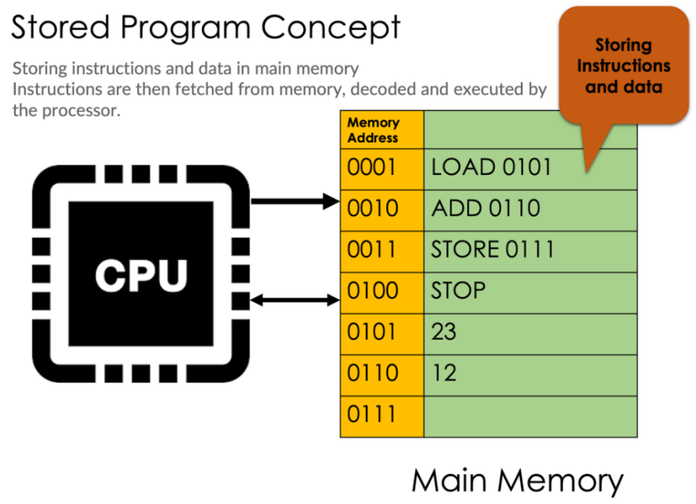
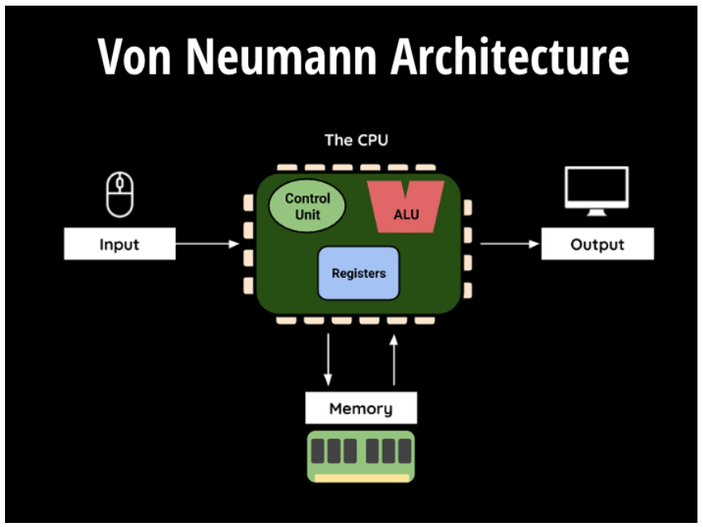
Hardware Knowledge Organiser

Stored Program Concept





Main CPU components:

- **Control Unit (CU)** – decodes instructions and sends signals to control how data moves around the CPU and memory.
- **Arithmetic Logic Unit (ALU)** – Carries out calculations and logical comparisons (e.g. greater than, less than).
- **CPU Registers -** temporary stores for instructions being processed):

CPU Registers:

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.

Buses

address bus

- *The address of memory (holding instruction) is placed on the address bus*
- **uni-directional**

data bus

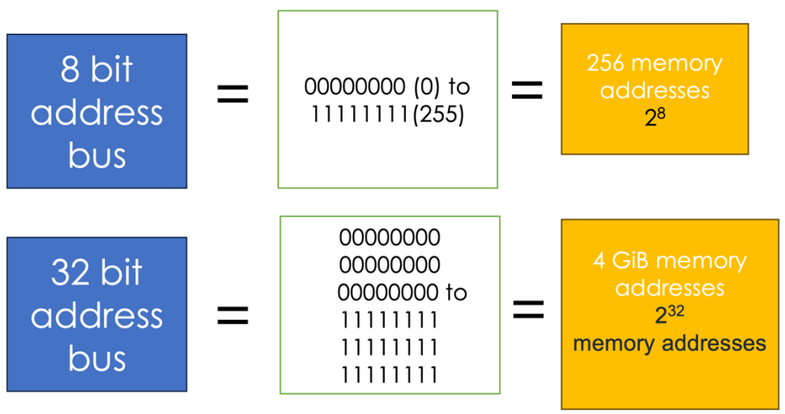
- *Contents (instruction/data) of the memory are placed on the data bus*
- **bi-directional**

control bus

- Control unit sends a signal on the control bus to start an operation and communicate with other devices within the computer.
- Receive status messages of devices.
- bi-directional

Address Bus Width

- Bus Width – number of connections on a bus
- Each connection represents a binary digit (0 or 1)
- A greater bus width means larger number values can be communicated



Clock Speed (Measured in hertz)

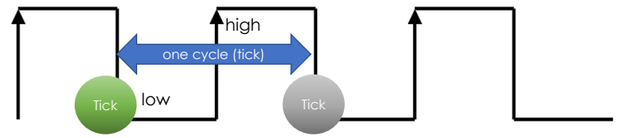
What does Synchronise mean?
Occur at the same time

The **clock signal** is used to **synchronise** the **operations** of the processor components.

What are computer operations?
A given task carried out by the CPU during the Fetch Decode Execute cycle

Current computers have clock speeds of **3GHz**, which means **3-billion cycles per second**

Clock cycle is known as a tick. Each cycle has High state and Low state.



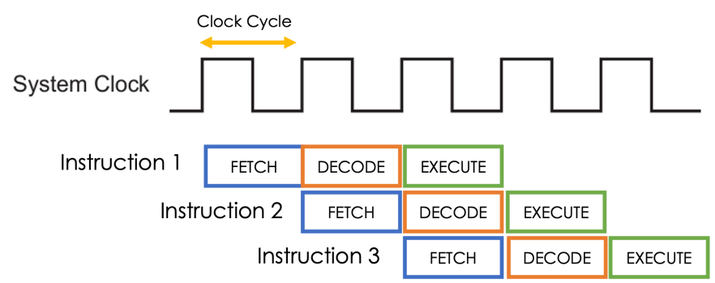
For each tick of the clock the CPU can process one or more instructions.

More clock ticks = faster that instructions can be processed

Exam Question: State the reason why a higher clock speed is desirable.
More instructions can be carried out each second.

Pipelining

When instructions are processed at the same time is known as pipelining



FDE Cycle The **fetch-decode-execute cycle** is the process of fetching instructions from memory, decoding the instructions and executing them.

Fetch Instruction

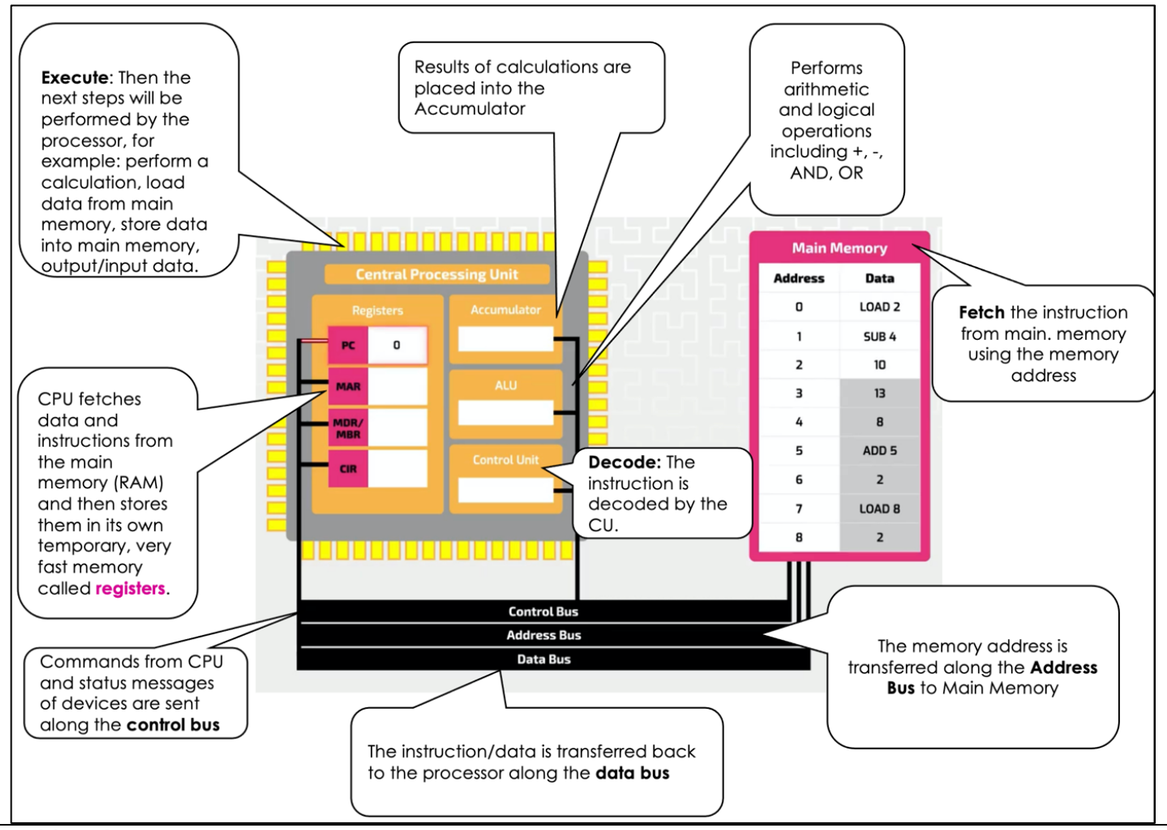
1. Memory address is copied from a CPU register(Memory Address Register) and sent along the **address bus** to main memory
2. The control unit sends a signal along the **control bus** to start a read operation
3. Instructions are fetched from the memory address and sent along the **data bus** to the CPU.
4. Iinstruction is copied into registers (Memory data register and moved to Current Address Register)
5. Increment program counter by 1

Decode Instruction

6. The instruction is decoded by the **Control Unit**.
The CPU is designed to understand a specific set of commands. These are called the '**instruction set**' of the CPU.

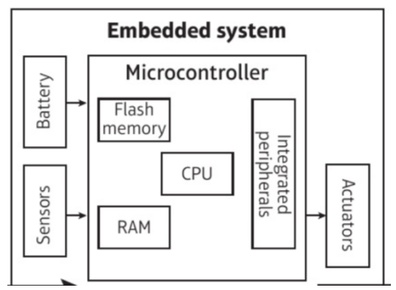
Execute Instruction

7. The instruction is executed
This could be:
- Load data from memory
- Write data to memory
- Do a calculation or logic operation using the ALU
- Change the address in the PC
- Halt the program



Embedded system	General-purpose system
Performs one specific function and has limited functionality.	Performs a wide range of functions.
Processing power is limited to what is needed for the function of the system.	Processing power is usually higher than required for everyday tasks.
Uses sensors for input.	Includes a standard keyboard and mouse for input.

All the components are all on a single chip – known as a microcontroller.
Senor readings (temperature sensor reading) are input into the system and stored in RAM.
CPU interprets and acts on the data according to the program instructions stored in **flash memory.**
A signal is sent to an **output device**, such as a **actuator** (switch cooling unit on and off).



Memory

RAM allows us to write data and store it…but the data is lost when it is switched off (volatile).

ROM

ROM allows us to store data when it has no power (non-volatile) but we cannot write to it. ROM holds boot up instructions

Secondary Storage

Used to permanently store data when the computer has no power. (non-volatile) and we can read and write to it.

Storage Technologies:

Magnetic storage
There is a magnetic/chemical coating on surface of the media.

An area that is magnetised represents a 1 and area that is demagnetised is a 0.

The data is read and magnetised using a read/write heads that move across the surface(known as a platter) using an arm.

They are a fairly cheap storage technology and can provide high storage capacities. Due to moving parts, they can damage easily if knocked. Furthermore, if a magnetic storage device comes in contact with strong magnets, the magnets can affect the device's magnetisable material, altering the data being stored, leading to data corruption.

Optical storage

Optical storage consists of 'marks' arranged in patterns.

A laser heats/burns areas of a disk which creates lands/pits representing binary 1s and 0s

This storage technology is not very durable as scratches on the surface of the disc can lead to data corruption. However, a benefit is that the media itself is very portable.

Solid State Storage (Flash)

SSD has no moving parts, small but large capacity and very energy efficient.

It uses chips called NAND flash, special king of transistors that can trap electrons in a 'pool'. Full pools represent 0's and empty pools represent 1's.

Billions of transistors can fit on a single chip!

Electrical currents are used to read and write data.

Overtime the erasing and writing causes the transistors to break down. This limits the life of a flash drive.

This storage technology is expensive

	Advantages	Disadvantages
Magnetic (Internal/ External hard drives) 	Large capacity Relatively cheap per GB Relatively Fast Access to retrieve data Fairly Reliable – data is not easily lost and be accessed many times	Moving parts so not portable Data loss if dropped, extreme heat and magnets
Solid State (USB memory sticks/ SD cards/ Solid state drives) 	Portability – SSDs can be made smaller than HDDs and can be lighter in weight. Durability – SSDs have no moving parts, HDDs are more fragile. SSDs are typically lower-powered, make less heat and make no noise. [4] Speed: Quick access/ fast transfer of data/ Fast read-write Highly reliable: flash media is highly reliable (not affected by extreme temperatures or magnets)	Capacity - Currently quite expensive so smaller capacity Cost – solid-state drives cost more per GB Durability issue: solid-state drives have a limited amount of read/writes – if lots of file transferral occurs then they might start to fail.
Optical (CD/DVD) 	Cheap Convenient to carry Universally readable by most computers	Durability issue – can be scratched and corrupt data Speed– slow to transfer data to it Not very reliable – needs protecting from extreme heat

Long Answer Questions

Southlands Hotel and Spa uses a booking system to record details of room bookings.

The workstations used at the hotel are old and are starting to run slowly when searching the files.

The hotel is considering two specifications for replacement workstations.

Specification 1: 3 GHz, 64-bit CPU and 8 GB RAM.

Specification 2: 4 GHz, 64-bit CPU and 4 GB RAM.

Compare the performance likely to be provided by the two specifications. [6]

Spec 2 has a higher clock speed and therefore will be able to deal with a **greater number of instructions** and **processing** will be **faster** than spec 1.

Higher clock speed of Spec 2 will use **more energy** and create more heat than the CPU in Spec 1.

Spec 1 has more RAM and therefore will be able to handle **more programs and operations at the same time** compared with Spec 2.

Level	Mark	Descriptor
	0	No rewardable content.
Level 1	1-2	Basic, independent points are made showing elements of knowledge and understanding of key concepts/principles of computer science. The discussion will contain basic information with little linkage between points made.
Level 2	3-4	Demonstrates adequate knowledge and understanding of key concepts/principles of computer science. The discussion shows some linkages and lines of reasoning with some structure.
Level 3	5-6	Demonstrates comprehensive knowledge and understanding by selecting relevant knowledge and understanding of key concepts/principles of computer science to support the discussion being presented. The discussion shows a well-developed, sustained line of reasoning which is clear, coherent and logically structured.

Describe how the CPU and main memory work together.[4]

Response identifies any **four** from:

- data and instructions are stored in main memory (1)
- data and instructions are fetched by the CPU (1)
- on the pulse of a clock (1) (as 'required'/ notified / assigned by the program counter)
- correctly identify role of address bus (1)
- correctly identify role of data bus (1)
- instructions decoded by the CU (1)
- instructions executed (with data, as appropriate) by the ALU (1)

Data and instructions are fetched from main memory (1), from addresses requested by the CPU (1) on the address bus (1).
(Data and instructions are **sent**) using the data bus (1).
(Data and instructions are then) decoded and executed in the CPU (1).
Results of operations are **sent back** to the memory (1) on the data bus (1).

Describe the role of the control unit, the control bus, the data bus and the address bus when fetching an instruction from memory.

(4)

A linked description that makes reference to the **four** following points:

- The address of memory (holding instruction) is placed on the address bus (1).
- The control unit sends a signal (1) on the control bus (to start a read operation) (1).
- The instruction is/the contents of the memory are placed on the data bus (1).