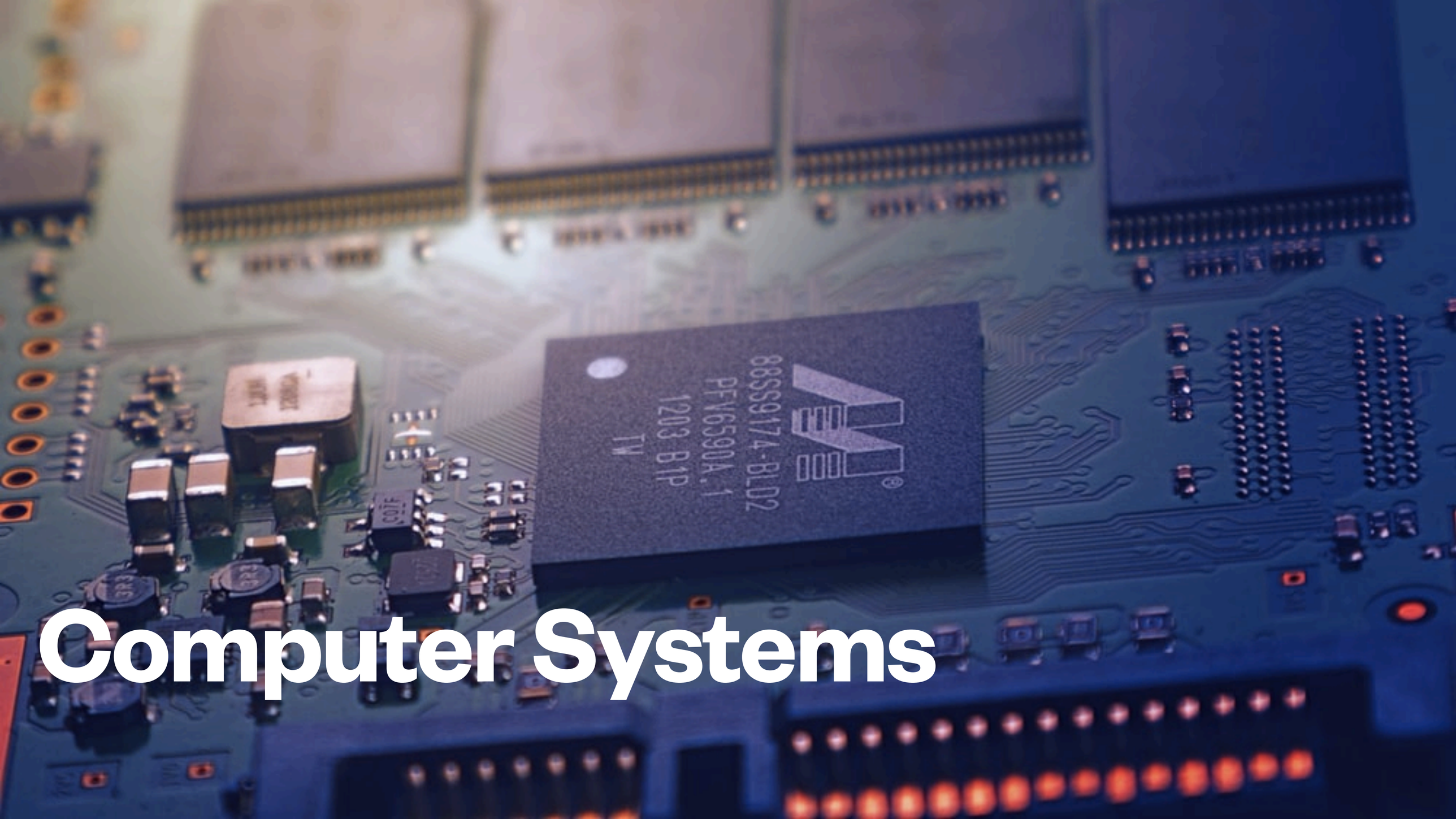


Computer Systems

Learning Intentions

- 2.11: Describe the different components within a computer and the function of those components.
- 2.14: Describe the difference between digital and analogue input.
- 1.13: Identify important computing developments that have taken place in the last 100 years and consider emerging trends that could shape future computing technologies

Topics covered
CPU: ALU, Registers, Program counter, Memory

What is a computer system?

- A system is a combination of many connected parts that work together to achieve a common goal.
- A computer system can also be made up of multiple computers or multiple programs.

What are some of the computer systems that are involved in a self driving car?

What are some of the components of the systems you identify?

What components must a device have to be considered a computer?

- A computer system can be described as a system that involves interactions between:
  - Hardware (The physical computer, keyboard, mouse, sensors etc)
  - Software
  - Data
  - User

2.11: Describe the different components within a computer and the function of those components.

What is a computer system?

- Both a mobile phone and a washing machine are computers, but they are different devices.

What makes these devices similar and different as computer systems?

- Computer systems can be classified as either general purpose or embedded systems.

- **General purpose** computers are devices that have a variety of uses, the user chooses the task for the computer to complete.

- **Embedded systems** are more specialised, they can only do a limited number of things, but they do them very well.

2.11: Describe the different components within a computer and the function of those components.

Spot the computer system

Look at the image of the sitting room to the right. Identify any general purpose computer systems and any embedded systems you can see.

General Purpose	Embedded System

2.11: Describe the different components within a computer and the function of those components.

What is a computer architecture?

- Computer architecture is the way that the different parts of a computer are physically and logically laid out and connected.
- Would a general purpose and embedded system need the same resources?

Consider the way in which architects design new houses.

Are all homes laid out the same way?

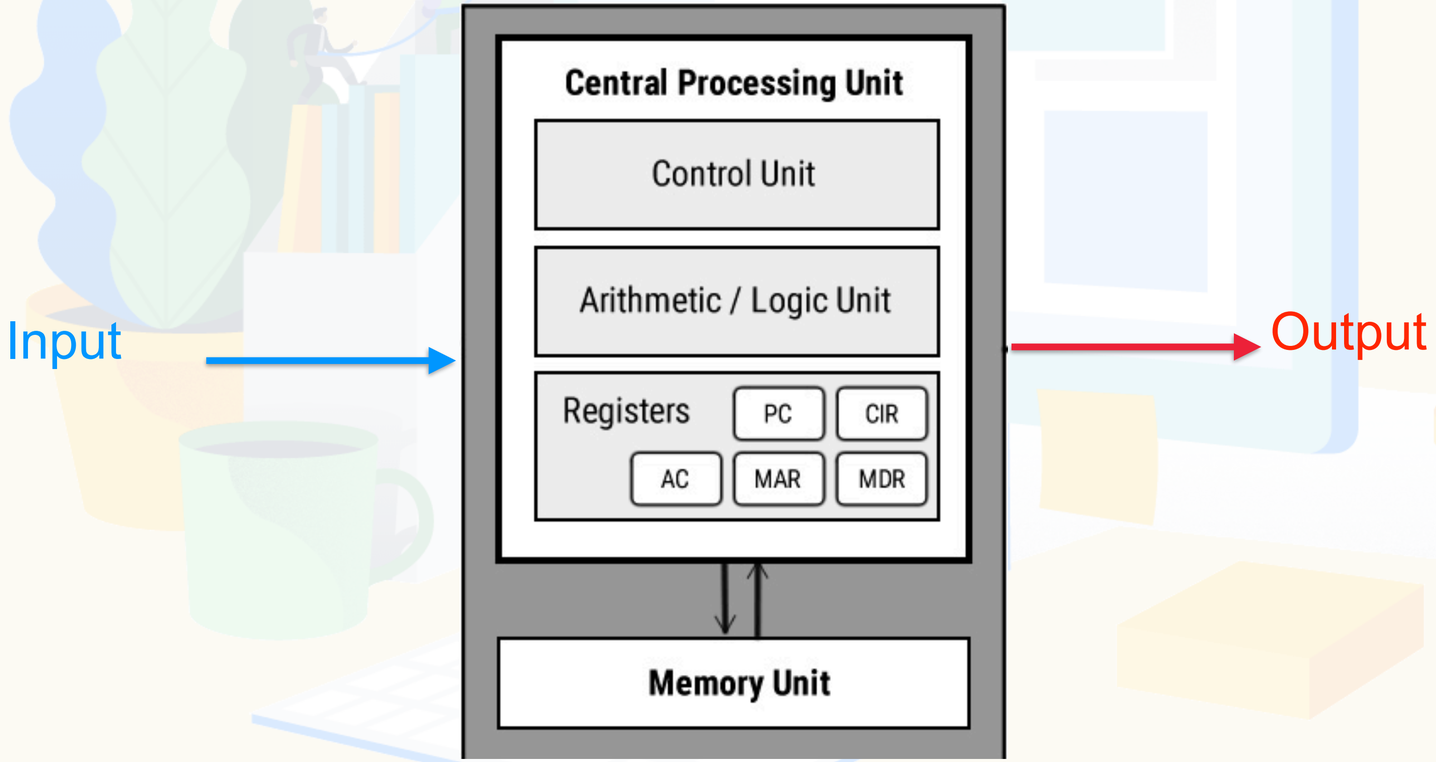
Do different homes have any rooms or features in common?

2.11: Describe the different components within a computer and the function of those components.

Von Neumann architecture

VN architecture

- Many of todays general purpose computers share a similar architecture.
- This common architecture is called Von Neumann architecture, named after John von Neumann who first proposed it in 1945.



2.11: Describe the different components within a computer and the function of those components.

Von Neumann architecture

- A central processing unit (CPU) which carries out the instructions.
- Memory which stores the data to be worked on, the instructions on how to operate on the data and the results of these operations.
- A bus that connects the CPU and memory, represented by the black arrows in the diagram.
- Input and output the allow data and instructions be given to the computer and received from the computer.

Research 1 other type of contemporary computer architecture and identify what kind of computer systems does it normally apply to and how it differs from Von Neumann architecture.

2.11: Describe the different components within a computer and the function of those components.

CPU: ALU, Registers, Program counter, Memory

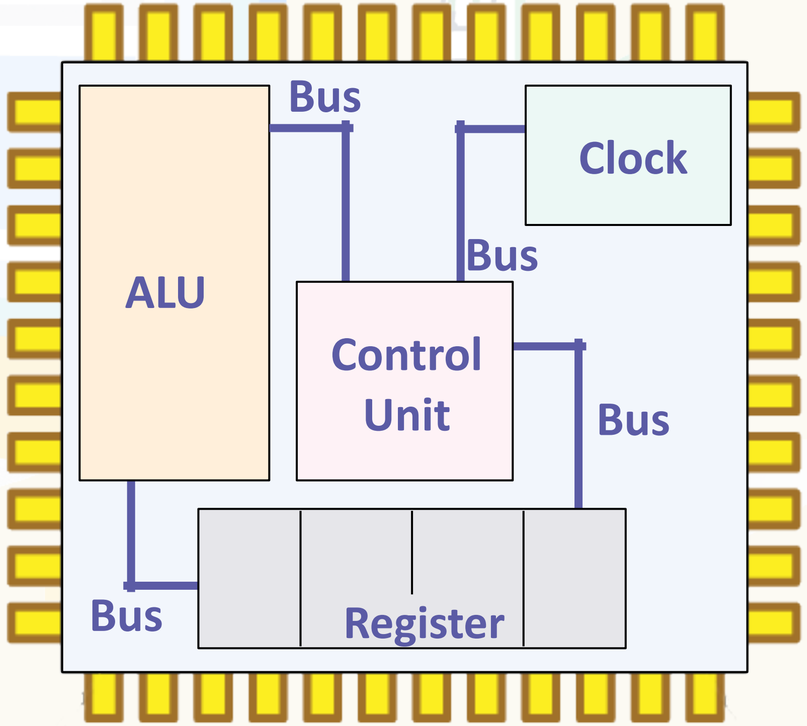
Components of a computer system - CPU

The purpose of the CPU is to process data by following instructions that result in an output. It is where processes such as calculating, sorting and searching takes place.

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**

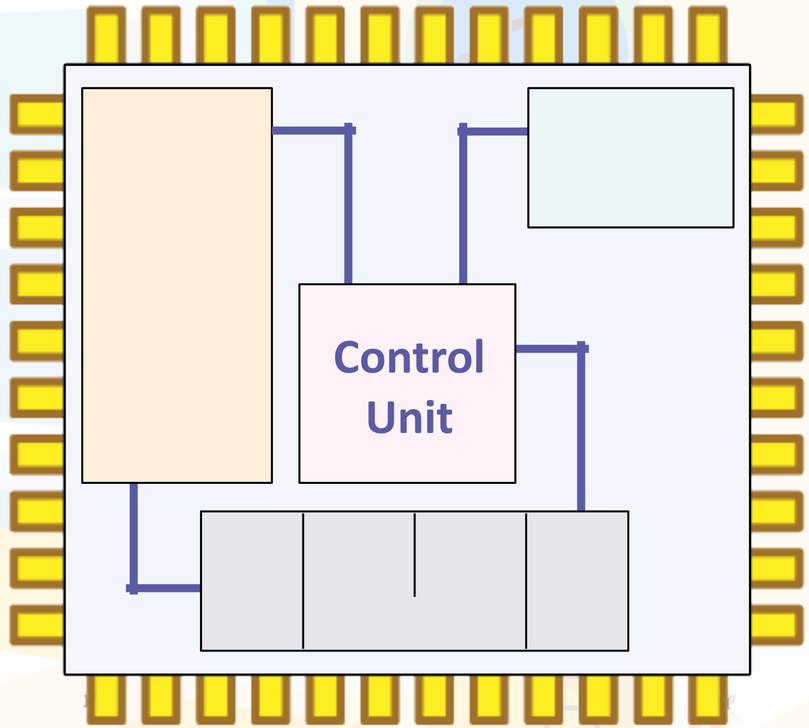


2.11: Describe the different components within a computer and the function of those components.

CPU: ALU, Registers, Program counter, Memory

Components of a computer system - CPU

- The Control Unit is the main component of the CPU.
- The Control Unit manages an instruction and controls the other components by telling them what they must do to cary out the instruction.



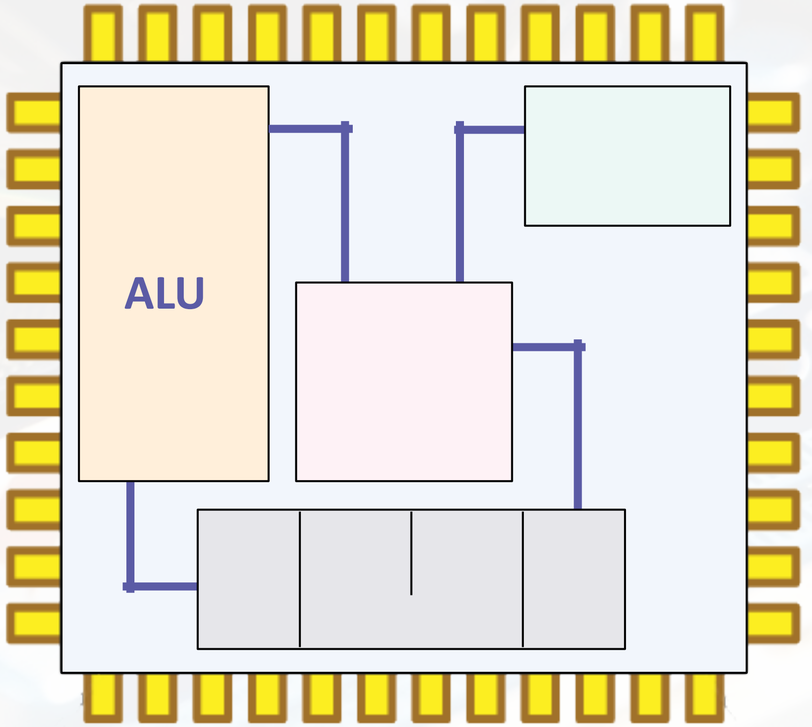
2.11: Describe the different components within a computer and the function of those components.

CPU: ALU, Registers, Program counter, Memory

Components of a computer system - ALU

The function of the Arithmetic and Logic Unit (ALU) is to carry out all the arithmetic and logical processes.

- The ALU manages two things:
  - Arithmetics, which deals with calculations. eg, 1+2=3
  - Logical functions which deals with any logical comparisons. eg, 5>3
- Every task your computer does is carried out here, even typing a word into Microsoft Word involves adding binary digits to a file and then calculating what should change on screen so you can see the characters. This all happens within the ALU.



2.11: Describe the different components within a computer and the function of those components.

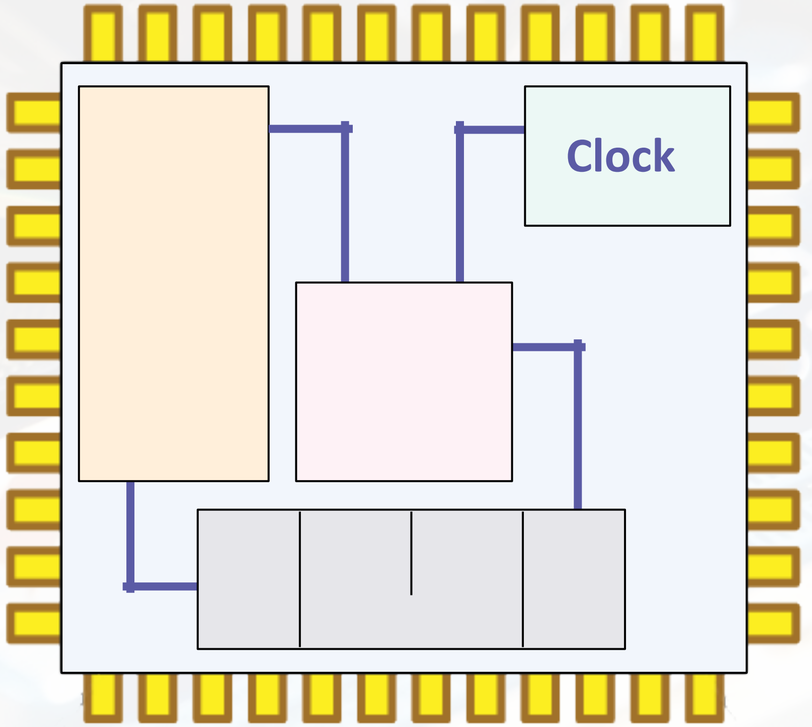
CPU: ALU, Registers, Program counter, Memory

Components of a computer system - Clock

AMD CPU Comparison

The function of the clock is to manage/regulate the number of operations carried out per second and synchronise the components.

- The primary factor effecting speed of a CPU is the clock speed.
- A CPU with a clock speed of 5GHz means it can carry out 5 billion instructions per second.
- Cores are parts of the CPU that execute and instruction, the more cores a CPU has the more instructions it can carry out simultaneously.



2.11: Describe the different components within a computer and the function of those components.

CPU: ALU, Registers, Program counter, Memory

Components of a computer system - Registers

Registers are temporary storage locations (memory) that the CPU can access very quickly when carrying out operations on data.

- The registers stores data from the ALU and CU so that instructions can be executed.
- Different processes have different sets of registers but there are typically 16 general purpose registers in the CPU.
- One important register is the program counter.

Research the role of the following registers and make note of their functions:

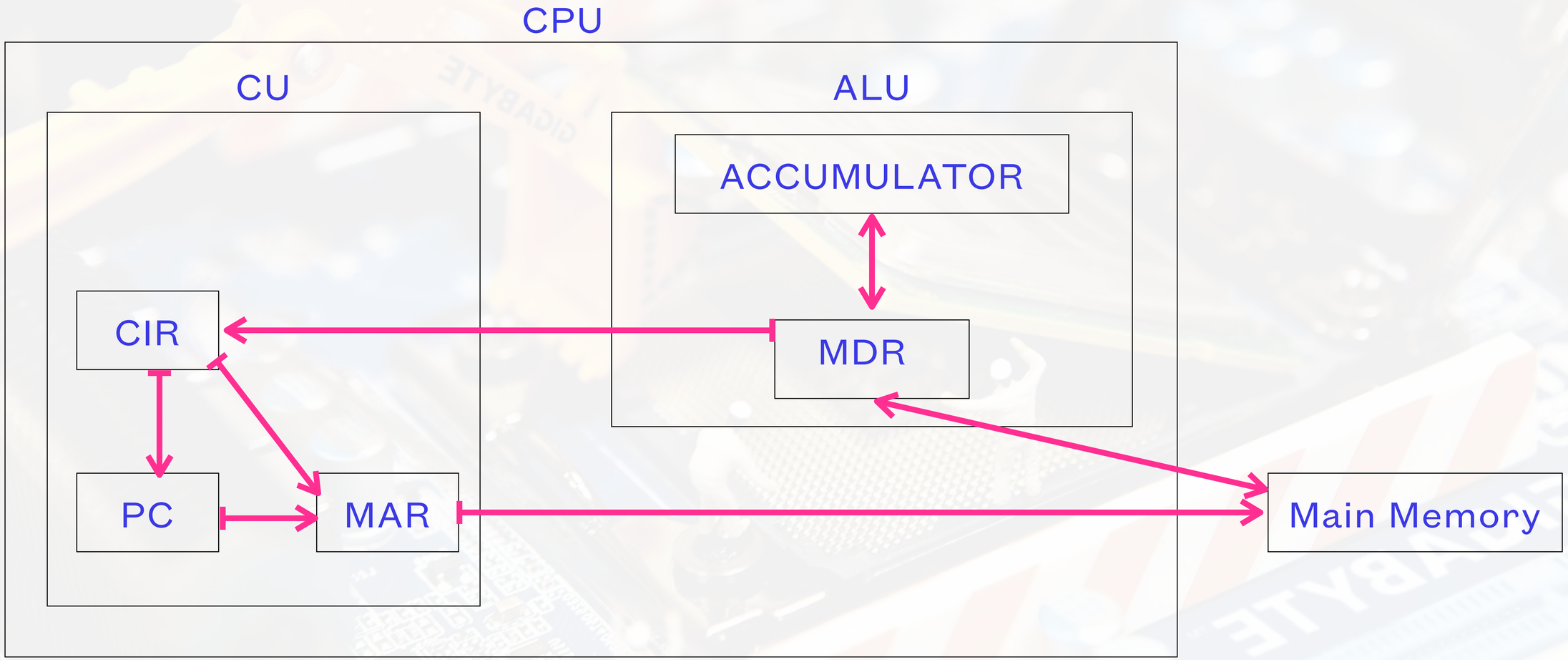
Program Counter

Memory Address register

2.11: Describe the different components within a computer and the function of those components.

CPU: ALU, Registers, Program counter, Memory

Components of a computer system - Registers



2.11: Describe the different components within a computer and the function of those components.

Function of each register

- PC - Program Counter: Points to the next Instruction address.
- MAR - Memory address register: Stores the address of the instruction/data to be retrieved from the memory (RAM)
- MDR - Memory Data Register: Stores the data that was in the memory at the address identified by the MAR.
- CIR - Current Instruction Register: Decodes the instruction/data from the MDR so the CPU knows what to do with it.
- Accumulator: Stores arithmetic and logic results

2.11: Describe the different components within a computer and the function of those components.

Fetch - Execute Cycle

Little Man Computer

SIM

- As a CPU processes instructions, it runs through a cycle called the ‘Fetch-Execute’ cycle.
- This is how the CPU fetches an instruction from the memory, RAM, and then executes that instruction.
- During the ‘Fetch-Execute’ cycle the CPU may need to use different registers to store data while it executes the instruction.
- This cycle happens millions of times per second

A single piece Python code may require several cycles of the ‘Fetch-Execute’ cycle.

Area = Length * Width

Try and identify each step the computer would need to take to return the Area variable to the user.

2.11: Describe the different components within a computer and the function of those components.

Fetch - Execute Cycle

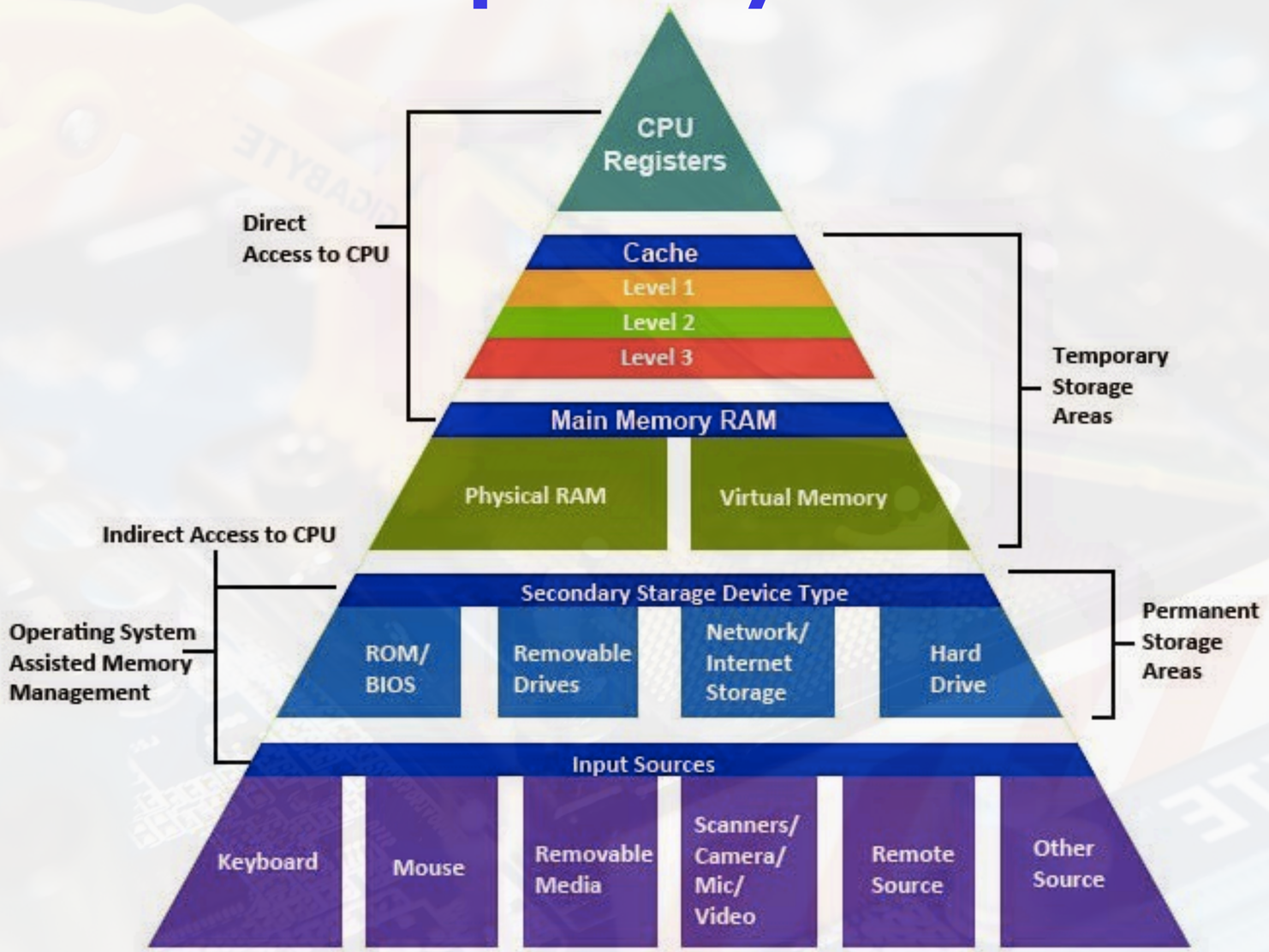
Little Man Computer

SIM

Fetch	Decode	Execute
Address of the instruction is copied from the PC to the MAR	MDR now contains the data fetched from the memory	Decoded instruction is executed
MAR now contains a memory address	The data can be an instruction e.g add or actual data e.g number 100	THis could be to perform a calculation on the ALU, locate data in memory etc.
CU fetches the data stored at that memory address from the memory	CU decodes the data to identify what to do.	Once the execute part of the cycle is complete the cycle begins again.
CU transfers that data to the MDR		
PC increments to next address to be queried, ready for the beginning of the next cycle		

2.11: Describe the different components within a computer and the function of those components.

Components of a computer system - Memory



2.11: Describe the different components within a computer and the function of those components.

Components of a computer system - Memory

Memory is the component of the computer system that holds data, programs and instructions that are in use by the system.

Primary Memory (storage)	Secondary Memory (storage)
Refers to the main internal memory such as RAM and ROM.	Refers to auxiliary memory such as a USB drive or Hard Drive
It is directly accessible by the CPU	It is not directly accessible by the CPU
It holds data or instructions that are currently in use	It is used to store and retrieve data on a long term basis
Data is lost when the device loses power. (Volatile)	Data is not lost when the device loses power. (Non-volatile)
Common examples are RAM, ROM and Cache memory	Common examples are DVD, USB drives, HDD etc

2.11: Describe the different components within a computer and the function of those components.

Components of a computer system - Primary Memory

- RAM and ROM are both types of primary storage that are used to store information for immediate use by the CPU

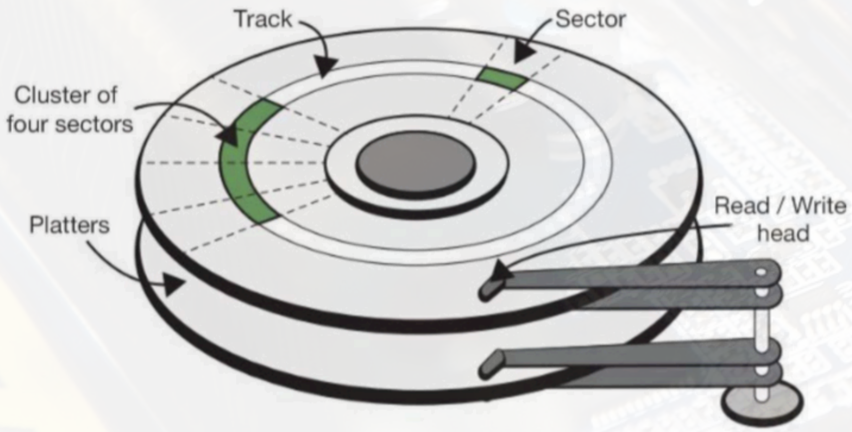
Random Access Memory (RAM)	Read Only Memory (ROM)
RAM is temporary memory, it holds the data and instructions currently in use by the CPU	ROM is non a permanent type of memory, it stores the computers startup routines.
It is constantly being written to and read from.	Contents cannot be changed by the computer or user.
Loses all data when it loses power (Volatile)	Retains data even after loss f power (Non Volatile)
Easy to upgrade and relatively cheap	Very difficult to change and expensive.

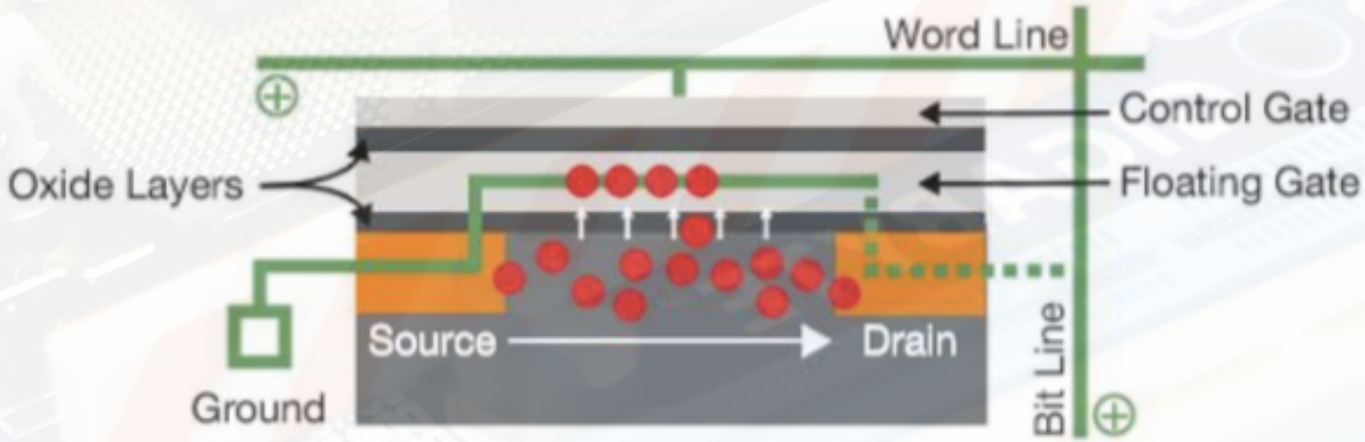
Do you think an embedded system will have ROM or RAM memory?

2.11: Describe the different components within a computer and the function of those components.

Components of a computer system - Secondary Memory

- Secondary storage devices are used to store data long term.
- Secondary storage devices such as USB devices, store data regardless of whether the device has power or not. (Non-volatile)
- Secondary storage is generally slower than primary memory devices but can store much much more data.
- Hard drives are one of the most common form of secondary storage devices, there are two main types, magnetic and solid state.



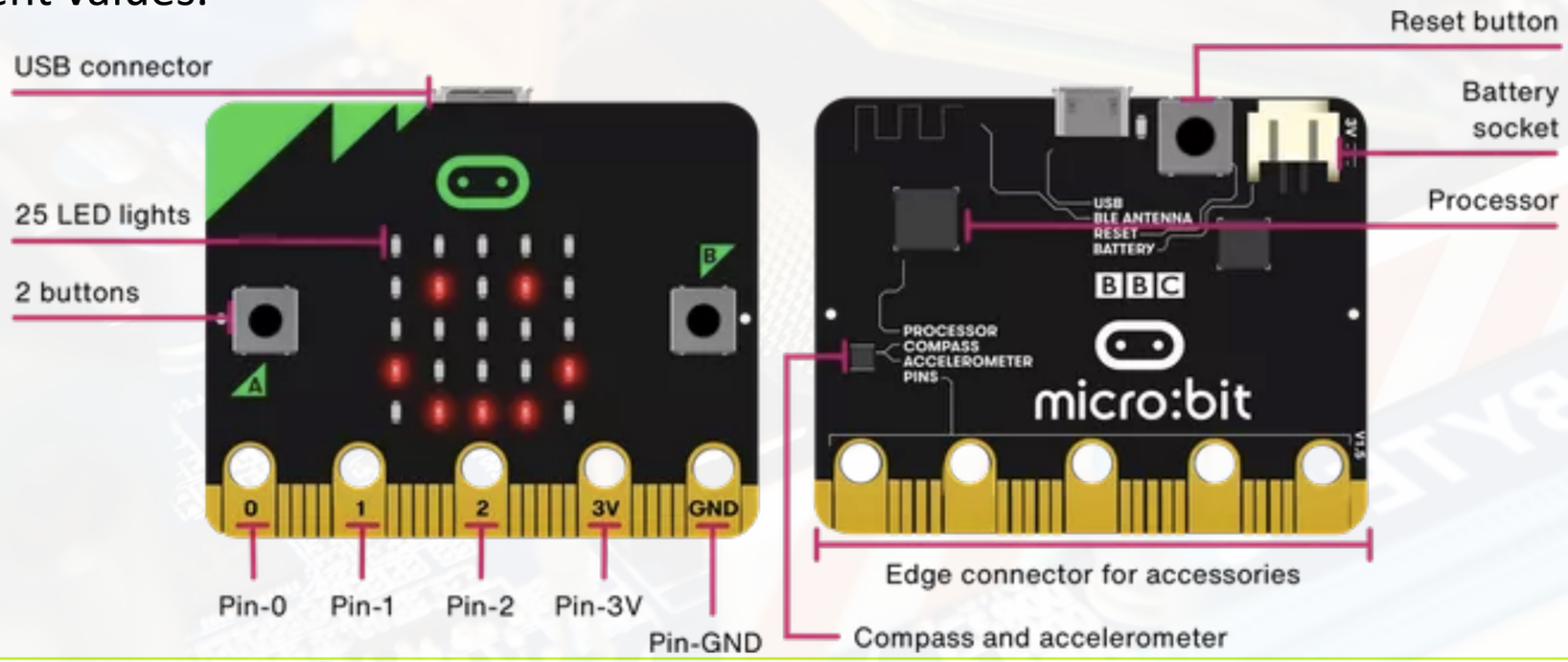


2.11: Describe the different components within a computer and the function of those components.

Inputs and Outputs

MakeCode editor

- Input and output devices can be classified as either being analogue or digital devices.
- Digital devices have only two possible states, on/off, think of like a light switch.
- Analogue devices are variable and can have multiple states, think of a thermometer, the temperature can vary across different values.



2.14: Describe the difference between digital and analogue input.

Learning Intentions

- 2.12: Describe the different types of logic gates **and explain how they can be arranged into larger units to perform more complex tasks**
- 2.13: Describe the rationale for using the binary number system in digital computing and how to convert between binary, hexadecimal and decimal

Topics covered
Basic electronics: voltage, current, resistors, capacitors, transistors

Binary Code

- Computer see everything in binary code, these are essentially electrical signals or voltages that are on or off.
- All data a computer processes must be converted to binary code before use.
- Binary code is represented by a series of 1’s and 0’s.
- Transistors are an electronic component that control if an electric current flows or not.
- Transistors are arranged to carry out boolean (logic) operations, these arrangements are called logic gates.

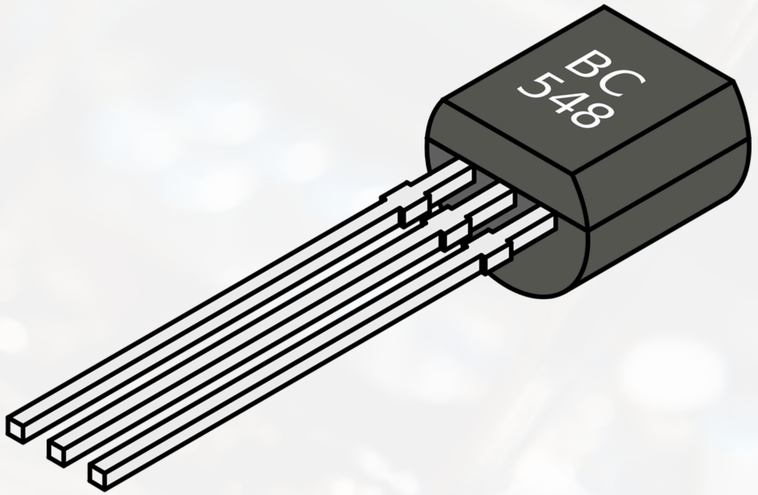
01001101 01100001 01110010 01110100 01101001 01101110

Find what your name is in binary code.

2.14: Describe the difference between digital and analogue input.

Logic Gates

- CPU is made up of billions of transistors.
- The transistors are arranged in a way in which they carry out Boolean operations such as AND, NOT and OR.
- These arrangements are called logic gates.



Logic Gate Type	And gate	Or gate	Not gate	Nand gate	Nor gate
Logic Gate Symbol					

2.14: Describe the difference between digital and analogue input.

Truth Tables

- Truth tables are used to identify the operation of a logic gate.
- Truth tables allow us predict an output for a given output.
- A gate input is driven by two different voltages 0v and 5v represent logic 0 and logic 1.
- Similarly, a gate output is either 0v or 5v, representing logic 0 and logic 1.

Are logic gates used in digital or analogue circuits? Why?

AND Gate

A	B	Output

2.14: Describe the difference between digital and analogue input.

Truth Tables

OR gate

A	B	Output

NOT gate

A	Output

Complete the truth tables for a NAND Gate and a NOR Gate

2.14: Describe the difference between digital and analogue input.