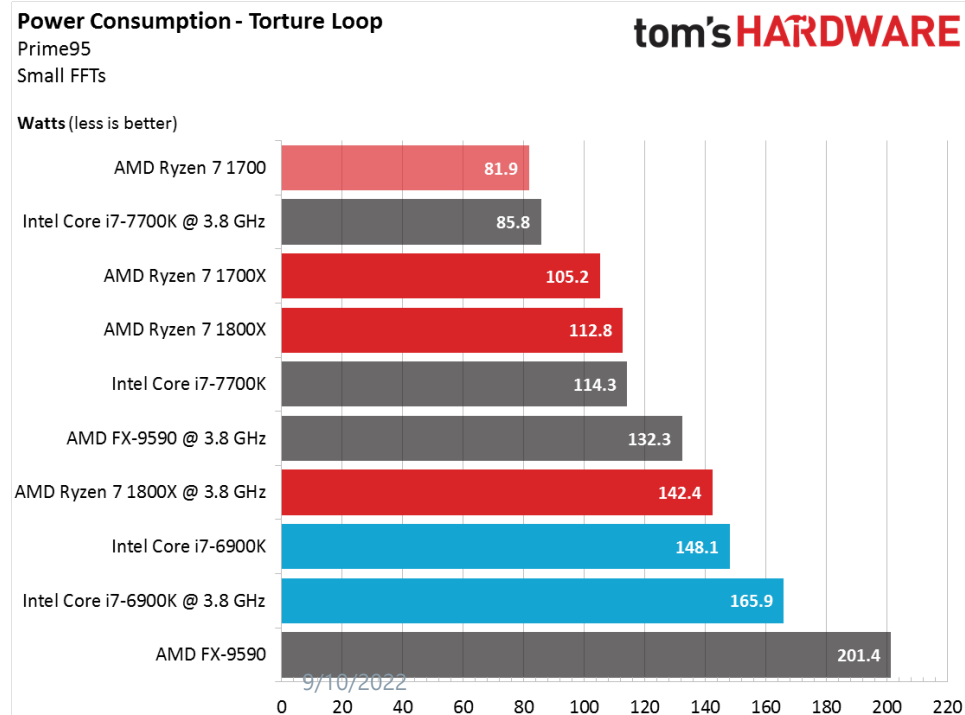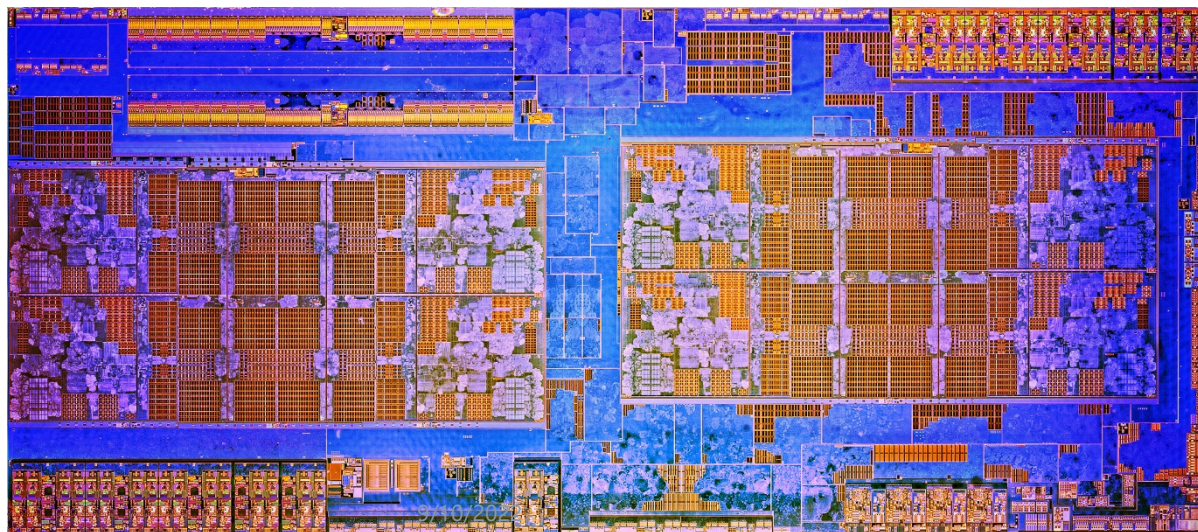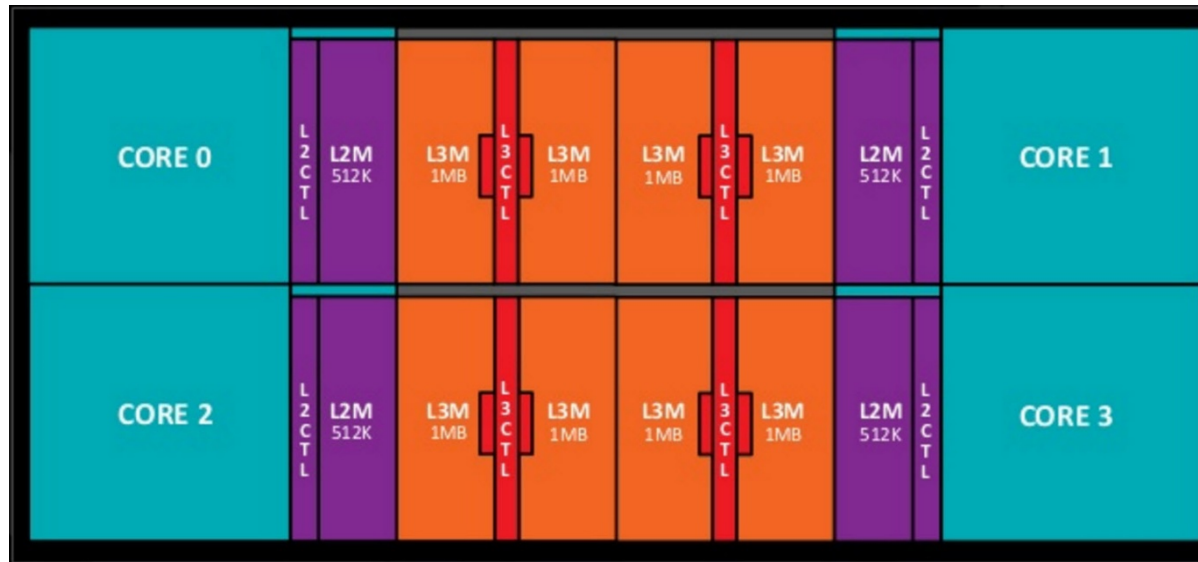# Evolution of Computer Power vs Cost

Evolution of Computer Power/Cost
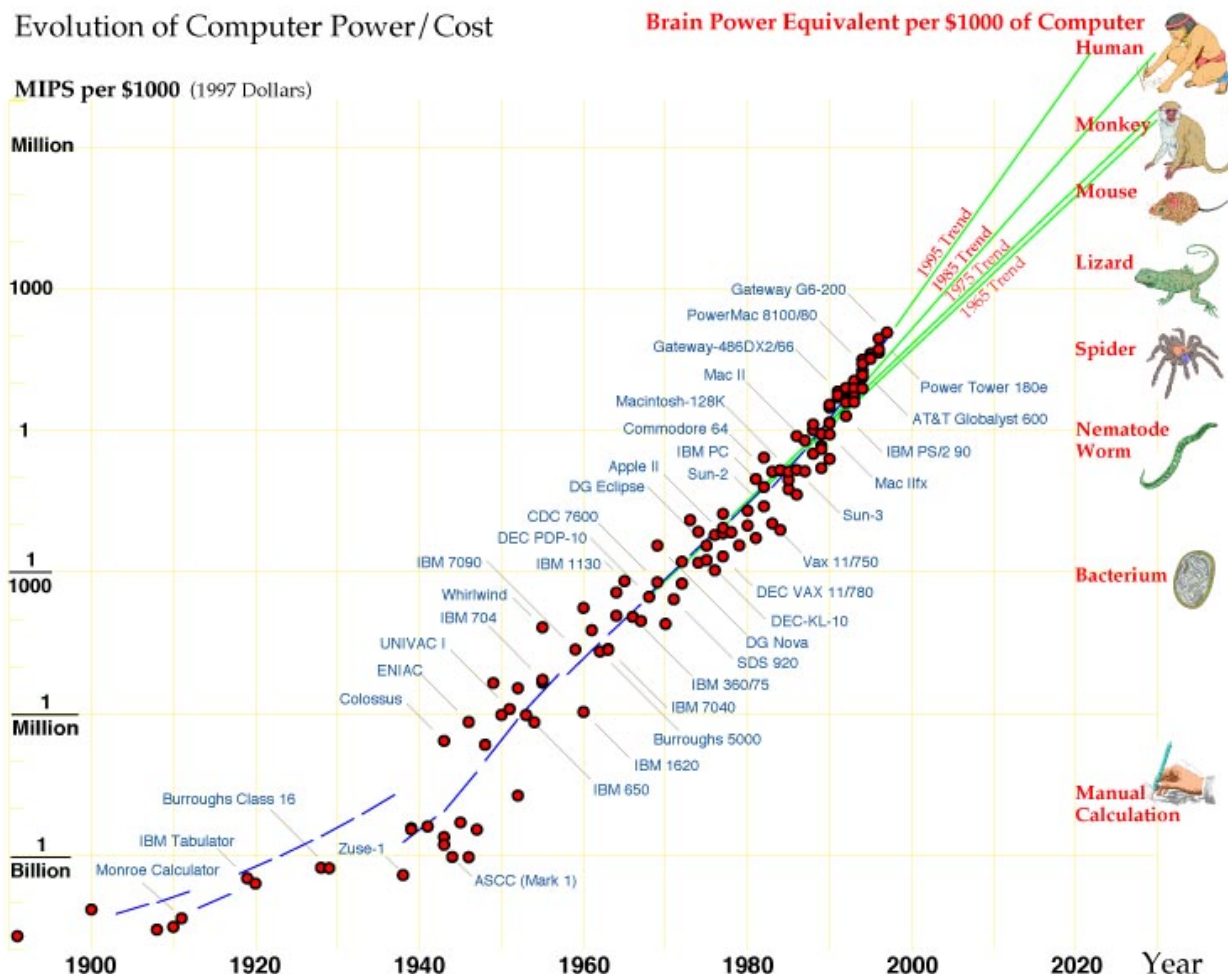
Fifth Generation?

› Multiple interconnected die (AMD)

– Away from monolithic chip designs.

› Multithreading, thread ripping

› The problem is power consumption

Power Consumption - Torture Loop
Prime95
Small FFTs

Watts (less is better)

Processor	Watts
AMD Ryzen 7 1700	81.9
Intel Core i7-7700K @ 3.8 GHz	85.8
AMD Ryzen 7 1700X	105.2
AMD Ryzen 7 1800X	112.8
Intel Core i7-7700K	114.3
AMD FX-9590 @ 3.8 GHz	132.3
AMD Ryzen 7 1800X @ 3.8 GHz	142.4
Intel Core i7-6900K	148.1
Intel Core i7-6900K @ 3.8 GHz	165.9
AMD FX-9590	201.4

tom's **HARDWARE**

Fifth Generation?

Infinity band (channel)

GPU Clusters

The five-server system uses a relatively new package of virtualization software that harnesses the power of 25 AMD Radeon graphics cards.

A password-cracking expert has unveiled a computer cluster that can cycle through as many as 350 billion guesses per second.
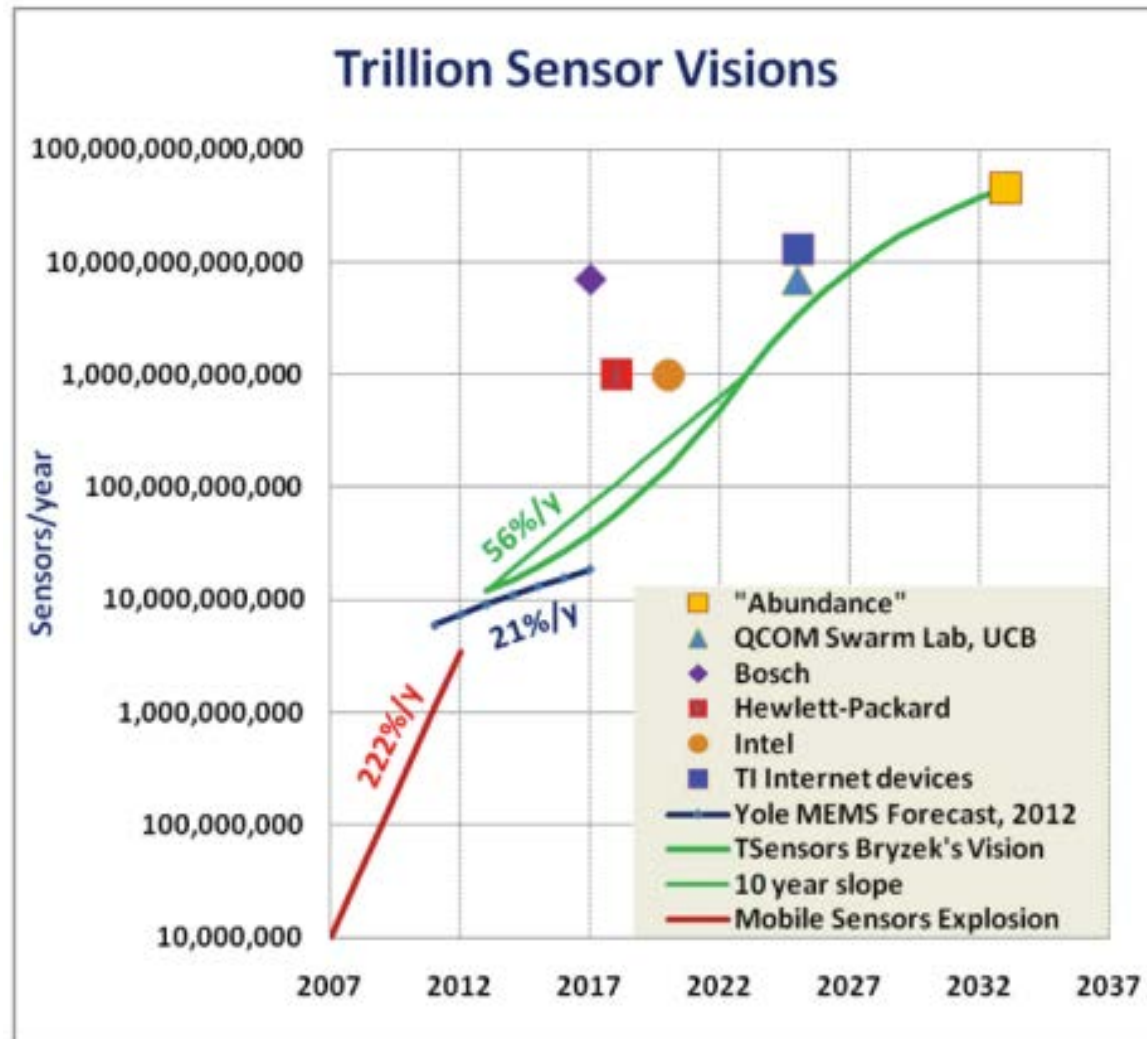
GPU Super servers

Into the Millennia

- Internet revolutionized communications
  - World Wide Web
  - Search Engines (Google, Yahoo, and Microsoft)

- Miniaturization of computing machines
  - Embedded (GPS, in automobile engines)
  - Smartphone

Internet of Things

Wearable devices

穿戴式產品主要產品型態

智慧手環 · 智慧耳機 · 智慧眼鏡

智慧衣 · 智慧手錶

智慧鞋 · 智慧襪 · 心跳感測帶 · 智慧戒指

Assignment

› Watch

– The IBM 1401 compiles and runs FORTRAN II

› https://www.youtube.com/watch?v=uFQ3sajIdaM

– 1946 ENIAC Computer History Remastered FULL VERSION First Large Digital Elec. Computer Educational

› https://www.youtube.com/watch?v=bGk9W65vXNA