## Hardware and Software

**Hardware** is the physical components of a computer system, whereas **software** is the programs that are run *using* the hardware. Generally, one is useless without the other.

## Software Classification

| Keyword | Definition | Example(s) |
|---|---|---|
| **Operating Systems** | Software loaded by the computer following the initial boot-up which controls both the hardware and software, incuding the processor, memory, I/O devices, and security. | Windows 10, macOS |
| **Systems software** | Software that controls the operation of hardware in a computer. | |
| **Applic-ation software** | Programs designed for the user to use to perform a specific task(s). | Internet Explorer, Microsoft Word |
| **Utility Programs** | A type of **systems software** that manages the computer's resources | Defrag-mentation, file encryption |

## Truth Tables for Logic Gates

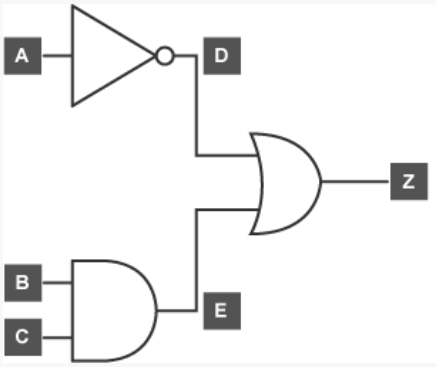
| Logic Gate | Truth Table |
|---|---|
| AND | **x y z**<br>0 0 0<br>1 0 0<br>0 1 0<br>1 1 1 |

## Truth Tables for Logic Gates (cont)

| | |
|---|---|
| OR | **x y z**<br>0 0 0<br>1 0 1<br>0 1 1<br>1 1 1 |
| NOT | **x z**<br>1 0<br>0 1 |

Here, 'x' and 'y' are the inputs, while 'z' is the output.

## Logic Circuits




https://www.bbc.com/education/guides/zc4bb9q/revision/3

## Truth Tables for Logic Circuits

| A | B | C | D | E | Z |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 0 | 1 | 1 |

This is an example of a truth table for the logic circuit above.



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## Embedded Systems

An **embedded system** is normally built into a larger device. It has a small number of specific functions. An example could be a satnav in a car. **Non-embedded systems**, on the other hand, carry out multiple functions and are not built into anything else

## Systems Architecture

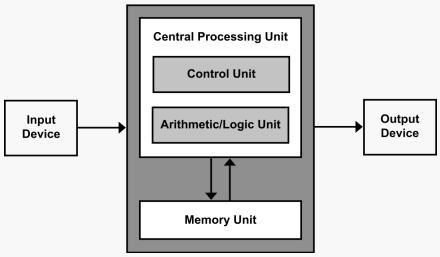
| Component | Purpose |
|---|---|
| **Central Processing Unit** (or **CPU**) | Processes data and instructions and make decisions. It is composed of many components (e.g. the CU, the ALU). |
| **Control Unit** (or **CU**) | Controls the operation of the ALU, memory and I/O devices; tells them how to respond to instructions it has fetched and decoded. |
| **Arithmetic Logic Unit** (or **ALU**) | Carries out arithmetic and logical operations. Results are stored in a **register**. |
| **Clock** | A crystal that vibrates at high speeds, dictating how many times a second the fetch-decode-execute cycle can be carried out. |
| **Bus** | Transports data and instructions around the CPU. |
| **Register** | Storage areas in the CPU. |
| **Main Memory** | Any form of memory directly accessible by the CPU (excl. cache, registers). |

## Systems Architecture (cont)

| | |
|---|---|
| **Cache** | Small, fast memory that is close to the CPU. Stores data that is used frequently. |

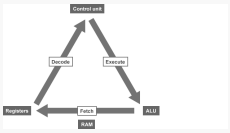
The AQA specification is only interested in the **Von Neumann Architecture**, which is also called the **Princeton Architecture**. Unlike in **Harvard architecture**, Von Neumann stores data and instructions together.

## Von Neumann Architecture




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

## Fetch-Decode-Execute Cycle



The fetch-decode-execute cycle is a process carried out by the CPU to process an instruction. In the 'fetch' stage, the instruction is loaded into the main memory. The computer then decodes and 'understands' the instruction and executes the instruction. This final stage may include calculation being carries out by the ALU.

## Secondary Storage

What is **secondary storage**?

> Any storage that isn't under the direct control of the CPU. It stores data and information when the computer is off.

What is **RAM**?

> **R**andom **a**cess **m**emory. Is volatile, so all data is lost once the power supply is switched off. Stores programs and data currently in use. Can be written to and read from.



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## Secondary Storage (cont)

What is **ROM**?

**R**ead **o**nly **m**emory. Stores programs needed to boot up the computer. Can only be read from. Non-volatile. Generally smaller in memory capacity.

## Types of Storage

Magnetic

Magnetic storage uses magnets to record data on rotating metal plates. The most common example is a hard drive.
Advantages:
1. Large storage capacity
2. Decent read/write access
3. Cheap
Disadvantages:
1. Moving parts result in wear and tear
2. Data can be lost/altered by magnets

Optical

Optical storage uses a lens and a light beam to read and write data onto a disk (e.g. CD, DVD).
Advantages:
1. Light and portable
2. Cheap
3. Durable
4. Some formats (e.g. CD-R) mean that data cannot be overwr-itten
Disadvantages:
1. Small storage capacity
2. Specific drive needed to read/write data to/from the disk

Solid State

Solid-state uses flash memories/electrical circuits to store data. It is commonly used in USBs and SD cards.
Advantages:
1. Very quick read/write speed
2. Compact
3. No moving parts
3. Robust
Disadvantages:
1. Expensive
2. Limited number of times that data can be written to

## Types of Storage (cont)

Cloud

Data is stored (using normal magnetic/solid state storage) at a remote location and is accessed via the Internet. Popular examples are Google Drive and Dropbox.
Advantages: 1. Can be accessed from anywhere in the world, granting increased flexibility
2. Can be accessed by multiple users at once
3. Users don't need to buy additional hardware
Disadvantages:
1. Requires an Internet connection
2. No control over the data in terms of security

## Factors Affecting CPU Performance

| | |
|---|---|
| **Clock Speed** (Hz) | Dictates the number of fetch-decode-execute cycles run per second. |
| **Number of Processor Cores** | Having multiple cores allows a CPU to process multiple instructions simultaneously. |
| **Cache Size** | Allows the CPU to store more instructions/data that are regularly used, reducing the time taken to process an instruction. |
| **Cache Type** | L1 cache is faster than L2 and L3 cache. |



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