U.S. DEPARTMENT OF ENERGY'S
CYBERFORCE® PROGRAM

CyberForce® 101

Intro to Computer Hardware

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Computer Hardware 101

OVERVIEW

Computer **hardware** refers to the physical components that make up a computer system. **Software** is data that's stored electronically, like an operating system (OS) or a text editor, which runs on the hardware. **Firmware** is used to tie hardware and software together so that a software program knows how to interface with a piece of hardware.

A **transistor** is a tiny electrically operated switch that can alternate between on and off. A **chip**
is a tiny piece of silicon that contains millions of transistors and other electrical components.

THE SYSTEM UNIT

The system unit is comprised of the motherboard, central processing unit, memory, ports, and expansion slots.

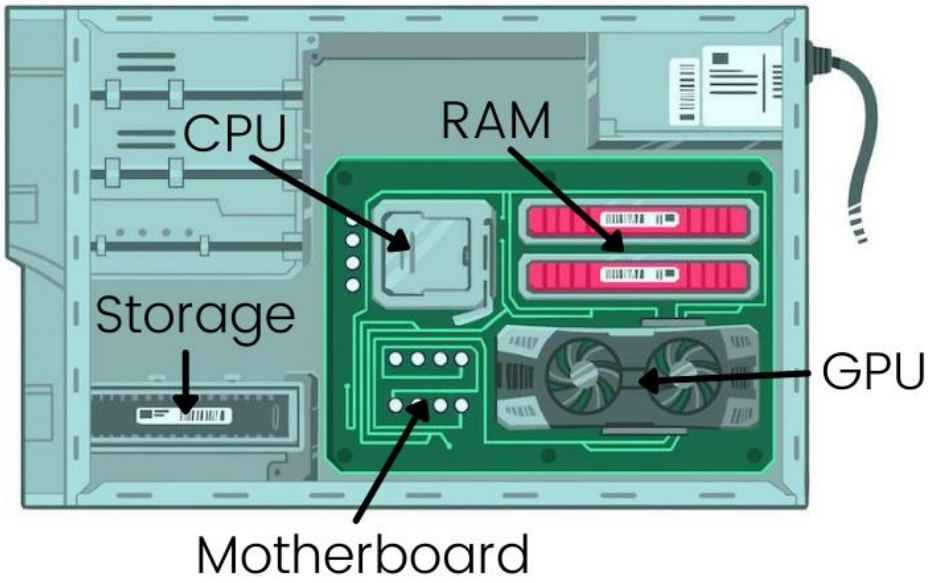


Figure 1. Main Components of Computer

The **motherboard** is the main circuit board for the computer. It contains both soldered, nonremovable components and sockets or slots for removable components. It holds the CPU, RAM, and ROM chips.

The **Central Processing Unit (CPU)** is the "brain" of the computer that executes instructions from software and tells other components what to do. Within the CPU, there are two parts: the ALU and the Control Unit.

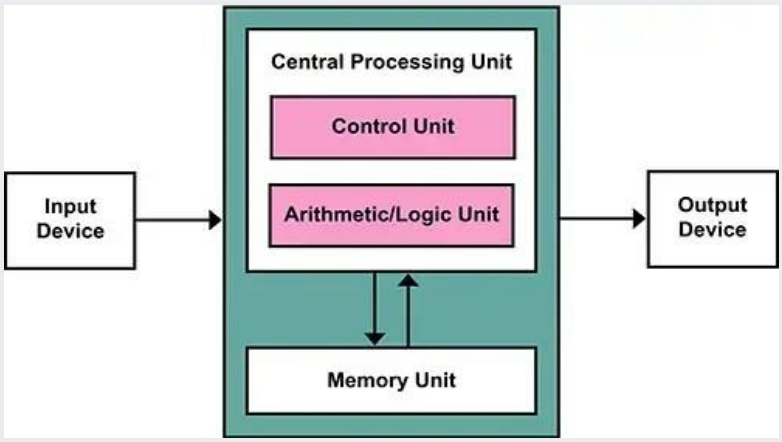
- The **Arithmetic Logic Unit (ALU)** performs arithmetic operations and logical operations.
  - The ALU uses **registers**, or local storage units, to hold the results of its operations.
- The **Control Unit** deciphers and carries out those instructions.

> **Instruction Types**
>
> Different CPUs have different instruction types. This means that software made for one type of CPU will not run on other kinds.

The **fetch-execute cycle** forms the basis for the operation of a computer. The CPU fetches each instruction from the memory unit and then executes that instruction before fetching the next instruction.

The Von Neumann Model

John von Neumann came up with a design architecture for computers in 1945. Below in the picture, the green part is the computer itself, consisting of a CPU that has a control unit and ALU. It uses input devices to feed data and instructions into the computer. After processing the data, the computer may show results or perform tasks on the output devices.



From Red-Dot-Geek

The Von Neumann architecture was a good starting point, but it only describes a single source of memory for both instructions and data and the CPU cannot run instructions and read/write data at the same time, which would create a **bottleneck**.

The **system clock** sends out a pulse of electricity at regular intervals which allows the electric components of the computer to work. The more pulses sent out by the system clock, the faster the computer.

Bus lines transmit bits of information between the CPU and other components. The **bus size** tells you how many bits can be transmitted at once. It should generally be the same as CPU **word size**, which tells you how many bits of data a CPU can process at once.

Ports are sockets that are on the outside of the system unit. **Serial ports** transmit one bit of data at a time. **Parallel ports** transmit 8 bits of data at a time. **Universal Serial Bus (USB)** ports are much faster than serial or parallel

ports, and multiple devices can be connected to the same port.

PRIMARY MEMORY AND SECONDARY MEMORY

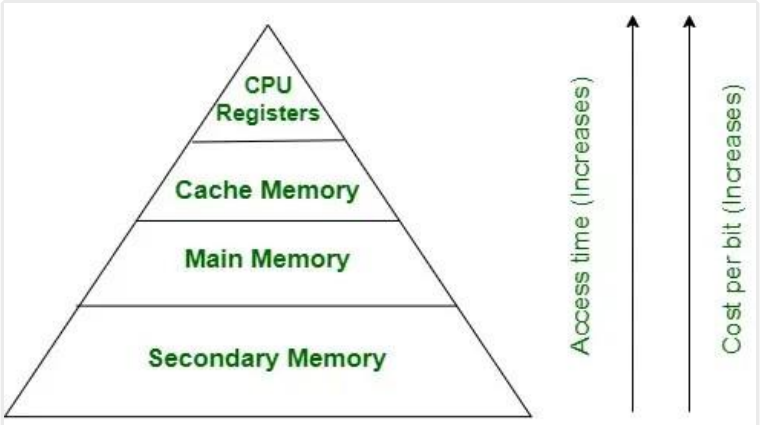
As described before, **CPU registers** are fast memory within the CPU itself to store immediate instructions. It is the highest level in the memory chain. **Cache** memory is high-speed memory that temporarily stores instructions and data that the CPU is likely to use frequently to speed up processing.

Primary storage is immediately accessible to the CPU, including hard disks and RAM. **Random Access Memory (RAM)** is used to hold instruction and data while they are being used. RAM is volatile, so its contents are lost when you turn the power off.

Secondary storage devices "permanently" hold data and information. It's non-volatile memory so when you turn it off the contents are still saved. It is used to store instructions and data while they are not being used.

A **hard disk drives (HDD)** use metal platters to store information. They can hold large amounts of data (hundreds of gigabytes). It uses a read/write head, which is like a magnet that allows you to read/write information from/to tracks. **Solid-state drives (SSD)** are non-volatile memory units that use flash memory instead of a spinning disk. They are much faster, more durable, and less susceptible to mechanical failure than HDDs.

Optical discs use optical technology, like lasers, instead of magnetic technology to store information. This includes things like CD-ROMs and DVD-ROMs.



Memory Hierarchy (From Red-Dot-Geek)

TYPES OF REGISTERS AND REGISTER OPERATIONS

There are many different types of registers, but several common ones include instruction registers, program counters, accumulator registers, input/output (I/O) registers, and data registers.

Program counters keep track of the current line of code, or which instruction the CPU is currently executing. **Accumulator registers** are used by the ALU for calculations. **I/O registers** work with various input and output devices. **Data registers** are used as temporary storage for data acquired from input devices or for data to be transmitted to output devices.

Registers usually follow three operations: fetch, decode, and execute. **Fetch** loads instructions from either main memory or from the user using an input device. **Decode** takes those instructions and interprets what they mean. **Execute** runs the instructions and usually produces some sort of results, which are then displayed on the screen or sent to a device.

TYPES OF BUSES

To avoid bottlenecks, the system bus is split into three different parts: the control bus, address bus, and data bus.

- **Control bus** carries commands from the CPU
- **Address bus** carries information on the target component the instructions are meant for
- **Data bus** carries the actual data

SOURCES

1. Everything You Need to Know about Computer Hardware
2. Computer Hardware Overview
3. An Overview of Computer Architecture
4. Basic Computer Architecture (Beginner's Crash Course)
5. Memory Hierarchy Design and its Characteristics
6. The 5 different parts of a computer-taking a look under the hood