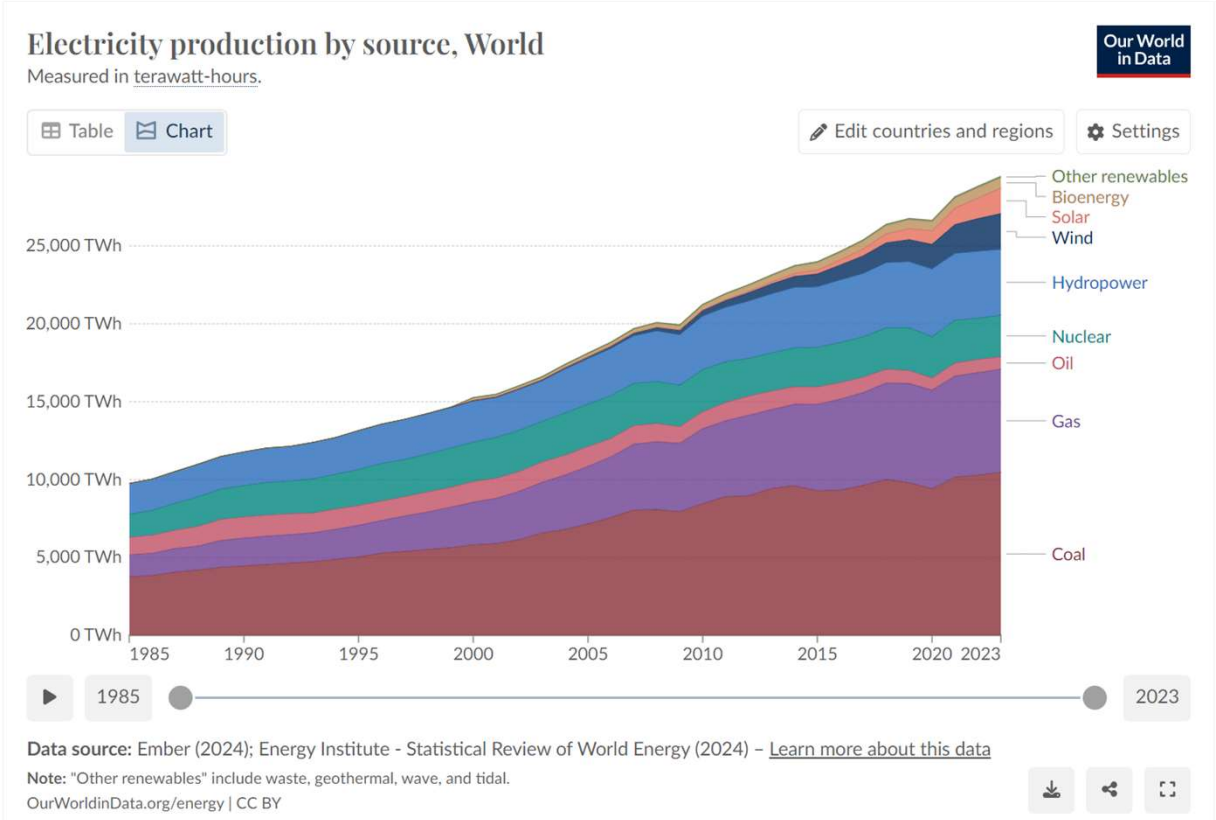
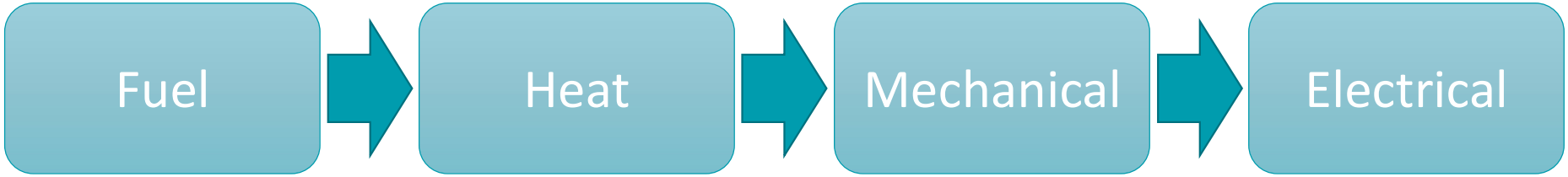
Review: Electricity Production

- Production tripled since the 1980s
- Combustion of coal and gases has been the primary source
- Other sources also increased quickly in recent years



Review: Fossil Fuel Combustion for Electricity Production

- **Converting fuel to heat, either through a boiler for systems that use water as the working fluid or a combustion chamber for gas-fired systems**
- **A turbine is used for converting heat energy to mechanical energy**
- **A generator for converting mechanical energy to electrical energy**



Credit to Prof. Yunlong Zi

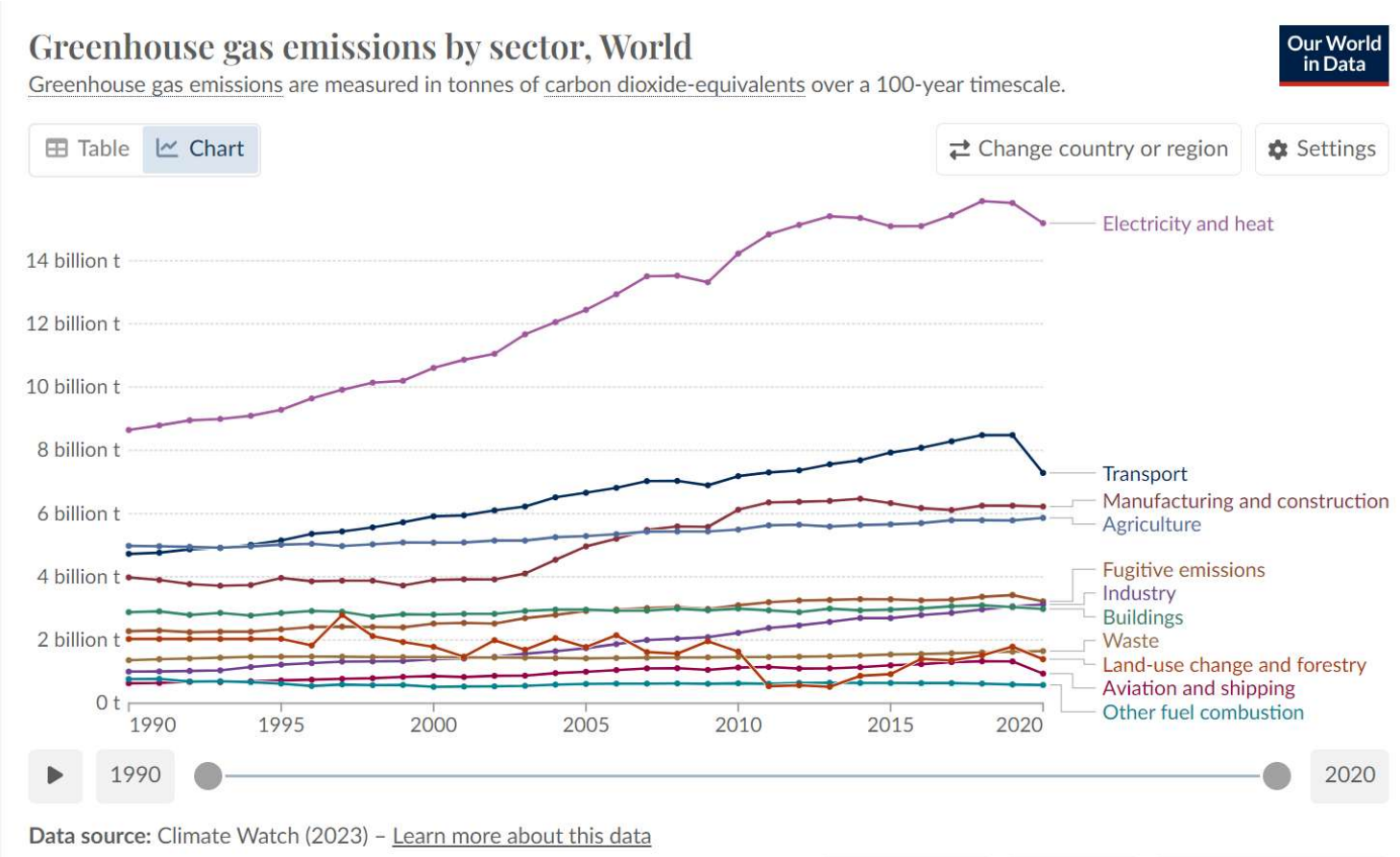
Review: Renewable energy: opportunities and challenges

- Wind
- Solar power
- Biofuel

https://www.jasc.ch/the-top-5-renewable-energy-sources-for-homes

Review: Carbon emission

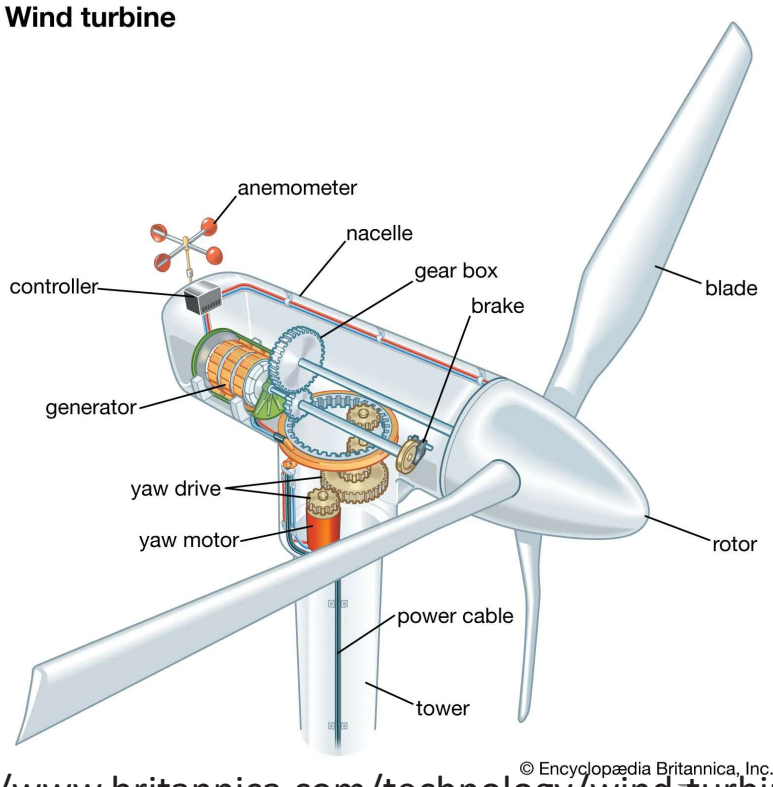
- Electricity and heat production is the primary contributor of the global greenhouse gas emission



Review: Wind Turbine

- The rotor blades convert wind energy into mechanical energy
- The blades turn the main shaft that turns the electric generator

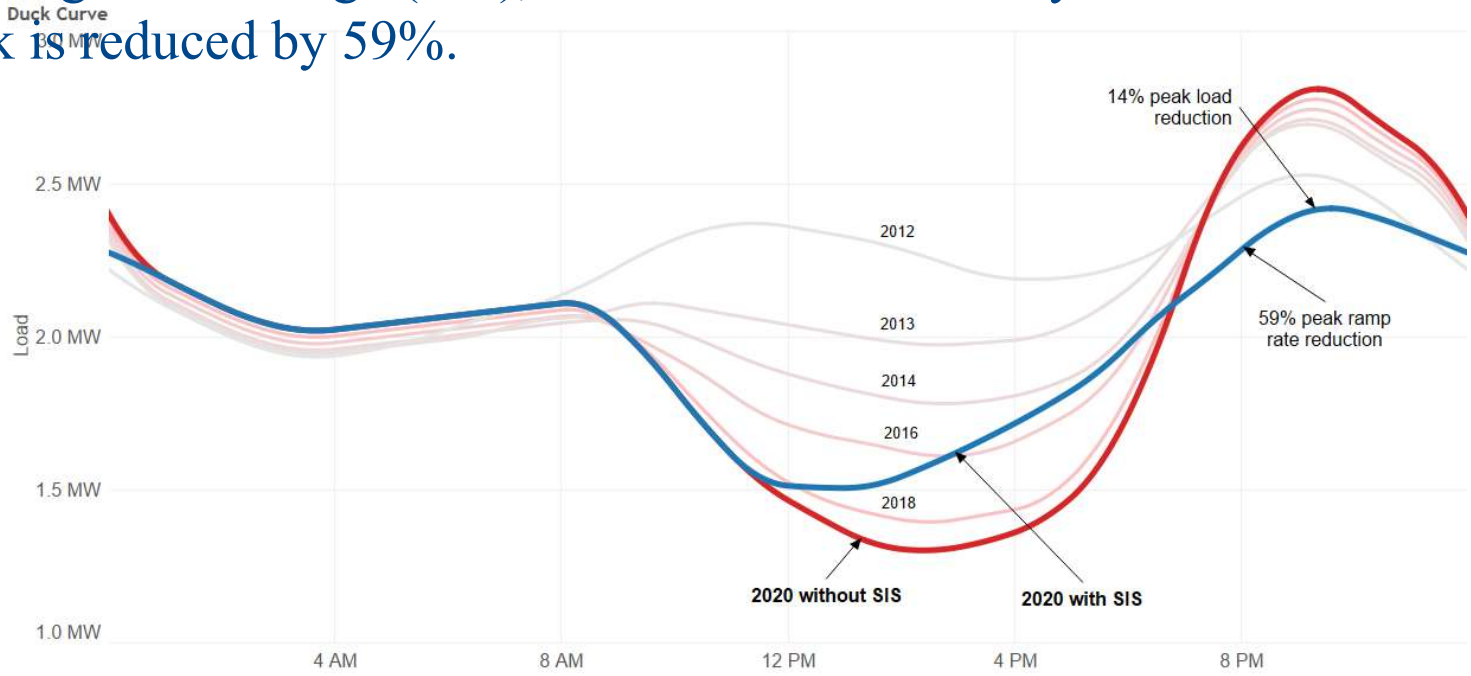
https://nsci.ca/2019/07/17/wind-power/



https://www.britannica.com/technology/wind-turbine

Review: How to solve the problem?

- Curves for successive years assume continued solar uptake consistent with historical growth in solar deployments.
- Unabated, we can see a widening of the gap due to reduced daytime demand, uptake of solar PV and evening demand peaks.
- With Solar Integrated Storage (SIS), load factor increases by 17% and the ramp rate for evening peak is reduced by 59%.



Review: Different types of energy storage

- Mechanical energy storage
- Thermal energy storage
- Electrochemical energy storage

https://www.azom.com/article.aspx?ArticleID=22831

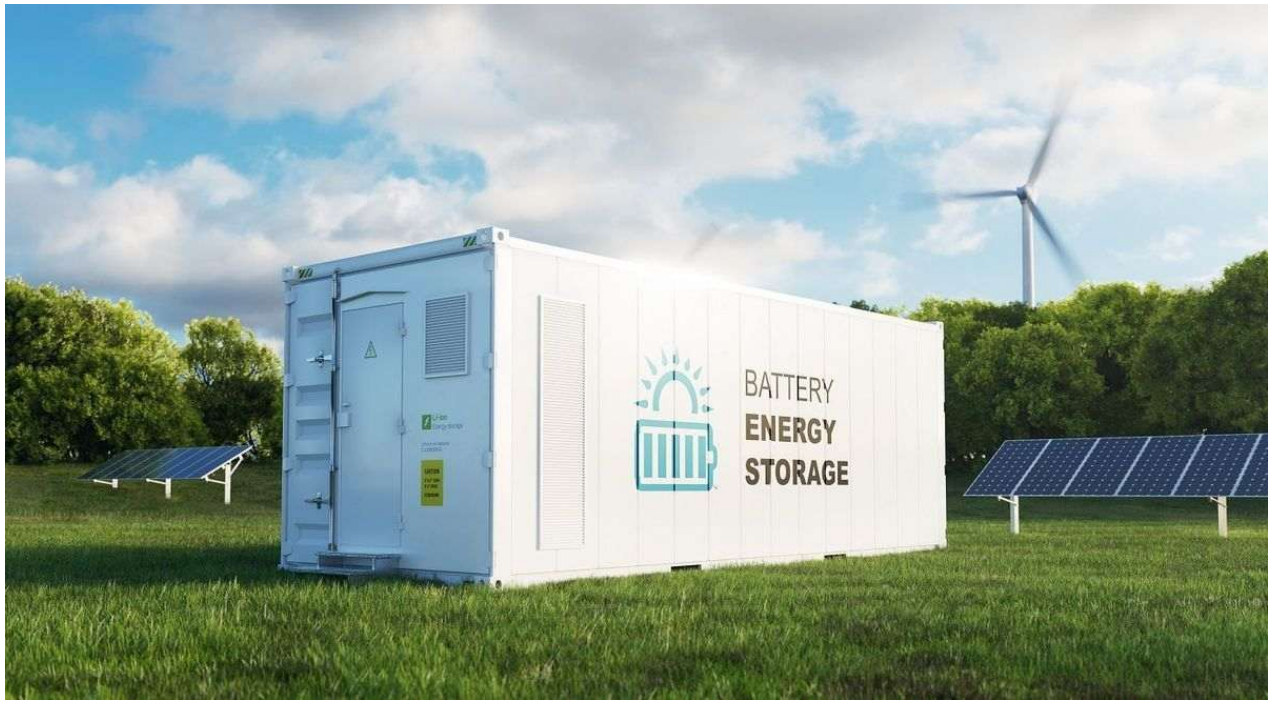
Review: Rechargeable Battery

- Can be charged and discharged for many times
  - ✓Lead-acid battery, for vehicles
  - ✓Nickel-metal hydride (NiMH) battery
  - ✓Lithium-ion (Li-ion) battery (best charge density, slow loss of charge, controllable risk)

Credit to Prof. Yunlong Zi

Review: Battery energy storage system

- Devices that enable energy from renewables, like solar and wind, to be stored and then released
- Grew five-fold between 2015 and 2020.
- Will replace dispatchable thermal plants
- Expect (680GW) to supersede pumped hydropower storage in 2030

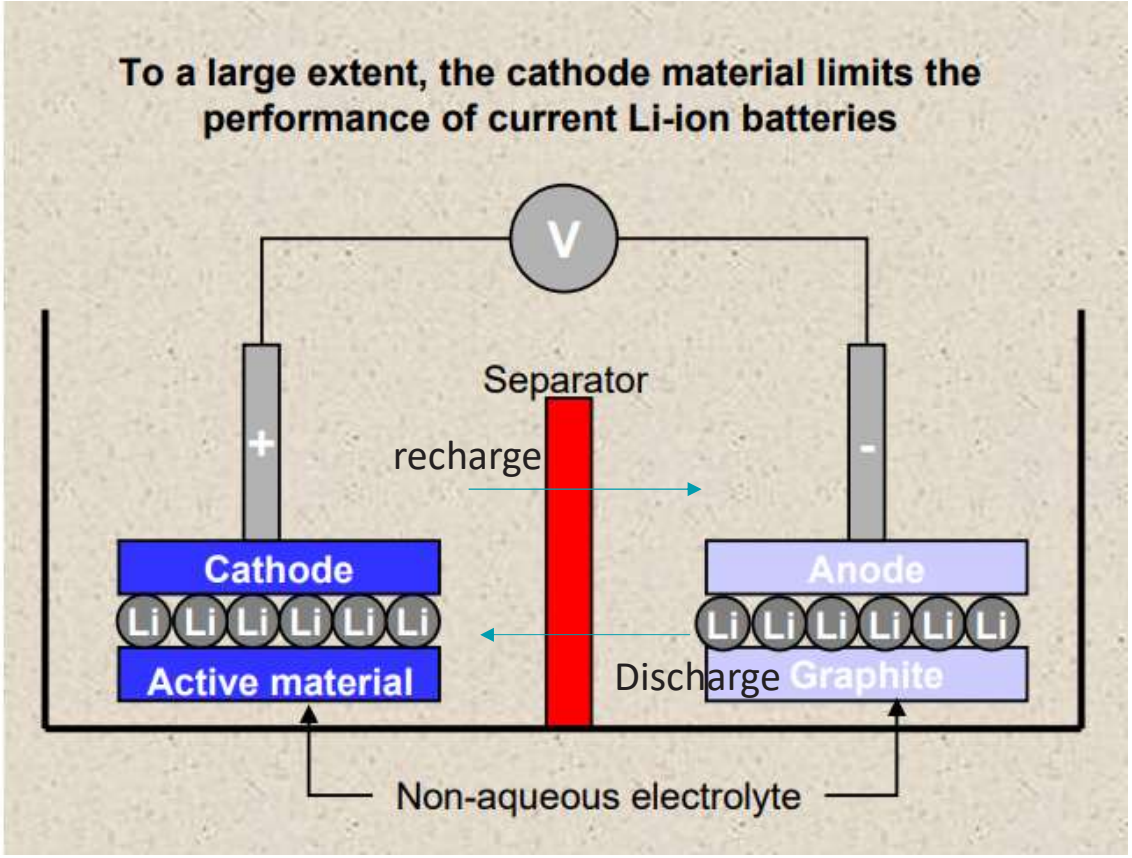


https://www.next-kraftwerke.com/energy-blog/flexibility-battery-storage

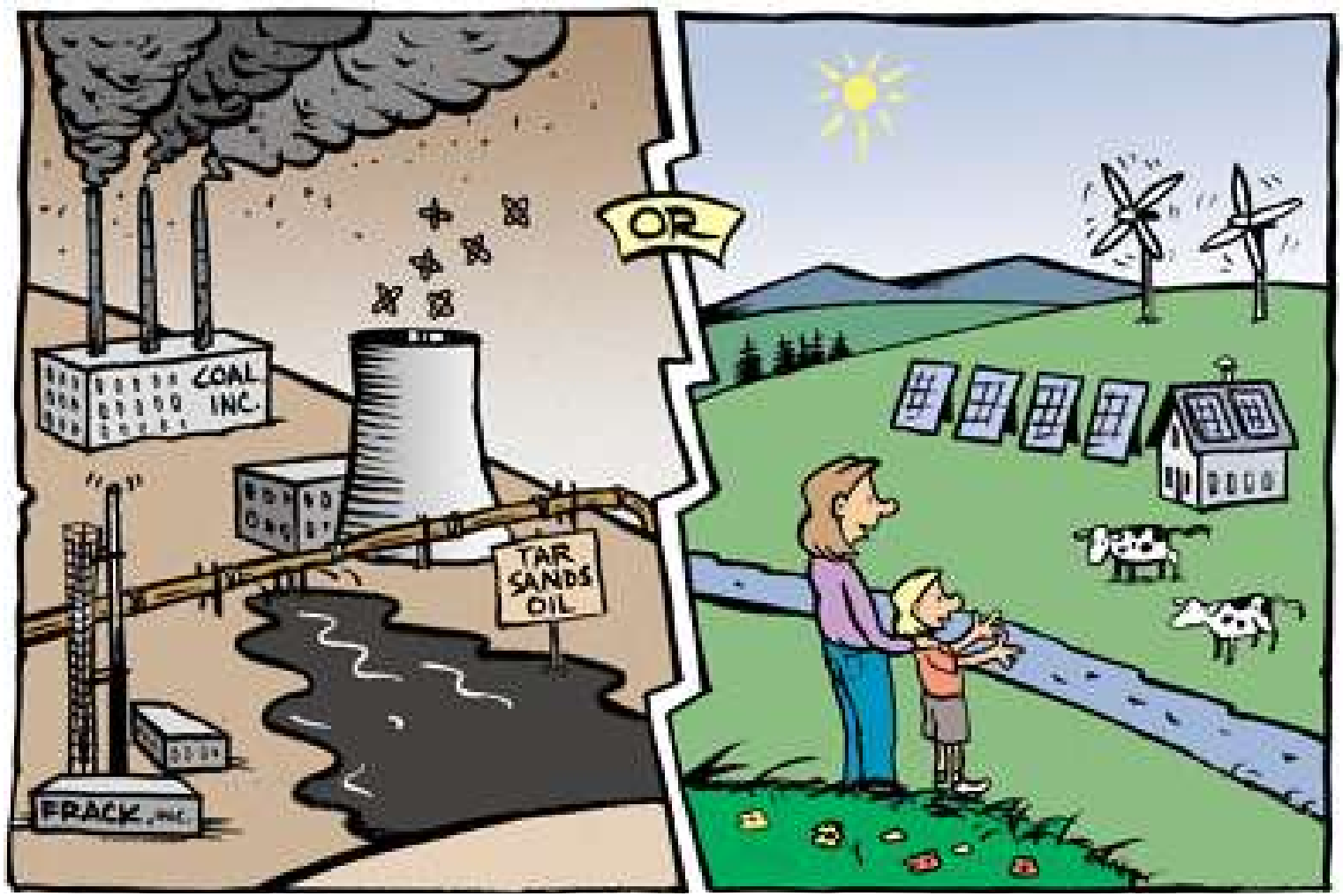
Review: Lithium-Ion Battery

Compared with traditional batteries, Li-Ion Battery has:

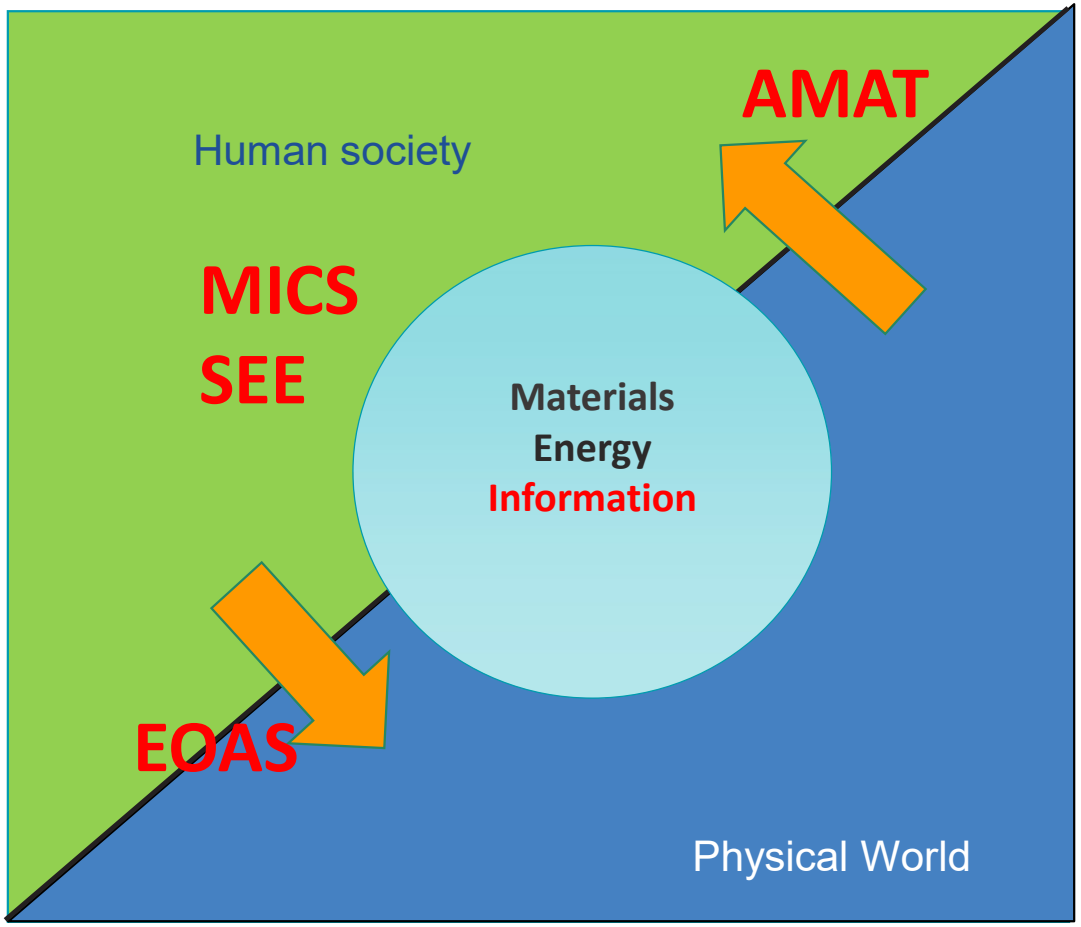
- Higher battery density
- Higher voltage
- Longer life span
- Lower self-discharge (1-2 % per month)



Renewable Energy: a solution for global warming



Thrusts of Function Hub



Lecture Topics

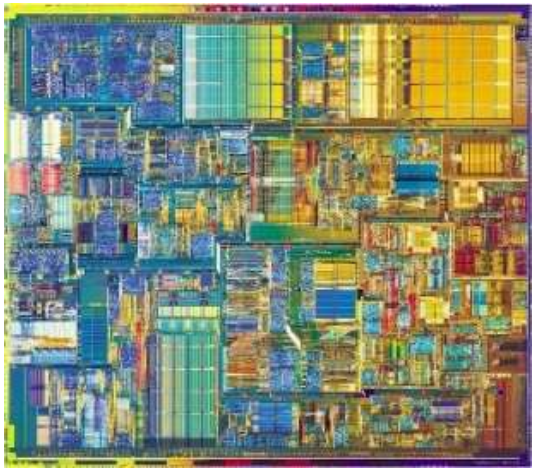
Fundamentals of the Human-nature system	Environmental challenges	Solutions for sustainable development	
➢ The history of material science and human civilization (**AMAT**) ➢ Polymers (**AMAT**) ➢ Graphene/AI Matter in Advanced Materials (**AMAT/SEE**)	➢ Climate change (**EOAS**) ➢ Hydrology and climate change **(EOAS**) ➢ Responses of Oceans to climate change **(EOAS)**	➢ Energy Production and Pollution(**SEE**) ➢ Renewable energy production (**SEE**) ➢ Energy storage (**SEE**)	➢ Development of computers (**MICS**) ➢ Chip production from sand (**MICS**) ➢ Supercomputing (**MICS/EOAS**)

12 lectures in total

Research of the MICS Thrust

MICS: “We offer fundamental trainings across different disciplines to prepare students to take on the challenge of the next century in the discovery and innovation of integrated circuits and systems”

- Device and Fabrication
- Circuits Technology
- Computer Architecture and System
- Electronic Design Automation



Tesla’s new investment

Introduction to Function Hub For Sustainable Future

Lecture 10： History of Computers

Qichun Yang

2024-11-18

香港科技大学(广州)
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY (GUANGZHOU)

Vocabulary of this lecture

- **Abacus:** 算盘
- **Decrypt:** 解密
- **Computer Architecture:** 计算机架构
- **Vacuum tube:** 真空管
- **Transistor:** 晶体管
- **Resistor:** 电阻
- **Capacitor:** 电容
- **Intelligentize:**智能化
- **Integrated Circuit:** 集成电路
- **CPU: Central Processing Unit,** 中央处理器
- **Clock speed :** 时钟频率
- **Dominant frequency:** 主频

Outline

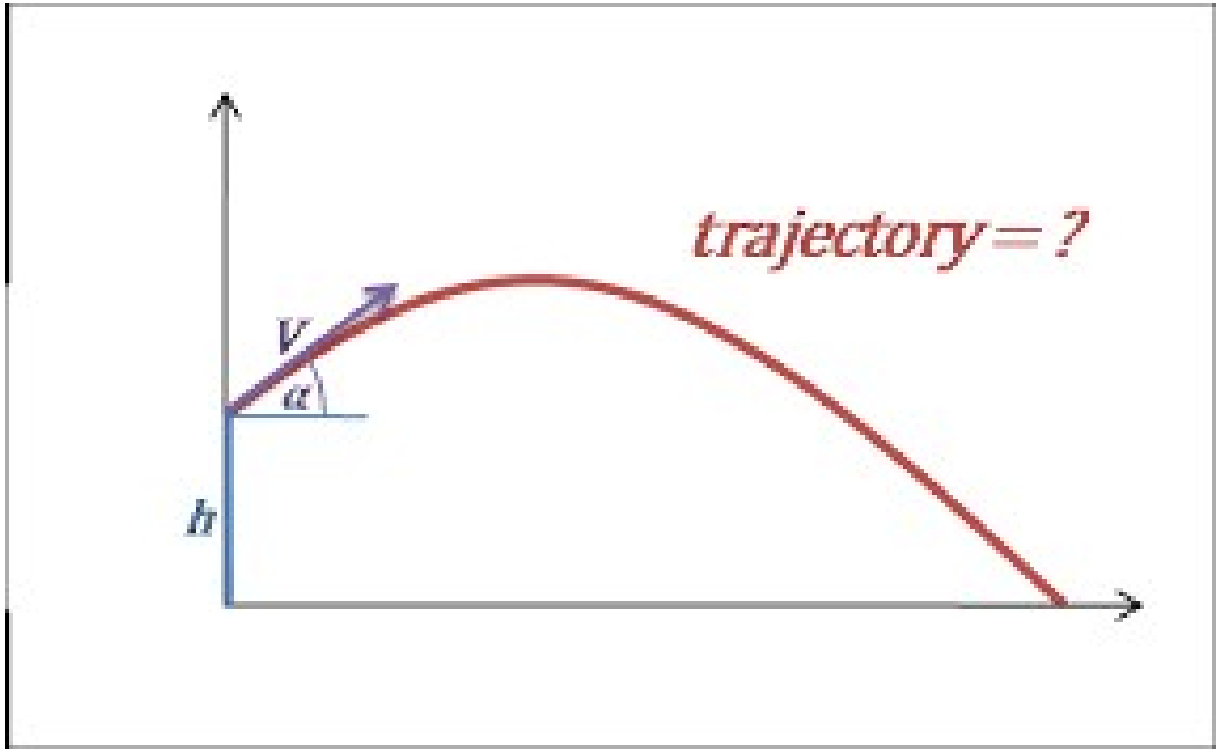
- History of computers
- Different types of modern computers
- Development of processors
- Future directions

Outline

- History of computers
- Different types of modern computers
- Development of processors
- Future directions

History of computers

- The term ‘computer’ was originally a job role.
- People who did 'computation’ for bomb trajectories or rocketry calculations



https://www.omnicalculator.com/physics/trajectory-projectile-motion

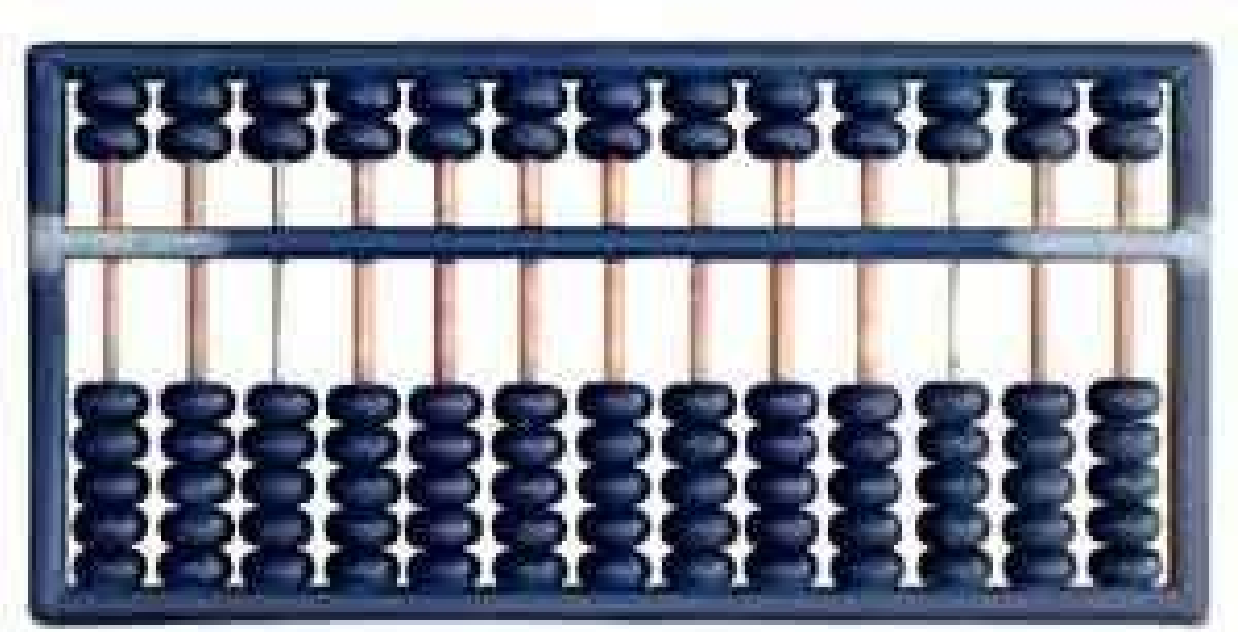
History of computers

NASA space scientist and mathematician Katherine Johnson, pictured here in 1962, was known as a human computer because of her precise mathematics calculations.

https://www.nationalgeographic.com/history/article/katherine-johnson-mathematician-sent-apollo-moon-wins-hubbard-medal

History of computers: mechanical calculator

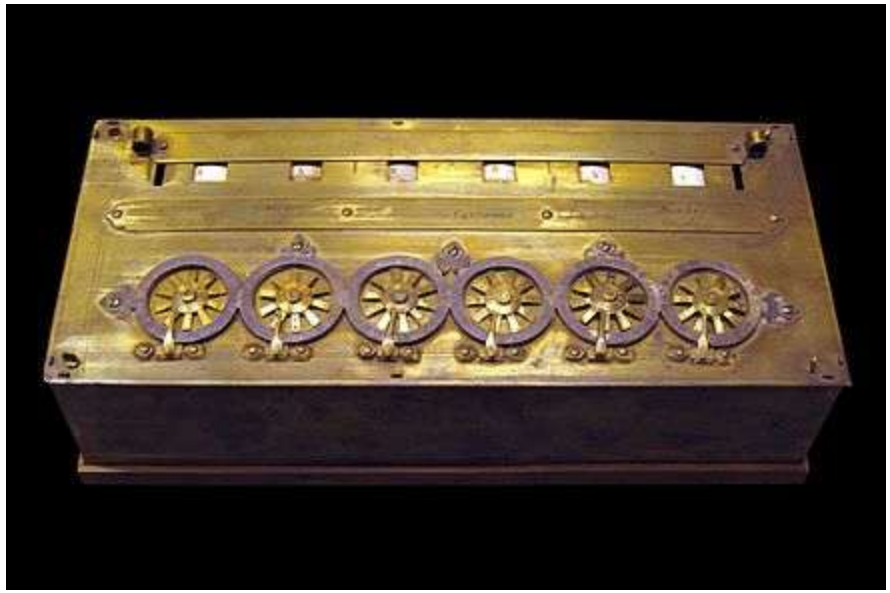
- Abacus, used in Babylon, China, etc., thousands years ago
- Move the bead up and down to add and subtract
- Could not do multiplication or division directly



https://www.omnicalculator.com/physics/trajectory-projectile-motion

History of computers: mechanical calculator

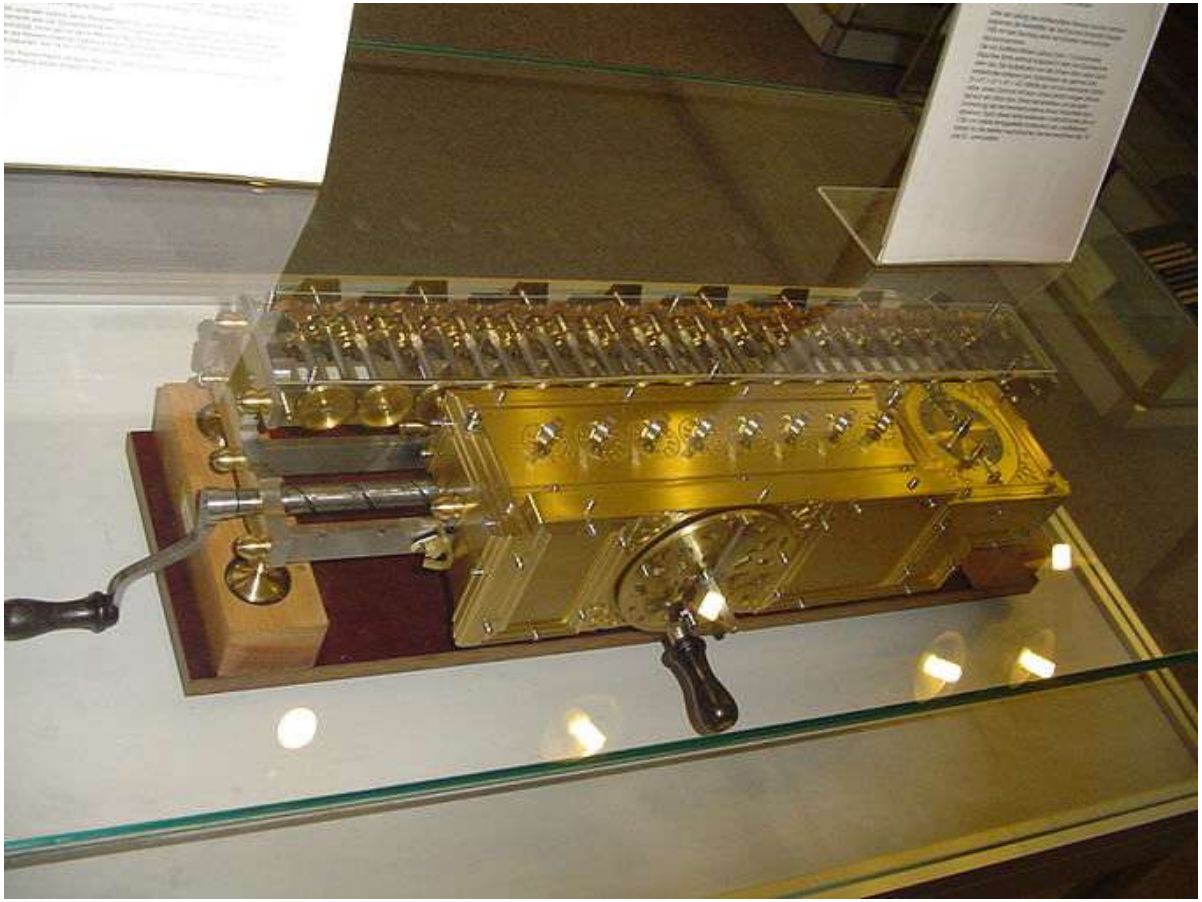
- Pascal's calculator
- invented by Blaise Pascal in 1642
- First calculating machine
- Was invented to calculate tax



https://www.omnicalculator.com/physics/trajectory-projectile-motion

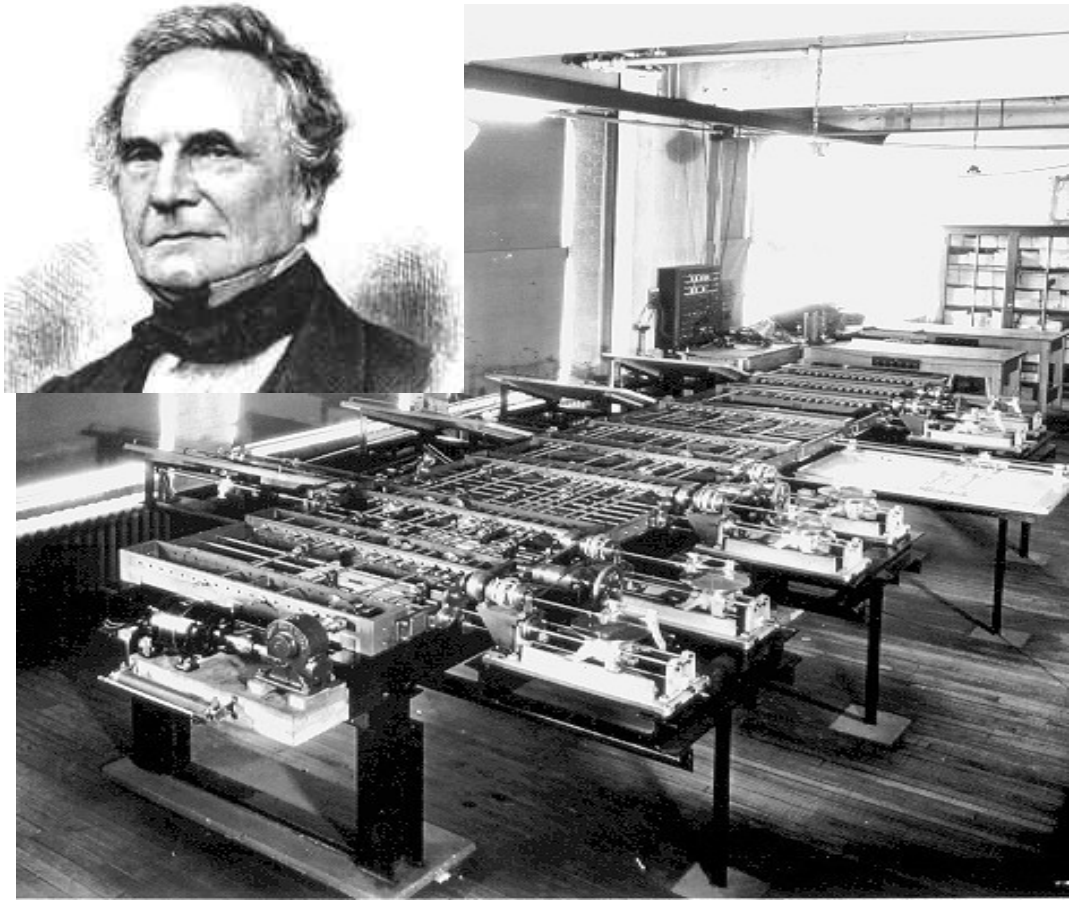
History of computers: mechanical calculator

- Stepped Reckoner
- Invented by *Gottfried Leibniz* in 1673
- The first machine can do all four basic arithmetic operations.



History of computers: mechanical calculator

- Analytical Engine
- Charles Babbage designed it in 1837.
- Used loops control an automatic calculator, based on the results of previous computations.
- Sequential control, branching, and looping.
- Charles Babbage is recognized today as the Father of Computers
- In 1941 that Konrad Zuse built the first general-purpose computer, Z3 machine



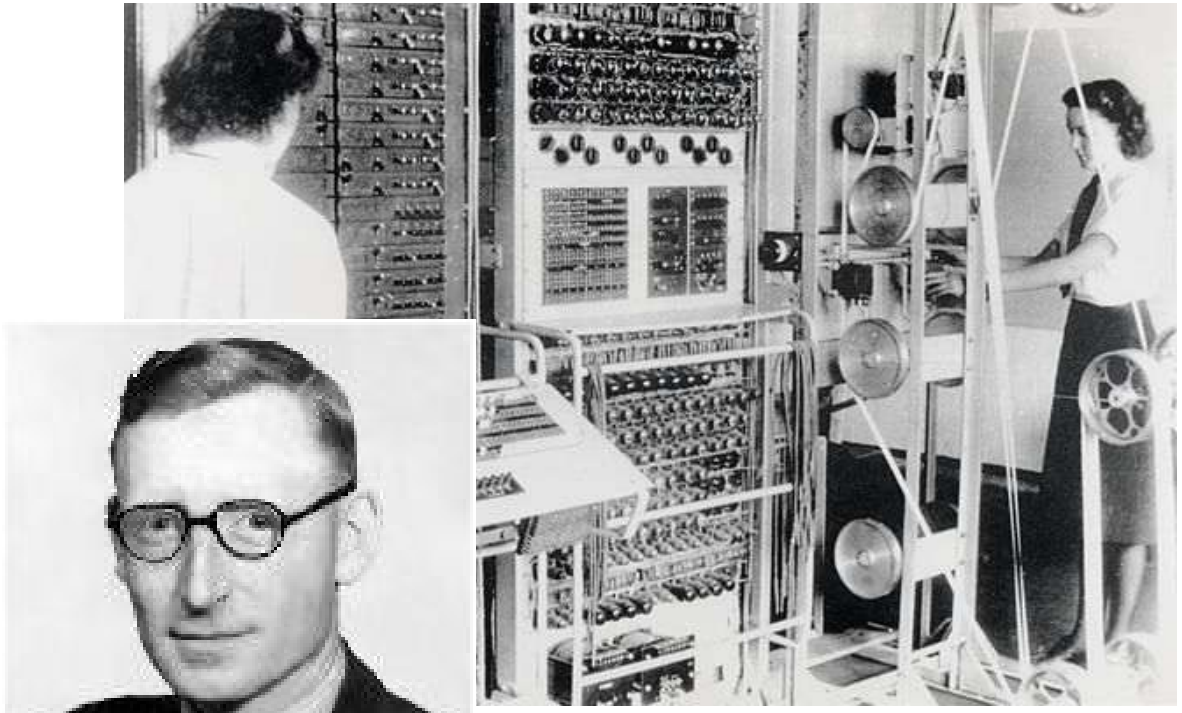
History of computers

During World War 2, code breakers used computational analytical models to try and work out what enemy messages meant.

Bletchley Park

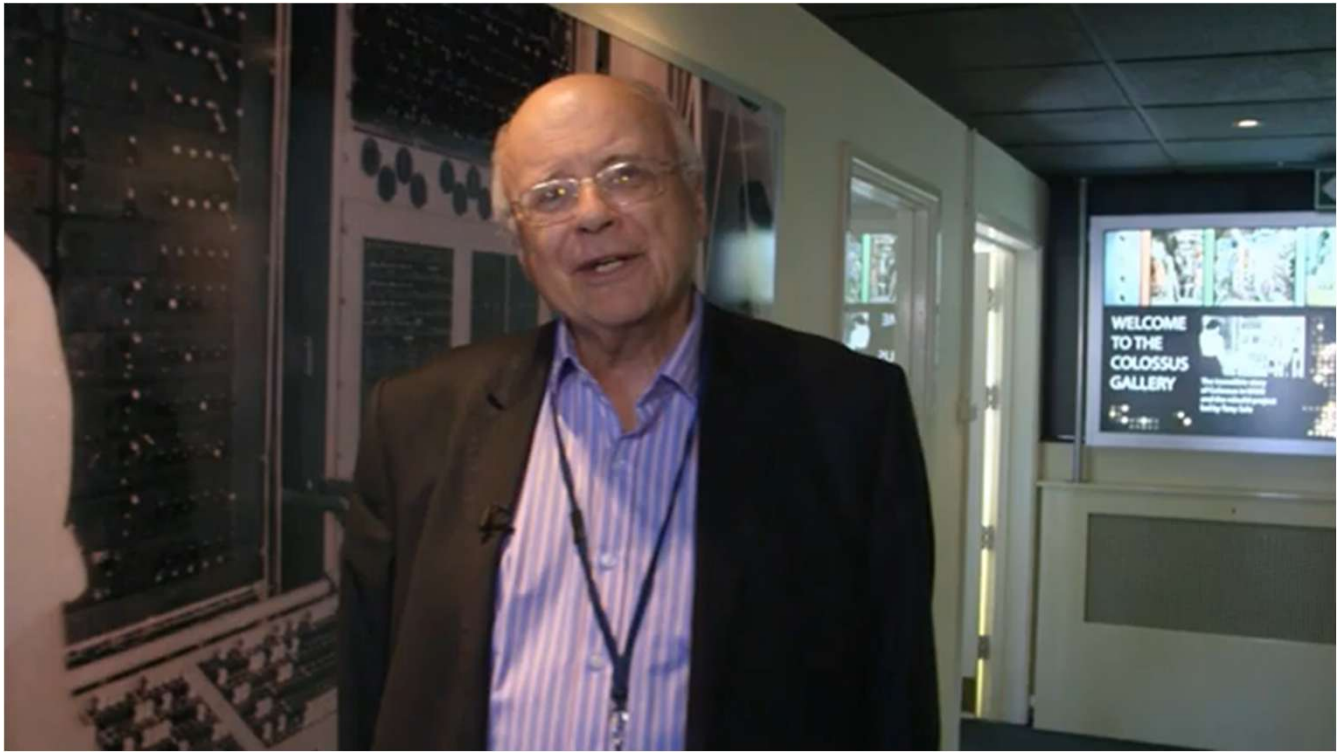
History of computers: electronic calculator

- **Colossus**
- Designed by **Tommy Flowers** and his colleagues in 1943-1945
- First programmable, **electronic**, digital computer
- It was used to crack the German's Enigma code
- Calculation it was able to solve in two hours, would take humans eight weeks to finish



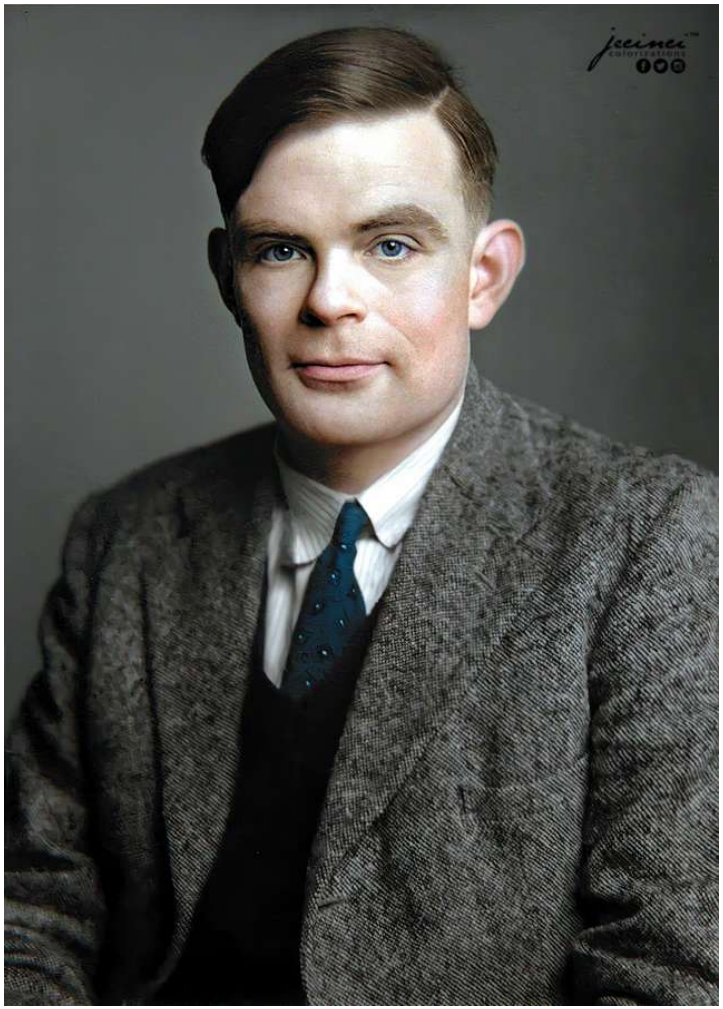
https://en.wikipedia.org/wiki/Colossus_computer

Colossus



History of computers

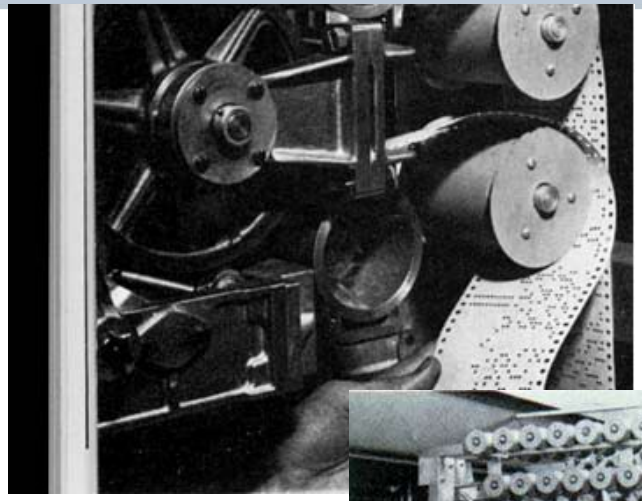
- **Alan Turing** also contributed to the **Colossus** machine
- '***On Computable Numbers***' in 1936
- The paper proved that a machine capable of processing a stream of 1s and 0s (binary) would be capable of solving any problem.
- Father of theoretical computer science

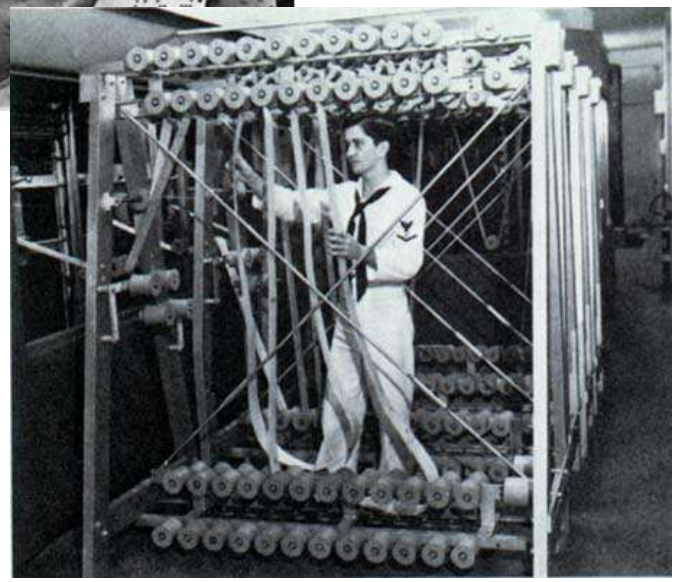


History of computers: 1st generation

- ASCC computer (Automatic Sequence Controlled Calculator), later names as **Mark I**
- **Howard Aiken**, of Harvard University
- Started in 1937 and finished in in 1944
- The first electromechanical calculator
- Solving gunning, ballistics, and naval design problems

It weighed five tons, had five hundred miles of wire

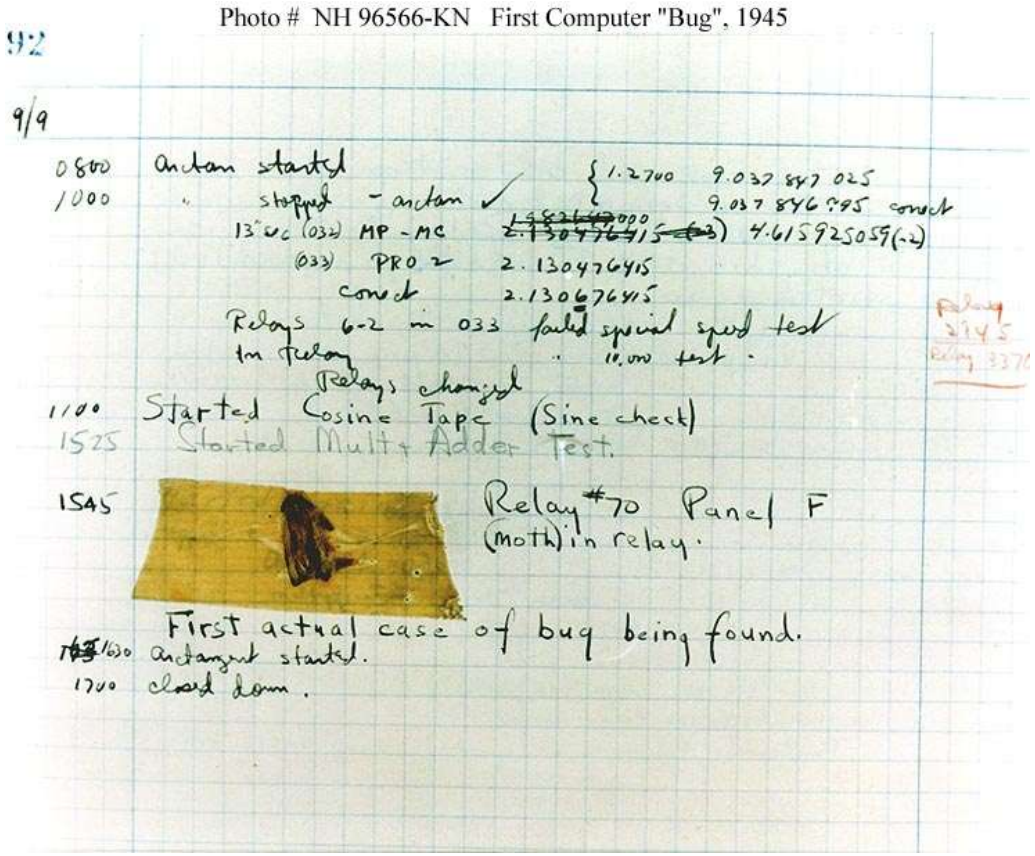




https://en.wikipedia.org/wiki/Pilot_ACE

History of computers : 1st generation

- 1947 A moth was found in MARK II
- ‘First actual case of bug being found’



History of computers : 1st generation

- The Pilot ACE (Automatic Computing Engine) ,
- Was one of the first computers built in the United Kingdom in the early 1950s
- Pilot ACE was built to a cut down version of Turing's full ACE design.
- 800 vacuum tubes

https://en.wikipedia.org/wiki/Pilot_ACE

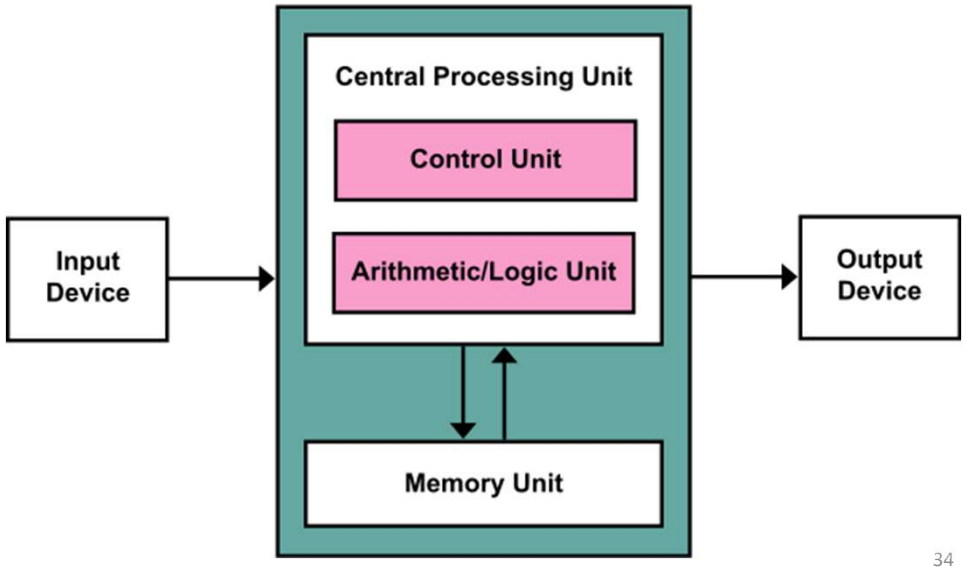
History of computers

First generation are those made with vacuum tubes.

Computer	Date	Units	Notes
IBM 604	1948	5,600	First all-electronic calculator for use with unit record equipment. Could multiply and divide data from punched cards. Had 1,250 tubes.
IBM CPC	1949	700	Combined an IBM 604 with other unit record machines to carry out a sequence of calculations defined by instructions on a deck of punched cards.
Ferranti Mark 1	1951	9	First commercially available stored program computer, based on Manchester Mark 1.
UNIVAC I	1951	46	First mass-produced stored-program computer. Used delay-line memory.
LEO I	1951	1	First computer for commercial applications. Built and used by J. Lyons and Co., a restaurant and bakery chain. Based on EDSAC design.

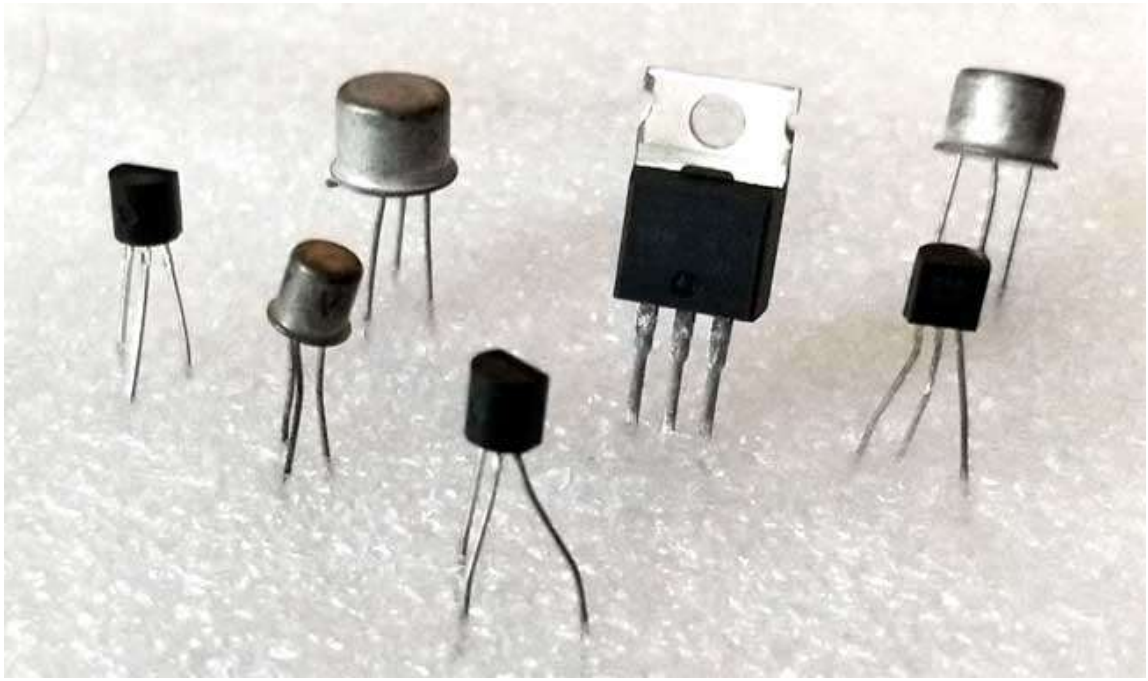
History of computers

- von Neumann architecture
- 1945, developed by von Neumann, based on discussions with John Presper Eckert and John Mauchly
- Adopted by most modern computers



History of computers : 2nd generation

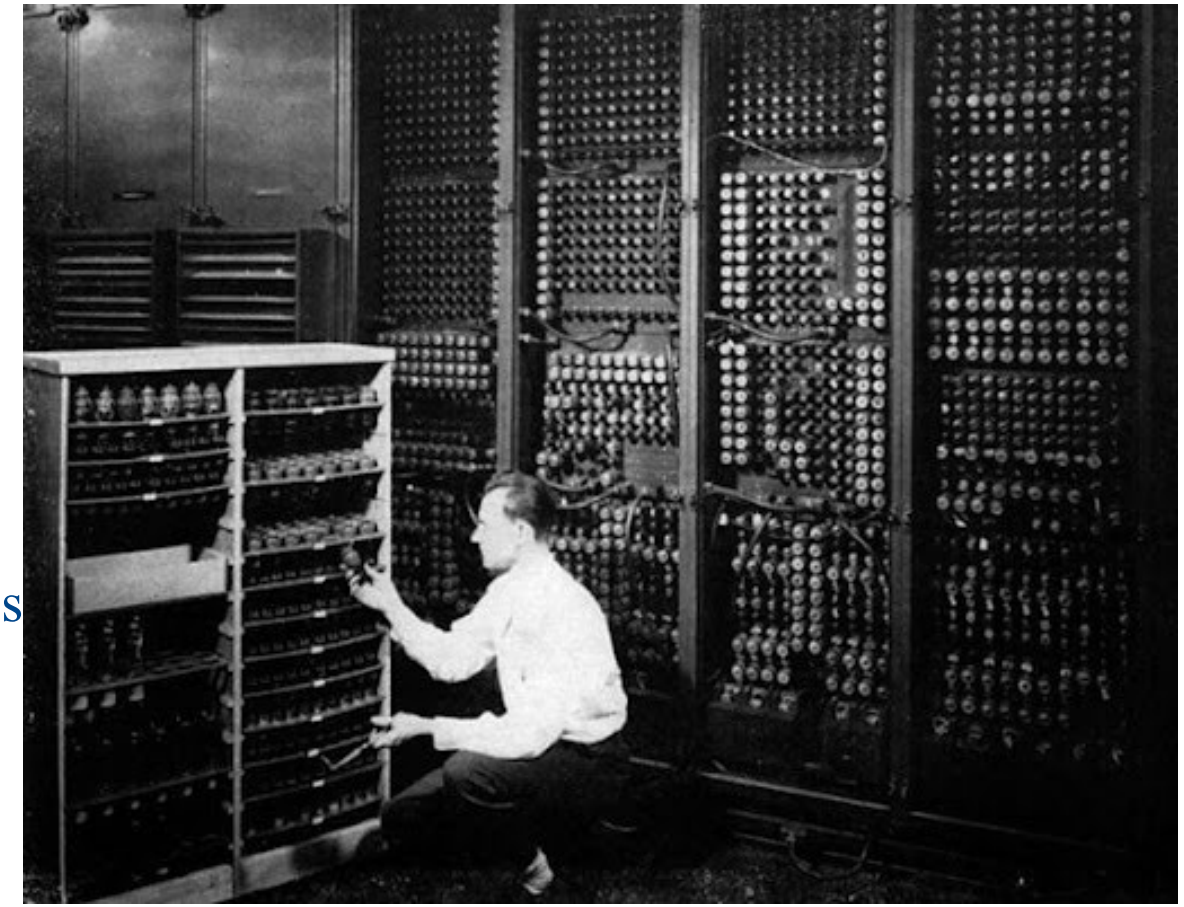
1950s-1960s – Second generation of computers (transistor computers) are produced.



https://www.circuitcrush.com/what-is-a-transistor/

History of computers: 2nd generation

- ENIAC (Electronic Numerical Integrator and Computer) was completed in 1946,
- At the University of Pennsylvania by Mauchly, Eckert, and Brainerd.
- It contained eighteen thousand vacuum tubes, seventy thousand transistors, ten thousand capacitors, six thousand switches and weighed thirty-five tons.
-
- It took up three to four times more space than the Mark 1

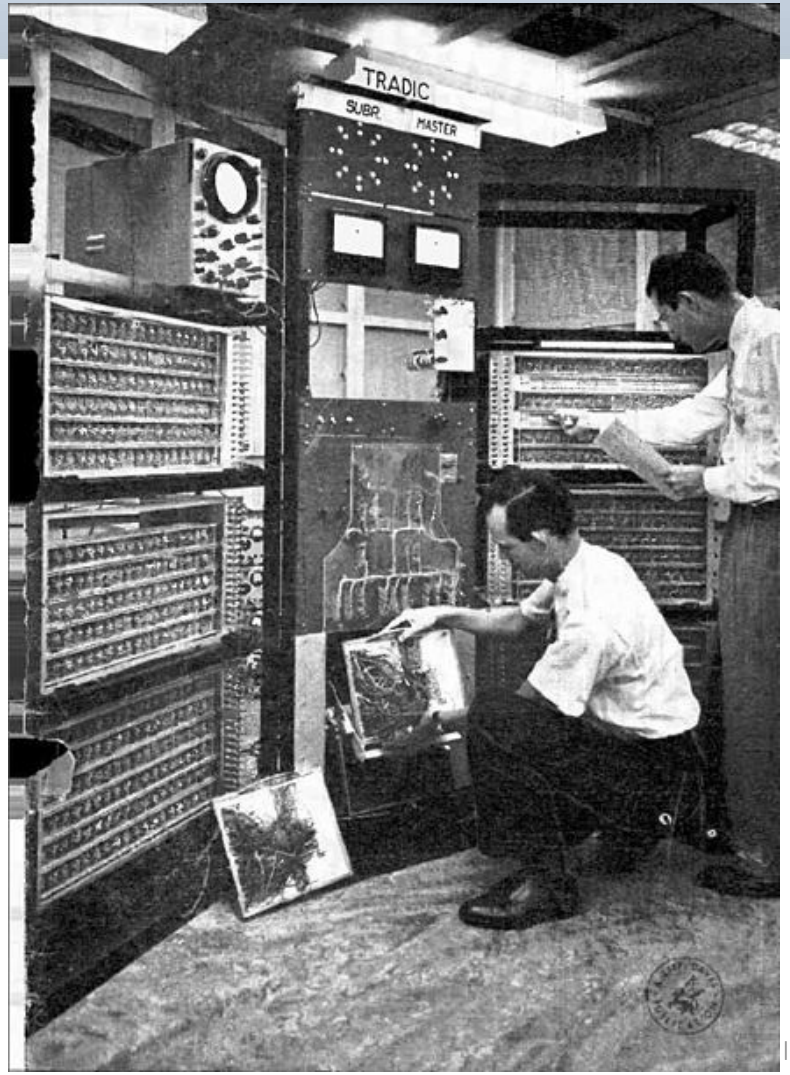


https://computerlab.tripod.com/1900-1950.htm

https://www.computerhistory.org/revolution/birth-of-the-computer/4/78

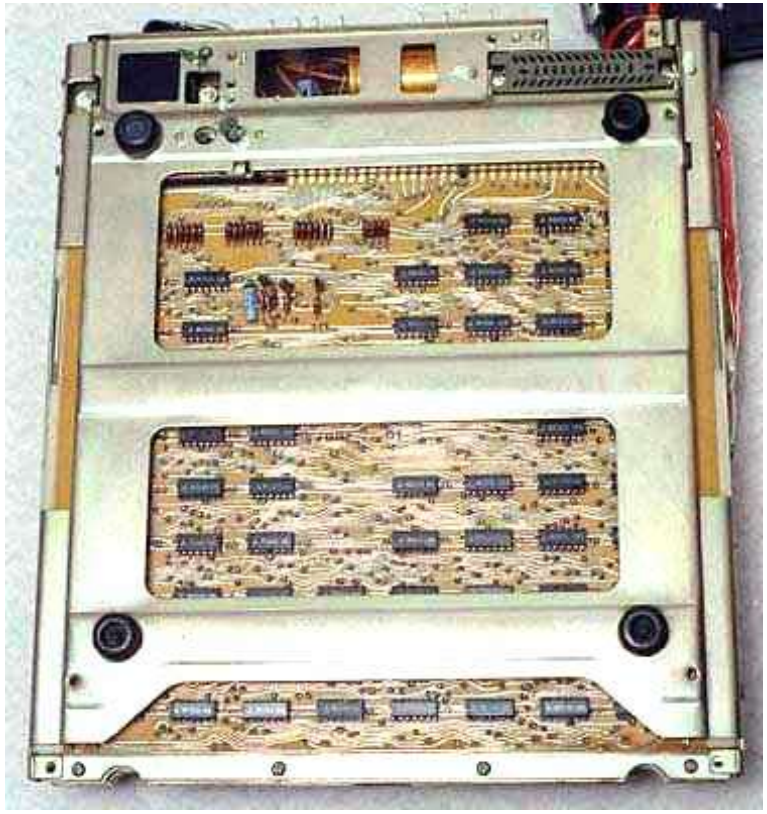
History of computers: 2nd generation

- Vacuum tubes were bulky and unreliable.
- Circuit boards filled with individual transistors and magnetic-core memory were used to built computers.
- **TRADIC** was the first transistorized computer in the U.S. completed in 1954.



History of computers: 3rd generation

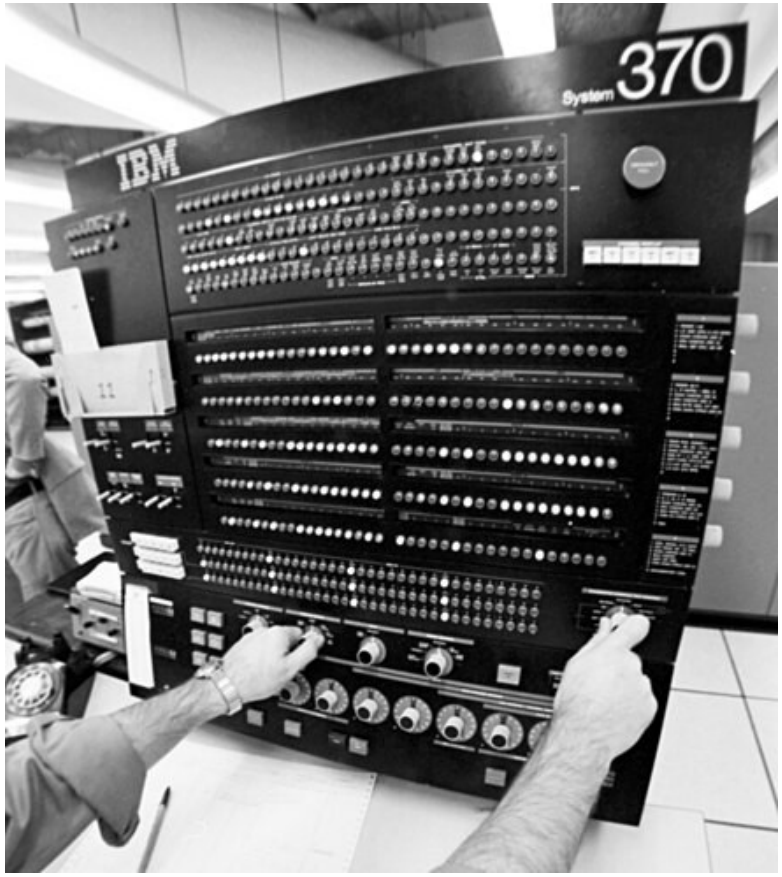
- For 2nd generation computers, dense packing of transistors in small devices hindered their repair
- Integrated circuit technology further reduce the size of computers
- Those use early (sub-1000 transistor) integrated circuit technology are the 3rd generation computers



http://www.vintagecalculators.com/html/integrated_circuits.html

History of computers: 3rd generation

- An example, IBM 370
- Moving from the individual transistors and small-scale integrated circuits to more modern devices using multiple transistors per integrated circuit
- Third-generation computers were offered well into the 1990s;



History of computers: 4th generation

- Very Large Scale Integrated (VLSI) circuits, VLSI circuits contained about 5000 transistors on a very compact chip: Microprocessor
- Microprocessor-based **fourth generation of computers**
- Data processing logic and control is included on a single integrated circuit (IC), or a small number of ICs.
- Before microprocessors, computers had been built using racks of circuit boards with many medium- and small-scale integrated circuits
- Microprocessors enables significant reduction of computer sizes

History of computers: 4th generation

- First Personal Computer (PC) by IBM in 1981
- Faster, smaller, and more-powerful PCs
- These computers were thus very compact and thereby required a small amount of electricity to run.

The IBM Personal Computer (PC) was introduced in 1981.

Apple's Lisa computer

5th generation computers

- ULSI technology
- Development of true **artificial intelligence**
- Development of Natural language processing
- Advancement in Parallel Processing
- Advancement in Superconductor technology
- More user-friendly interfaces with multimedia features
- Availability of very powerful and compact computers at cheaper rates

History of computers

The Generation of Computer Evolution is Generally Divided Into 5 Categories.

S.no	Time-period	Generations of Computer	Evolving Hardware
1	1940-1950	First-generation	Vacuum-Tube Based
2	1950-1960	Second generation	Transistor Based
3	1960-1970	Third generation	Integrated-Circuit Based
4	1970-Present	Fourth Generation	Microprocessor-Based
5	Present-Future	Fifth Generation	Artificial Intelligence Based

https://www.vedantu.com/coding-for-kids/computer-generations

Outline

- History of computers
- **Different types of modern computers**
- Development of processors
- Future directions

Different types of modern computers

- **General-purpose computers**
  - Supercomputer, desktop, laptop, etc.
  - Has the ability to perform a wide-range of tasks
- **Domain-specific computers (embedded computers)**
  - Mobile phones, eBook, etc.
  - Designed to excel in a limited types of tasks

Credit to Prof. XU

Super computers

- **High performance computer systems**
  - primarily for scientific and engineering work requiring exceedingly high-speed computations.
  - Applications including weather forecasting, nuclear weapons, earthquake simulations
- **Significant progress was made in the first decade of the 21st century.**

https://www.britannica.com/technology/supercomputer

Top500

Rank	System	Cores	Rmax (PFlop/s)	Rpeak (PFlop/s)	Power (kW)
1	**Frontier** - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE DOE/SC/Oak Ridge National Laboratory United States	8,699,904	1,206.00	1,714.81	22,786
2	**Aurora** - HPE Cray EX - Intel Exascale Compute Blade, Xeon CPU Max 9470 52C 2.4GHz, Intel Data Center GPU Max, Slingshot-11, Intel DOE/SC/Argonne National Laboratory United States	9,264,128	1,012.00	1,980.01	38,698
3	**Eagle** - Microsoft NDv5, Xeon Platinum 8480C 48C 2GHz, NVIDIA H100, NVIDIA Infiniband NDR, Microsoft Azure Microsoft Azure United States	2,073,600	561.20	846.84	
4	**Supercomputer Fugaku** - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan	7,630,848	442.01	537.21	29,899
5	**LUMI** - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE EuroHPC/CSC Finland	2,752,704	379.70	531.51	7,107

https://top500.org/lists/top500/2024/06/

Top500

Embedded computers

- Embedded in specific device
- Increased quickly in civic applications

Credit to Prof. XU

Outline

- History of computers
- Different types of modern computers
- **Development of processors**
- Future directions

Development of hardware

- Provide physical functions to software
- Processor
- Memories
- Data storage
- Mouse, keyboard, monitor …..

Credit to Prof. XU

Development of Processor

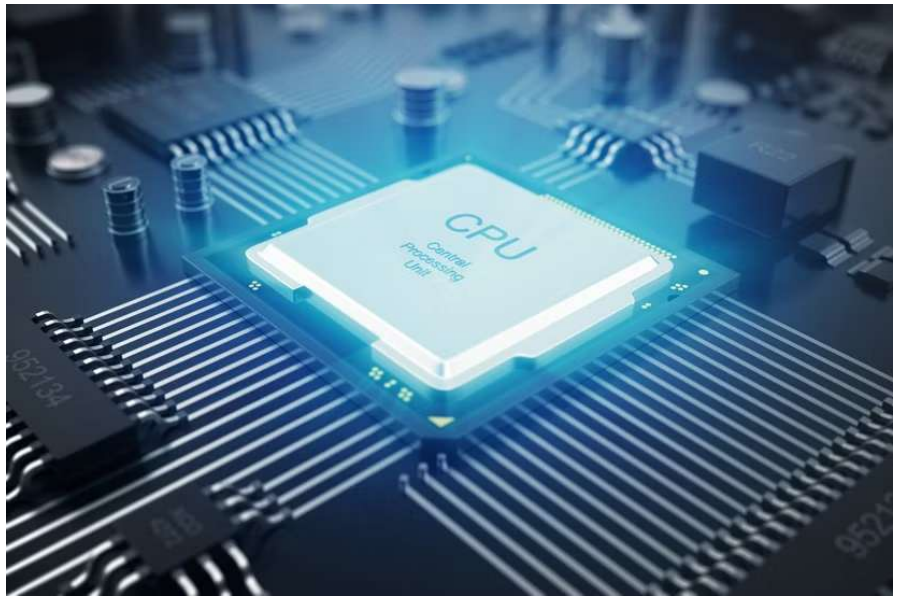
- General purpose processors (GPP), also known as central processing units (CPUs). e.g., Intel, AMD
- Application-Specific Instruction-Set Processor. e.g., those used in TVs, cell phones
- Single-Purpose Processor (SPP). e.g., digital camera

	GPP	ASIP	SPP
Performance	Low	Average	High
Energy efficiency	Low	Average	High
Size	Large	Average	Small
Time-to-market	Quick	Average	Slow

Credit to Prof. XU

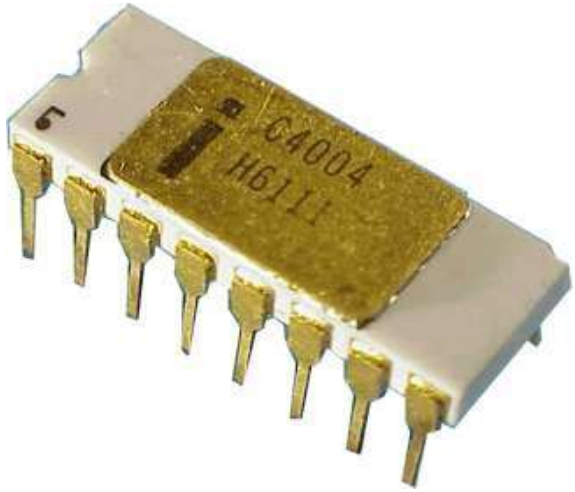
Development of Processor

- General purpose processors, also known as central processing units (CPUs),
- The processor is the “brain” of the computer
- A higher transistor density in a CPU generally means more processing power and functionality
- The processor is an essential component of a computer system, as it determines the speed and performance of the system.



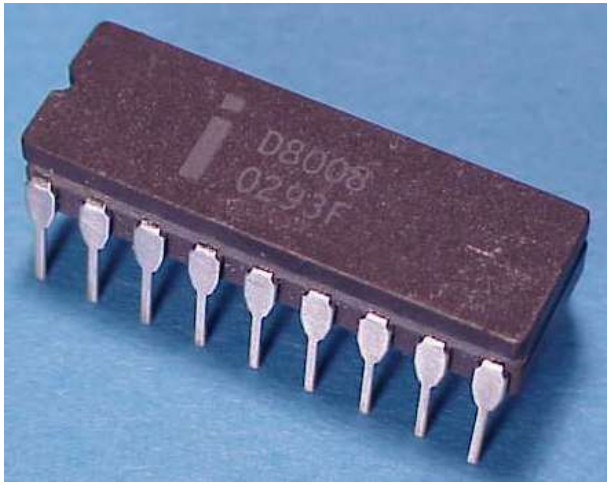
INTEL 4004

- Introduced in 1971.
- It was the first microprocessor by Intel.
- It was a 4-bit μP.
- Its clock speed was 740KHz.
- It had 2,300 transistors.



INTEL 8008

- Introduced in 1972.
- It was first 8-bit µP.
- Its clock speed was 500 KHz.

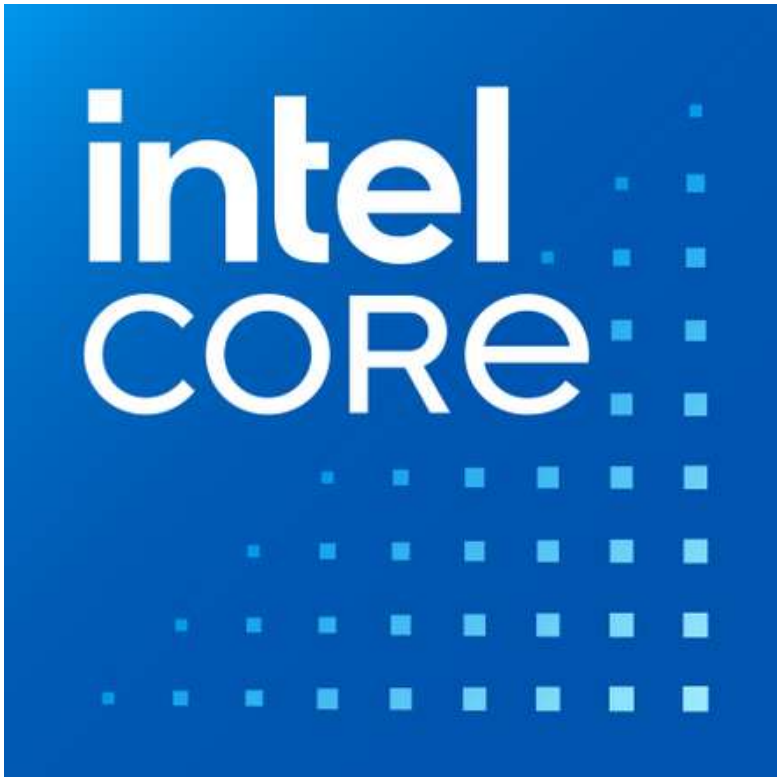


INTEL PENTIUM

- Introduced in 1993.
- It was originally named 80586.
- Its clock speed was 66 MHz.
- It was also 32-bit µP.

Multiple core CPU

- Early computers would only have a single processor core, so the CPU was limited to processing one set of instructions at a time.
- This is why these older computers were relatively slow, and it was a time-consuming affair to process data.
- Multi-core processors, with phrases like dual-core, quad-core, and octa-core frequently adorning PC marketing material.
- More recently, processor designers found a way to further increase performance by making a single-core processor act as though it had two cores (hyper-threading)

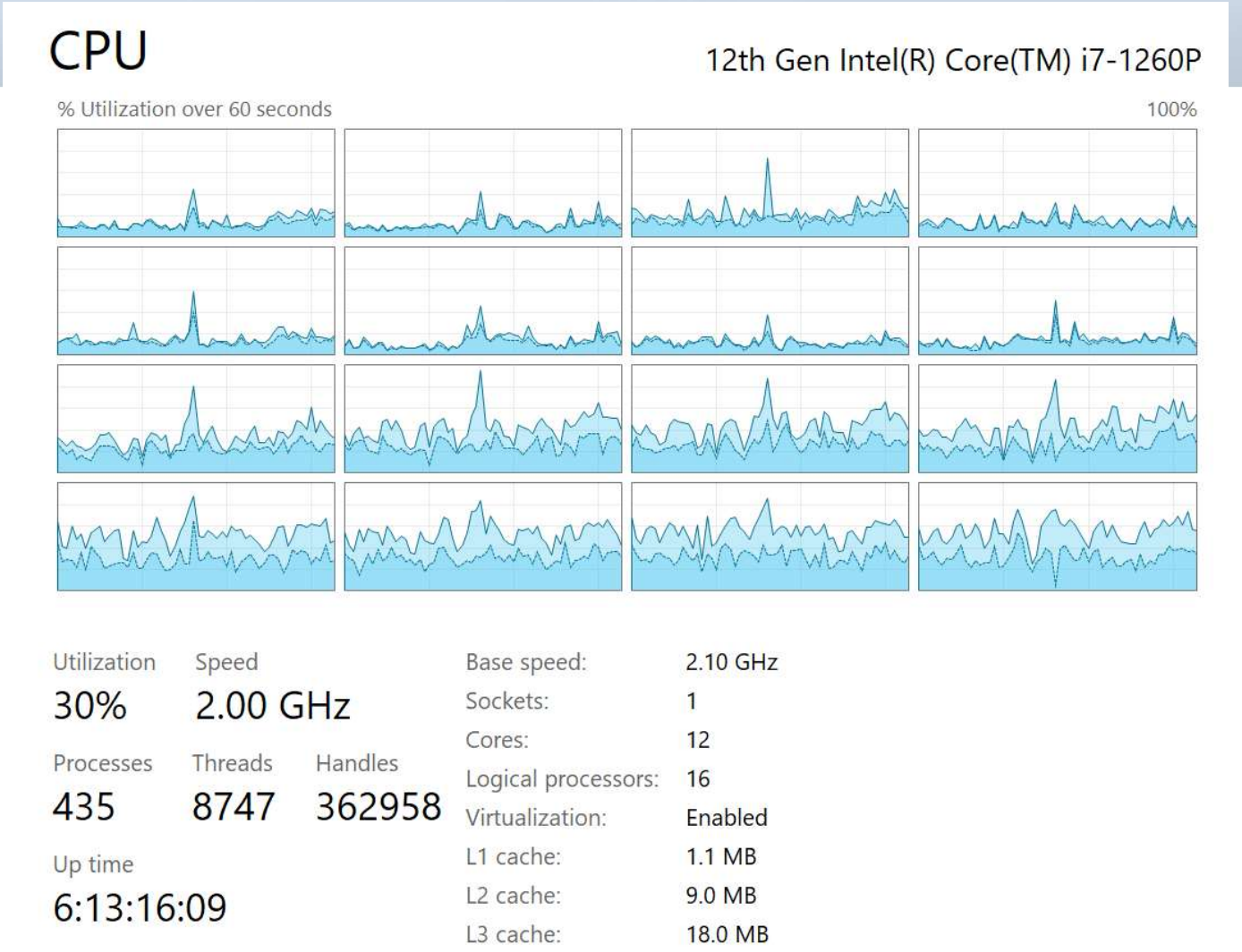


https://www.makeuseof.com/tag/cpu-technology-explained/

INTEL DUAL CORE

- Introduced in 2006.
- It is 32-bit or 64-bit μP.
- It has two cores.
- Clock speed of 1.3 GHz to 3.4 GHz

Multiple core CPU



https://www.makeuseof.com/tag/cpu-technology-explained/

Outline

- History of computers
- Different types of modern computers
- Development of processors
- **Future directions**

Quantum computers

Classical computing vs. quantum computing

Classical computing	Quantum computing
Used by large-scale, multipurpose computers and devices.	Used by high-speed, quantum mechanics-based computers.
Information is stored in bits.	Information is stored in quantum bits.
There is a discrete number of possible states: 0 or 1.	There is an infinite, continuous number of possible states.
Calculations are deterministic, meaning repeating the same input results in the same output.	Calculations are probabilistic, meaning there are multiple possible outputs to the same input.
Data processing is carried out by logic and in sequential order.	Data processing is carried out by quantum logic at parallel instances.
Operations are defined by Boolean algebra.	Operations are defined by linear algebra over Hilbert space.
Circuit behavior is defined by classical physics.	Circuit behavior is defined by quantum mechanics.

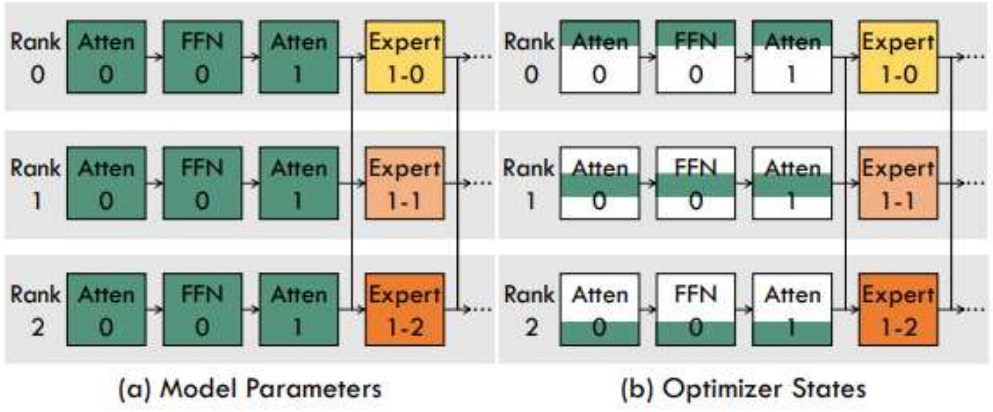
https://www.techtarget.com/searchdatacenter/tip/Classical-vs-quantum-computing-What-are-the-differences

Quantum computers

Research related to computer hardware in the MICS Thrust

Jiang XU 须江

Jiayi HUANG 黄嘉逸



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