

Learning Aims

- Define what is meant by the 'stored program concept'
- Describe the hardware components used in the **Von Neumann architecture**
- Be able to describe the following components in the Central Processing Unit (CPU)
 - Arithmetic Logic Unit (ALU)
 - Control Unit (CU)
 - System Bus



CPU

Arithmetic Logic Unit (ALU)

Control Unit (CU)

Registers

Main memory

Stored program concept

Data Bus

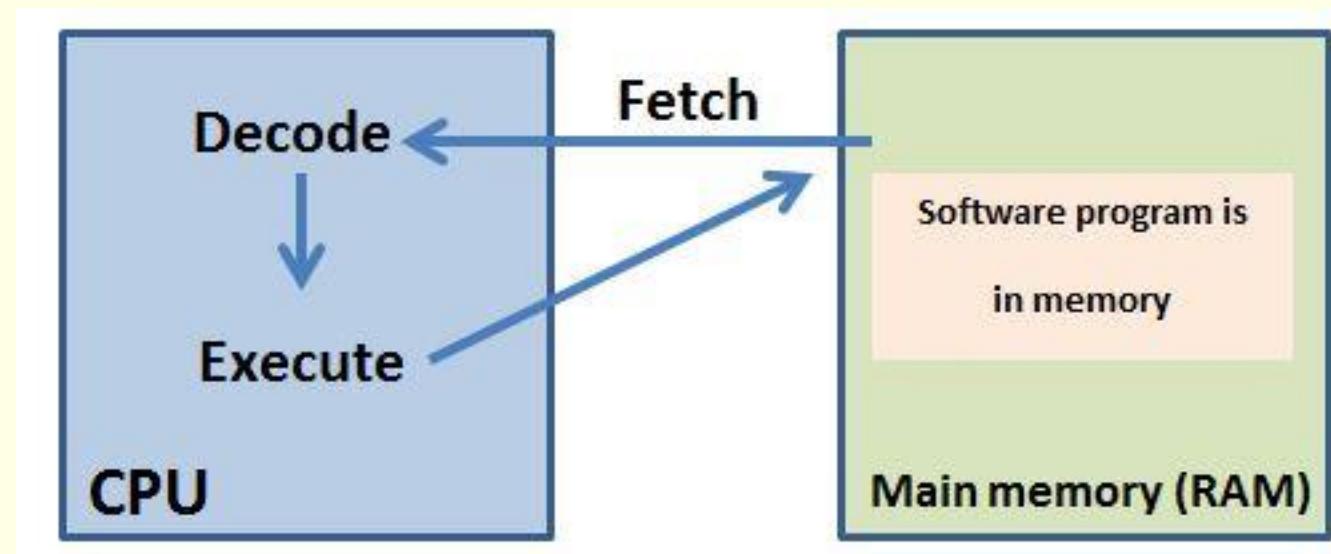
Address Bus

Control Bus



CPU: What does it do?

- The “brains” of the computer
- Processes data (CPU also known as “The Processor”)
- Retrieves data/instructions from main memory (Fetch)
- Works out what to do with the instruction (Decode)
- Carries out instructions (Execute)



History of computers

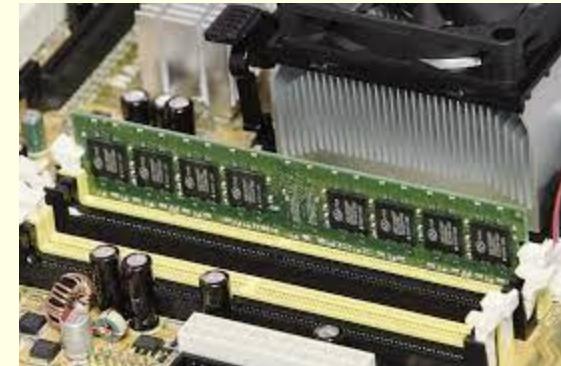
mechanical devices



Electrical
devices
Using programs
on punched
tape

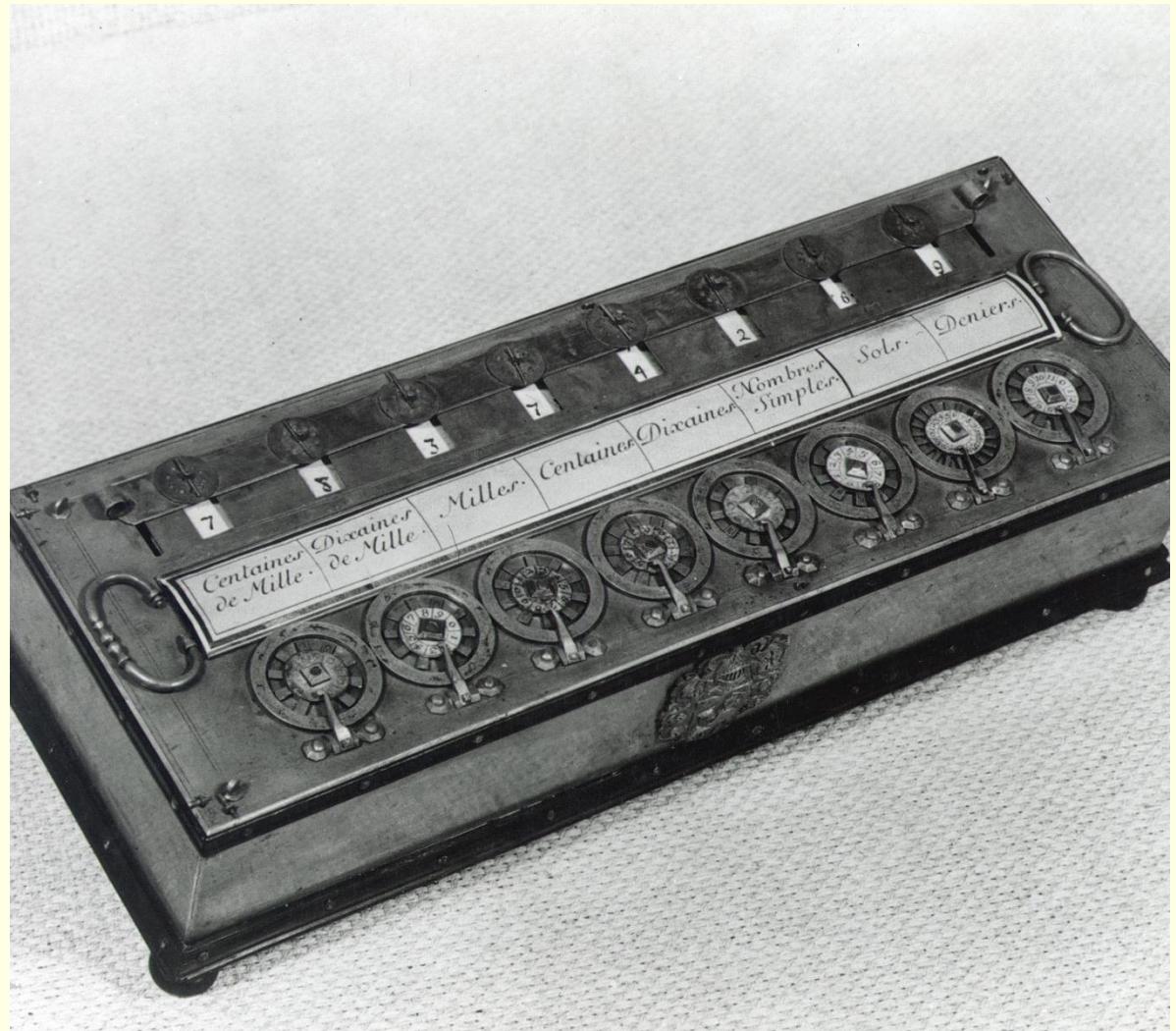


Digital Computers
Programs and
data stored in
memory

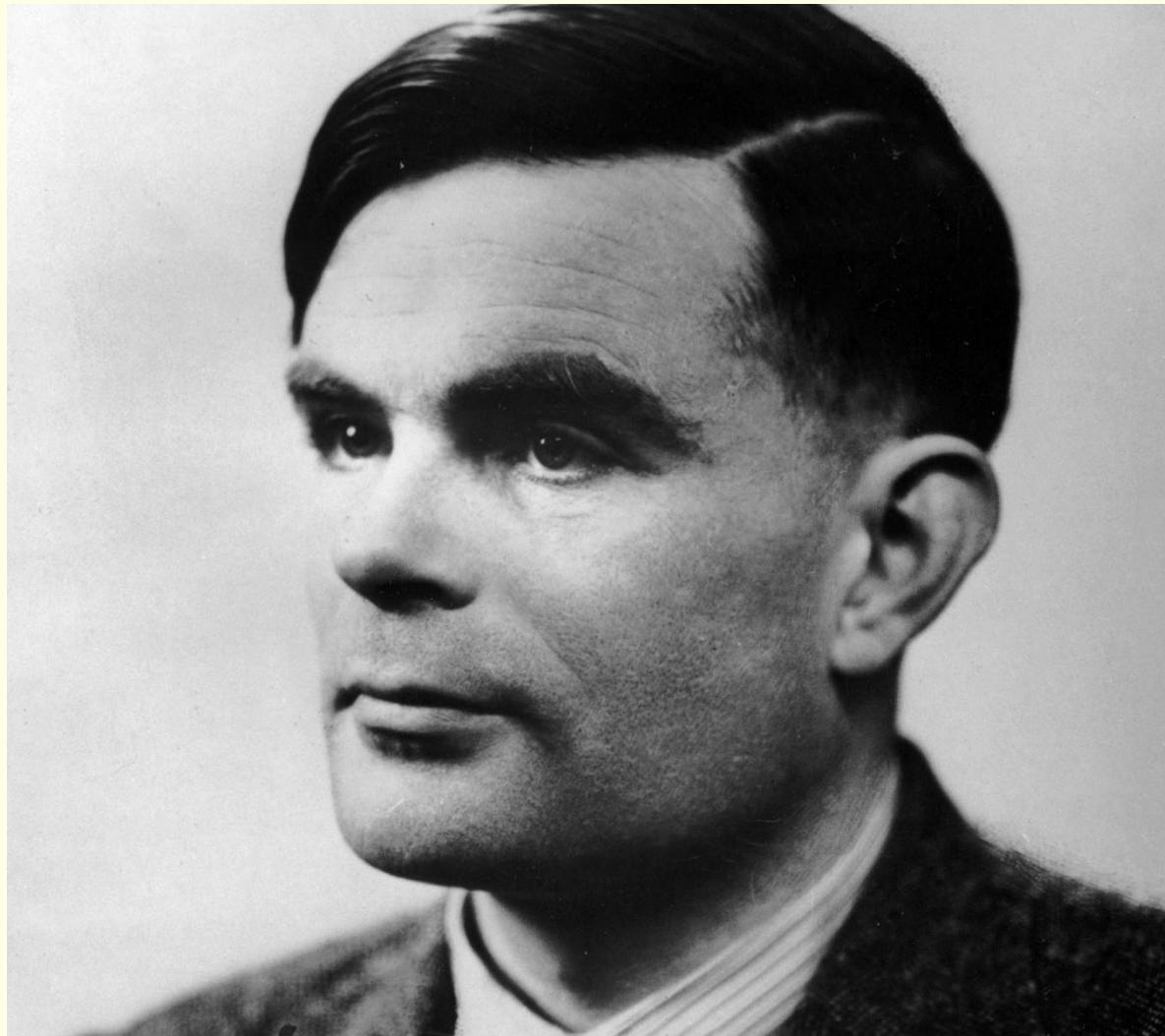


A little history

- As long ago as the 1640s, Mathematicians were creating **mechanical devices** that could perform mathematical operations. They had hundreds or even thousands of moving parts.
- These devices were created to fulfil a single purpose. If you wanted to change the purpose of such a device, it needed to be rebuilt or rewired.
- Pascal's calculator (shown here) was designed and built by the famous mathematician in 1642 (when he was 19 years old!) to help him with tax calculations. It performed multiplications and divisions.



Programmable machines



- In 1936, Alan Turing proposed a device he called the 'Universal Computing Machine'.
- He proposed that a computing machine could be designed that could be 'programmed' by giving it instructions on punched tape.
- It was around this time that the work of engineer Tommy Flowers meant that computing devices were becoming electrical instead of mechanical machines.



Stored programs



- The next step was to move programs from tape and store them electronically within a computer.
- In 1945, the mathematician and physicist John von Neumann, working at the University of Princeton USA, published a paper about the computer he and his team had designed and built.
- It was the first computer that used the basic component architecture we recognise in modern computers.
- **He identified that data and instructions could be stored in the same memory known as the stored program concept**

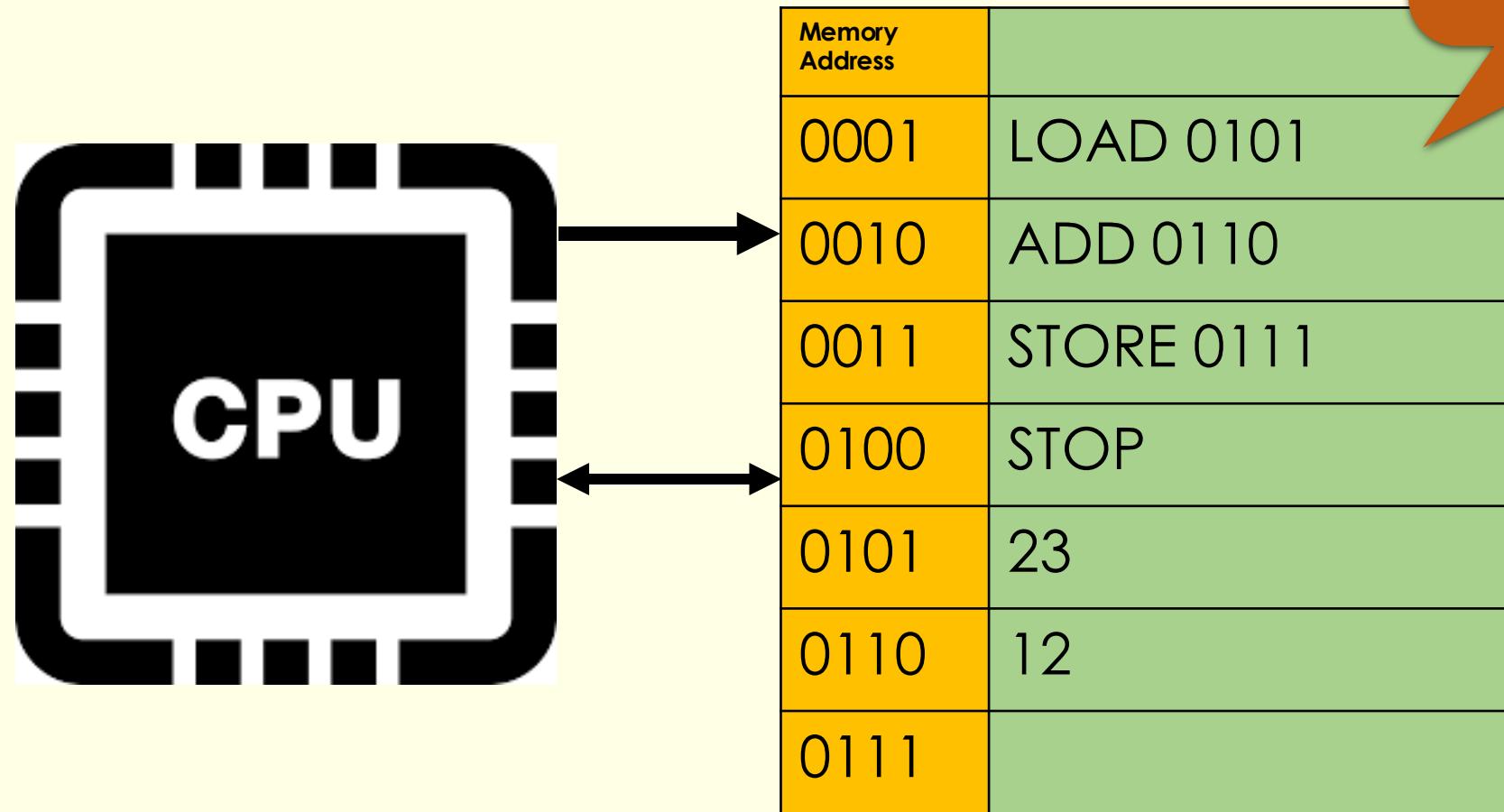


Stored Program Concept

Storing instructions and data in same main memory

Instructions are then fetched from memory, decoded and executed by the processor.

Storing
Instructions and data



Main Memory

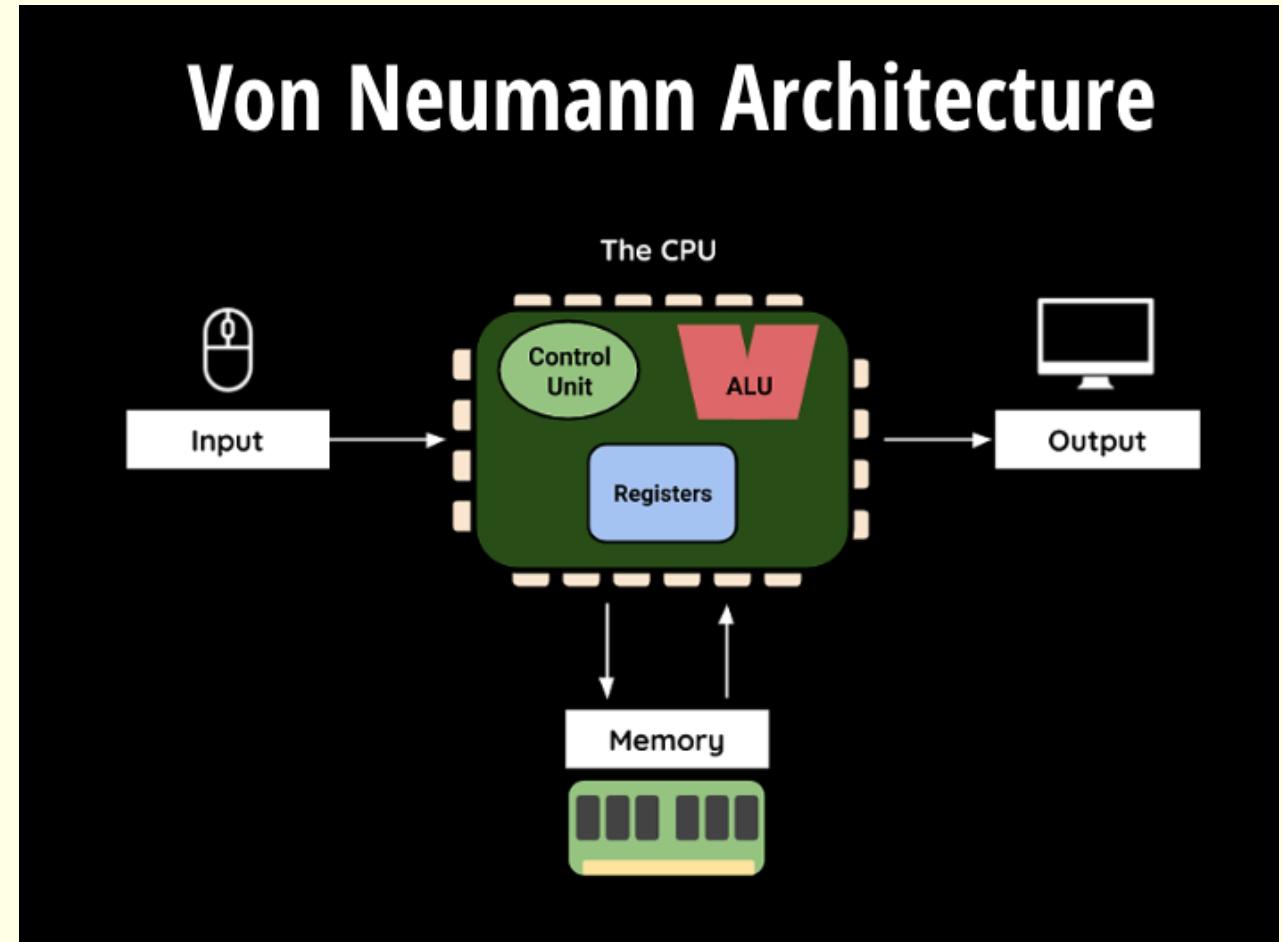


Inside the CPU

CPU stands for **central processing unit**.

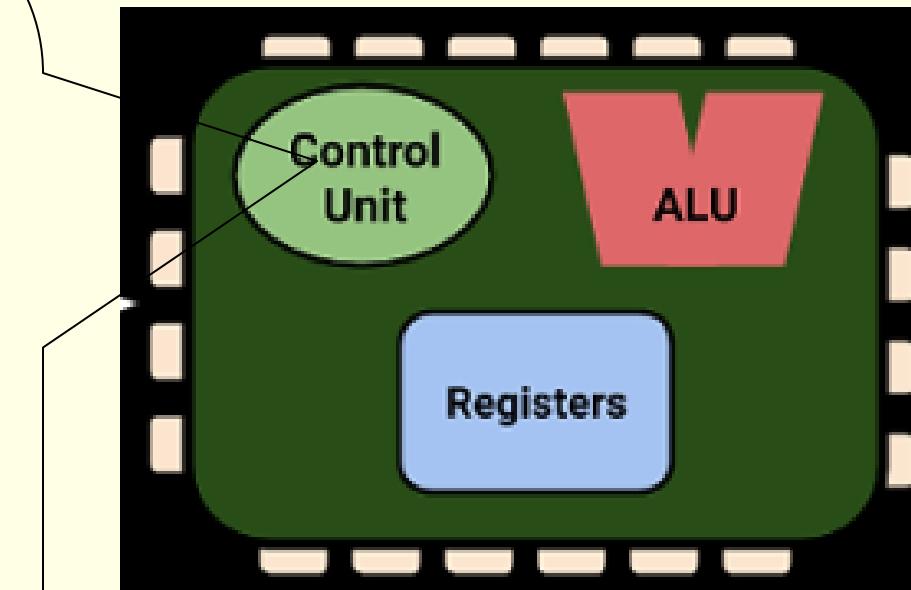
Inside of the CPU, there are a number of key components:

- 1. Control unit**
- 2. Arithmetic logic unit**
- 3. Buses**
- 4. Registers**
- 5. Clock**

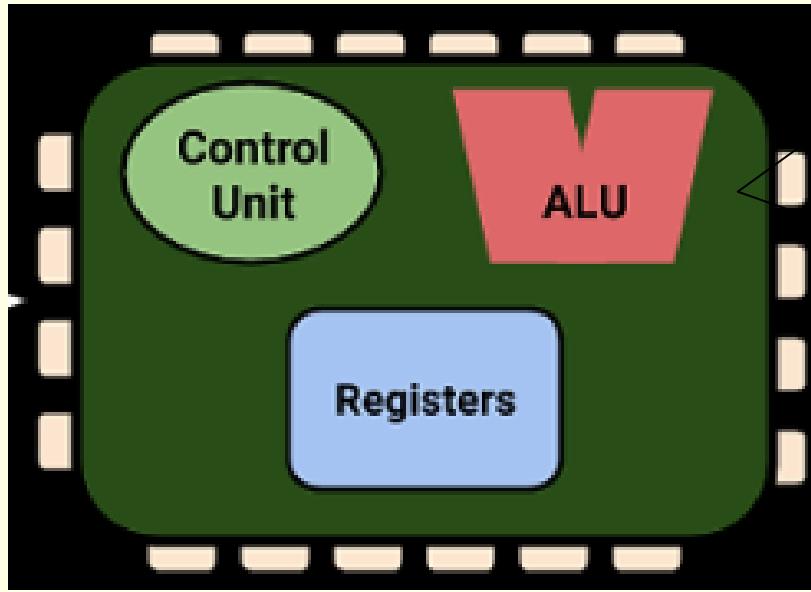


Control Unit

- 1. Decodes instructions and manages the execution of instructions**
- 2. The Control Unit (CU) manages the flow of data and instructions in the CPU.**
- 3. It sends control signals to make sure the right parts of the computer do the right job at the right time.**



Arithmetic Logic Unit - ALU



Carries out arithmetic calculations

$$5 + 6 = 11$$

Addition

Subtraction

Shifts (multiplication and division)

Carries out logical operations

AND

OR

NOT

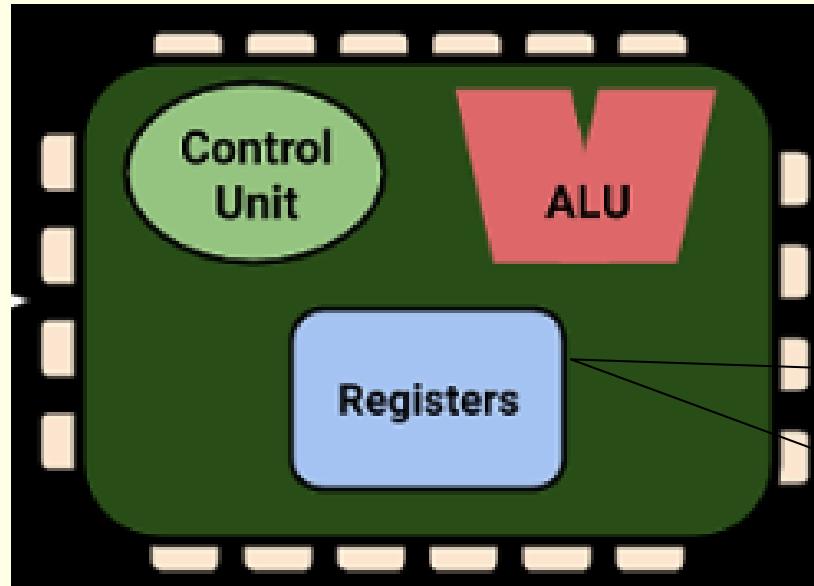
Less Than <

Greater Than >

if $x > y$



Registers



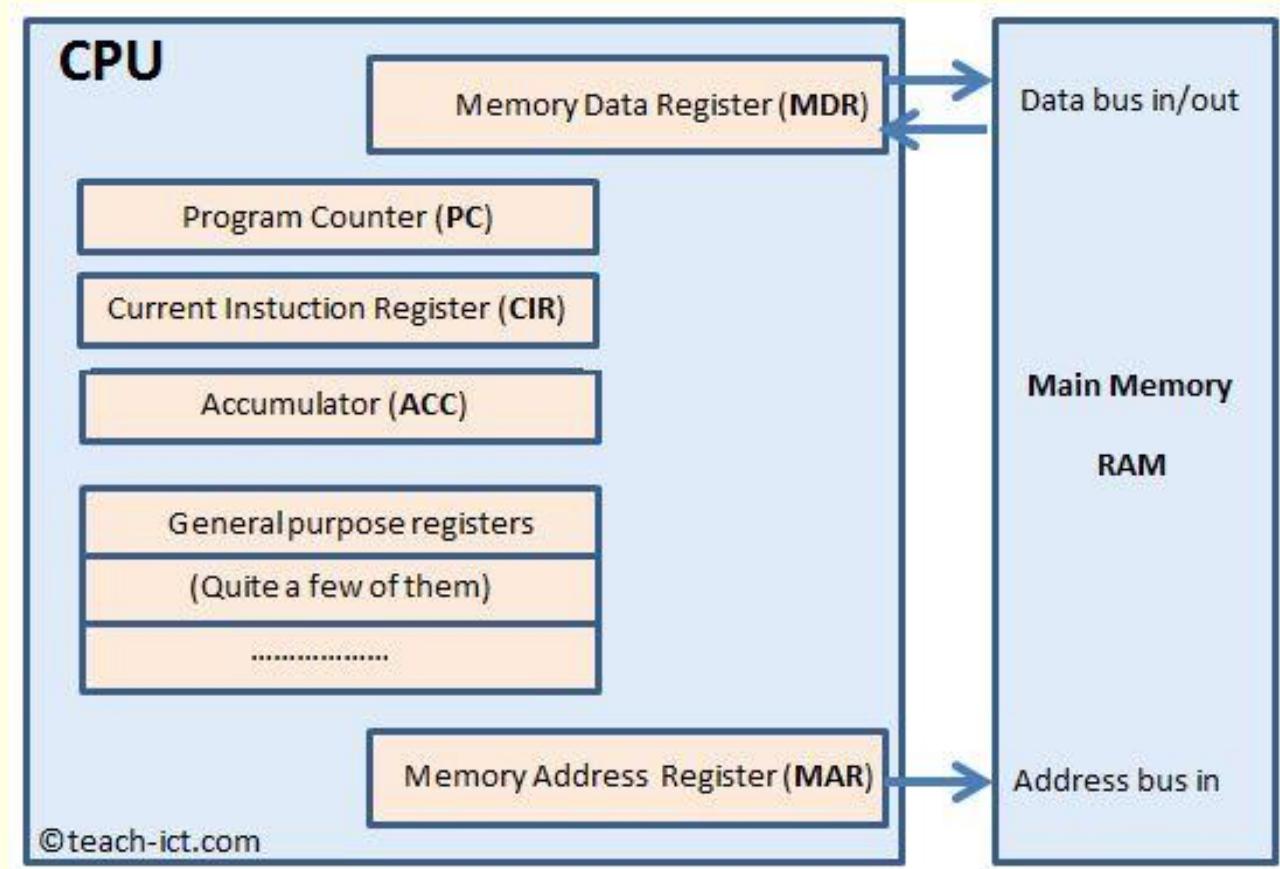
Registers

Registers are small areas of memory in the CPU



CPU Registers - Registers are small areas of memory in the CPU

- **Program Counter** – keeps track of where the CPU is in the program. Points to the next instruction in the cycle.
- **Memory Address Register (MAR)** – holds the address of the instruction to be fetched.
- **Memory Data Register (MDR)** – stores the instruction about to be executed.
- **Accumulator** – stores the most recent result of processing.
- **Current instruction register (CIR)** - instruction to be executed



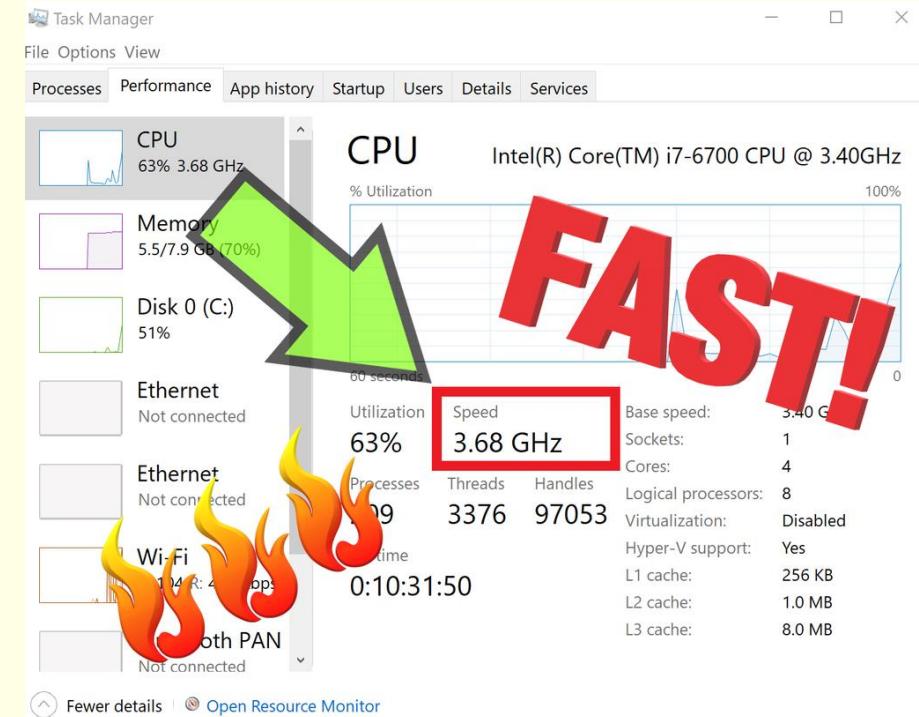
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You do not need to learn the names or purposes of individual registers.



System Clock

- A clock determines the speed of the CPU.
- Regular electrical pulse which synchronises all the components.
- **The faster the clock the more instructions can be executed per second**
- The speed of the clock is measured in **Hertz** (Hz), which is the **amount of cycles per second**.
- **A clock speed of 500Hz means 500 cycles per second.**
- Current computers have clock speeds of **3GHz**, which means **3-billion cycles per second**.
- Each 'tick' means that one part of the fetch-decode-execute cycle can be carried out.



System Bus

- **address bus**

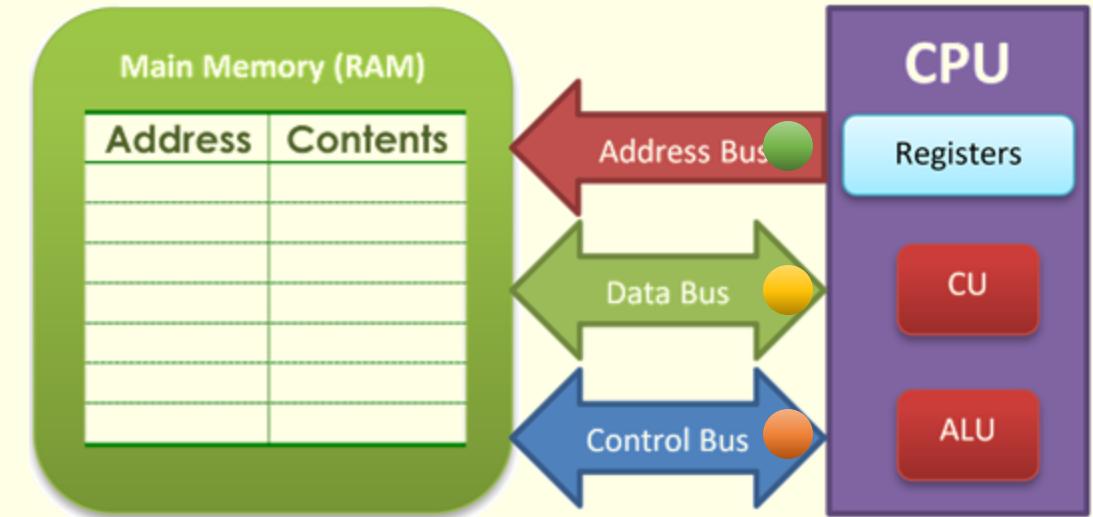
- Used to send a memory address
uni-directional

- **data bus**

- Used to send instructions and data
- bi-directional

- **control bus**

- Used to send command signals to different components and receive status messages of devices.
- bi-directional



Execute: Then the next steps will be performed by the processor, for example: perform a calculation, load data from main memory, store data into main memory, output/input data.

CPU fetches data and instructions from the main memory (RAM) and then stores them in its own temporary, very fast memory called **registers**.

Commands from CPU and status messages of devices are sent along the **control bus**

Results of calculations are placed into the Accumulator

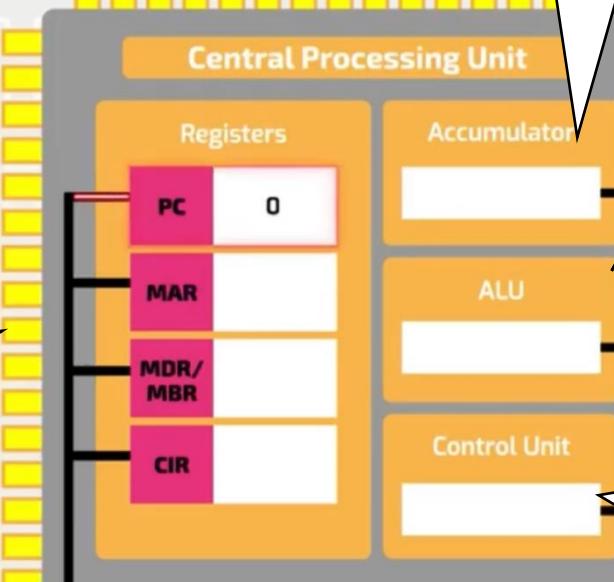
Performs arithmetic and logical operations including +, -, AND, OR

Main Memory

Address	Data
0	LOAD 2
1	SUB 4
2	10
3	13
4	8
5	ADD 5
6	2
7	LOAD 8
8	2

Fetch the instruction from main. memory using the memory address

Decode: The instruction is decoded by the CU.



The instruction/data is transferred back to the processor along the **data bus**

The memory address is transferred along the **Address Bus** to Main Memory

