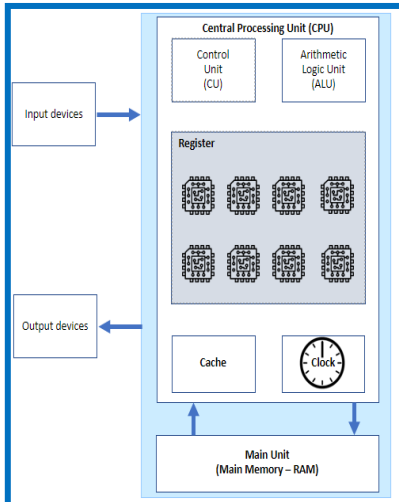
# GCSE Computer Science Knowledge Organiser
# SLR 1.1 System Architecture:
# *Architecture of the CPU*




**The CPU consists of the following components:**

- **Arithmetic Logic Unit (ALU):** Performs arithmetic calculations and makes logical decisions.
- **Control Unit (CU):** Sends signals to control how data moves around the CPU.
- **Cache:** Provides fast access to frequently used instructions and data.
- **Registers:** Tiny, super-fast pieces of onboard memory inside the CPU, each with a specific purpose.

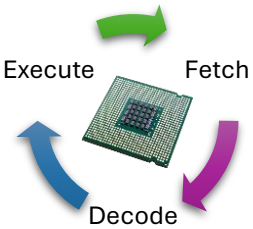
## Fetch-Decode-Execute Cycle

**1. Fetch Stage**

- Fetch the next instruction from main memory (RAM).
- Bring it back into the CPU.

**2. Decode Stage**

- Inspect the instruction to find out what needs to be done.




**3. Execute Stage**

- Carry out the instruction, which could be:
  - Going back to main memory and fetching data.
  - Performing a calculation.
  - Storing information back in main memory.

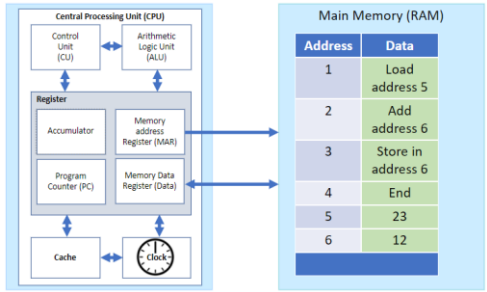
## What is a computer?

A computer is an electronic device that:

- takes input;
- processes data; and
- delivers output.


The purpose of the CPU is to fetch, decode and execute instructions.

## Von Neumann architecture




Notice how both instruction data *and* program data are stored in the same memory in binary form.

The von Neumann architecture is based on the stored program concept.

Both instruction data *and* program data are stored in the same memory in binary form. There is no way to know if the pure binary held in memory represents instructions or data simply by looking at it.

A von Neumann CPU contains the following registers:

- **Program Counter (PC):** Holds the address of the next instruction to be executed in memory.
- **Memory Address Register (MAR):** Holds the memory address where data is to be fetched from or written to.
- **Memory Data Register (MDR):** Holds data fetched from memory or to be written to memory.
- **Accumulator:** Holds the results of calculations.

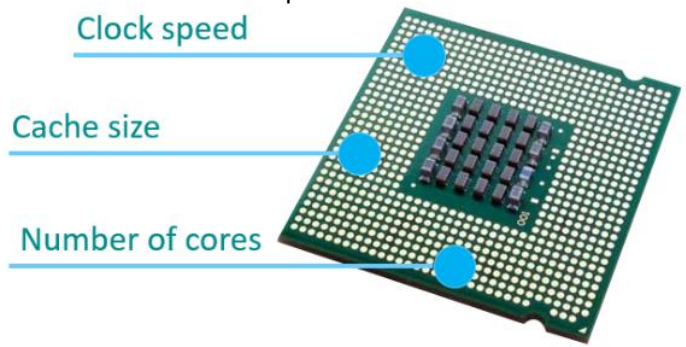
| Key Terminology | BCS Definition |
|---|---|
| CPU | **Central Processing Unit:** "The main part of the computer, consisting of the registers, ALU and control unit." |
| Fetch – Decode - Execute | "The complete process of retrieving an instruction from storage, decoding it and carrying it out. Also known as the instruction cycle." |
| ALU | **Arithmetic Logic Unit:** "Performs calculations (e.g., x = 2 + 3) and logical comparisons (e.g., IF x > 3) in the CPU." |
| CU | **Control Unit:** "Decodes instructions. Sends signals to control how data moves around the CPU." |
| Cache | "Memory in the processor that provides fast access to frequently used instructions and data." |
| Register | "Tiny areas of extremely fast memory located in the CPU, normally designed for a specific purpose where data or control information is stored temporarily – e.g., MAR, MDR, etc." |
| Von Neumann Architecture | "Traditional computer architecture that forms the basis of most digital computer systems. Instructions are fetched, decoded and executed one at a time." |
| MAR | **Memory Address Register:** "Holds the address of data ready to be used by the memory data register or the address of an instruction passed from the program counter. Step two of the fetch-decode-execute cycle." |
| MDR | **Memory Data Register:** "Holds data fetched from or to be written to memory. Step three of the fetch-decode-execute cycle." |
| Program Counter | "Holds the address of the next instruction to be executed. Step one of the fetch-decode-execute cycle." |
| Accumulator | "Holds the result of calculations." |

# GCSE Computer Science Knowledge Organiser
# SLR 1.1 System Architecture:
# *How common characteristics of CPUs affect their performance*

| Key Terminology | BCS Definition |
|---|---|
| Clock Speed | "Measured in hertz, the clock speed is the frequency at which the internal clock generates pulses. The higher the clock rate, the faster the computer may work. The clock is the electronic unit that synchronises related components by generating pulses at a constant rate." |
| Cache Size | "The larger the cache, the more data that can be stored without having to go back to main memory (RAM) – this has a significant impact on processing speed." |
| Cores | "Part of a multi-core processor, a single component with two or more independent CPUs that facilitate the fetch-decode-execute cycle." |

**Factors affecting the performance of the CPU**

A CPU's overall performance can be affected by several factors. The three most important factors are:

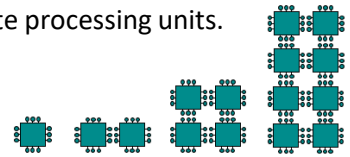



**Clock Speed**

- Measured in the number cycles per second – or hertz (Hz).
- Modern processors operate at billions of cycles per second – or gigahertz (GHz).
- 3.2GHz clock speed = 3.2 billion instructions fetched per second.

**Number of Cores**

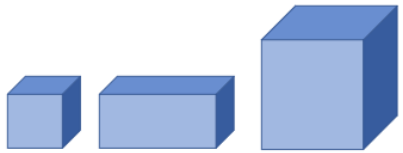
- A core is, in very simple terms, a complete copy of a CPU.
- A quad-core processor has four separate processing units.
- Each processing unit has its own:
  - Registers
  - ALU
  - Accumulator
  - Control unit, etc.



- CPUs with multiple cores have more power to run multiple programs at the same time.
- Doubling the number of cores won't double processing speed.
- Cores need to communicate with each other, which takes time.
- Many programs are not designed to make use of multiple cores.

**Cache Size**

- Temporary storage of data and instructions being read from and written to main memory (RAM).
- Located on or very near the CPU.
- Stores copies of recent data and instructions.
- Much quicker to read from than main memory (RAM).
- Reduces the need to go and get instructions and data from memory, saving time.



# GCSE Computer Science Knowledge Organiser
# SLR 1.1 System Architecture:
# *Embedded systems*

| Key Terminology | BCS Definition |
|---|---|
| Embedded Systems | "A computer built to solve a highly specific problem. Not easy to change. For example, the operating system placed inside a washing machine, microwave or set of traffic lights." |

**Embedded system:** A computer system with a dedicated function within a larger mechanical system.

**Typical properties of embedded systems**
Properties of embedded systems compared to general-purpose computers include:
- Low power consumption
- Small size
- Rugged operating ranges
- Low cost per unit

These benefits come at the cost of limited processing resources, making them more difficult to program and interact with.

Embedded systems are dedicated to a specific task – this means design engineers can optimise the system to:
•Reduce the size and cost of the product
•Increase its reliability for the given task
Many embedded systems are mass-produced, meaning further benefits can be gained from economies of scale.

**Embedded Systems**
98 percent of processors are manufactured as components of embedded systems.
One of the earliest examples of an embedded system was the Apollo guidance computer for the moon missions.

**Other examples include:**
- Digital clocks
- Traffic lights
- Domestic appliances
- Factory equipment
- Engine management systems
- Hospital equipment


**In what ways is this washing machine a computer?**

- It takes inputs – button and dial inputs from the user; readings from the water level and temperature sensors.
- It processes sequences of instructions that tell it how to fill with water, extract detergent, and spin and drain the drum.
- It outputs sounds and lights to indicate progress and signify when the program is complete.
- Instructions are stored on ROM chips on the motherboard.