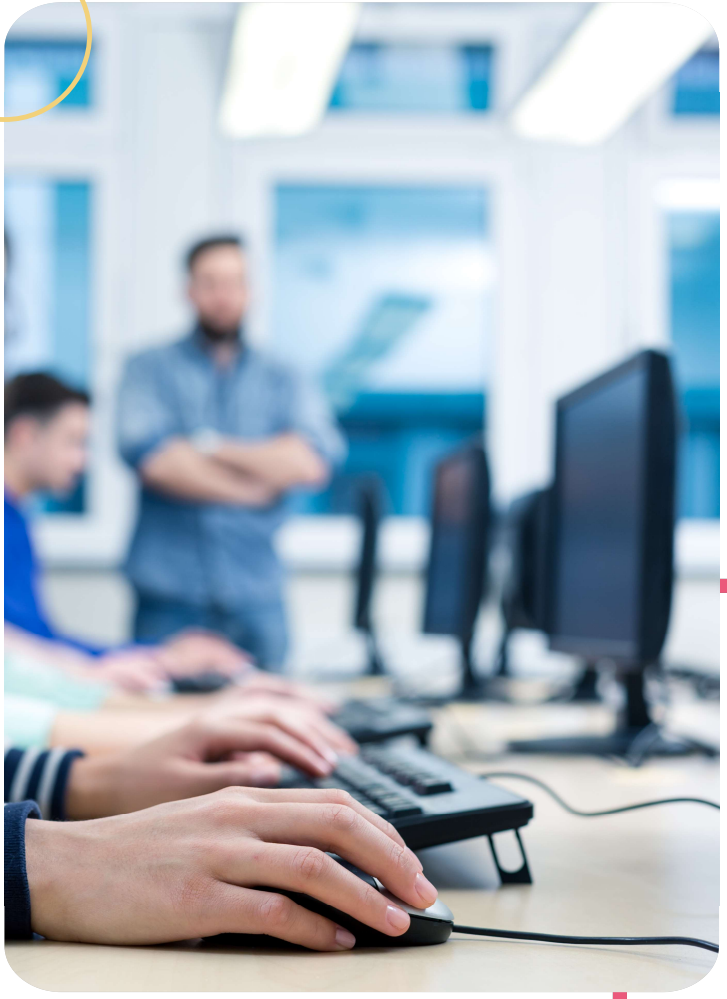
Diploma in

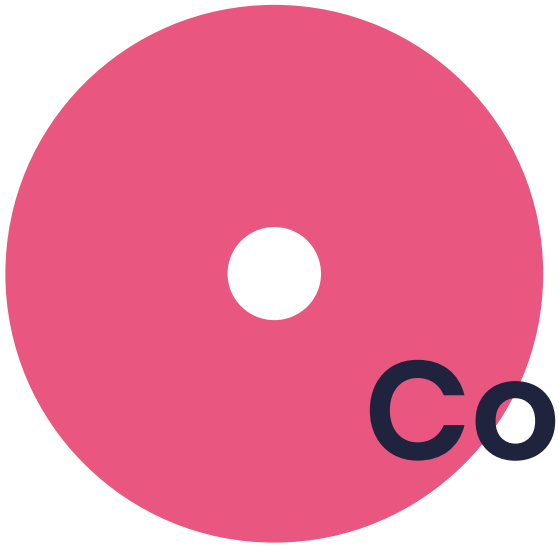
Computer Science

Measuring computing power



Objectives

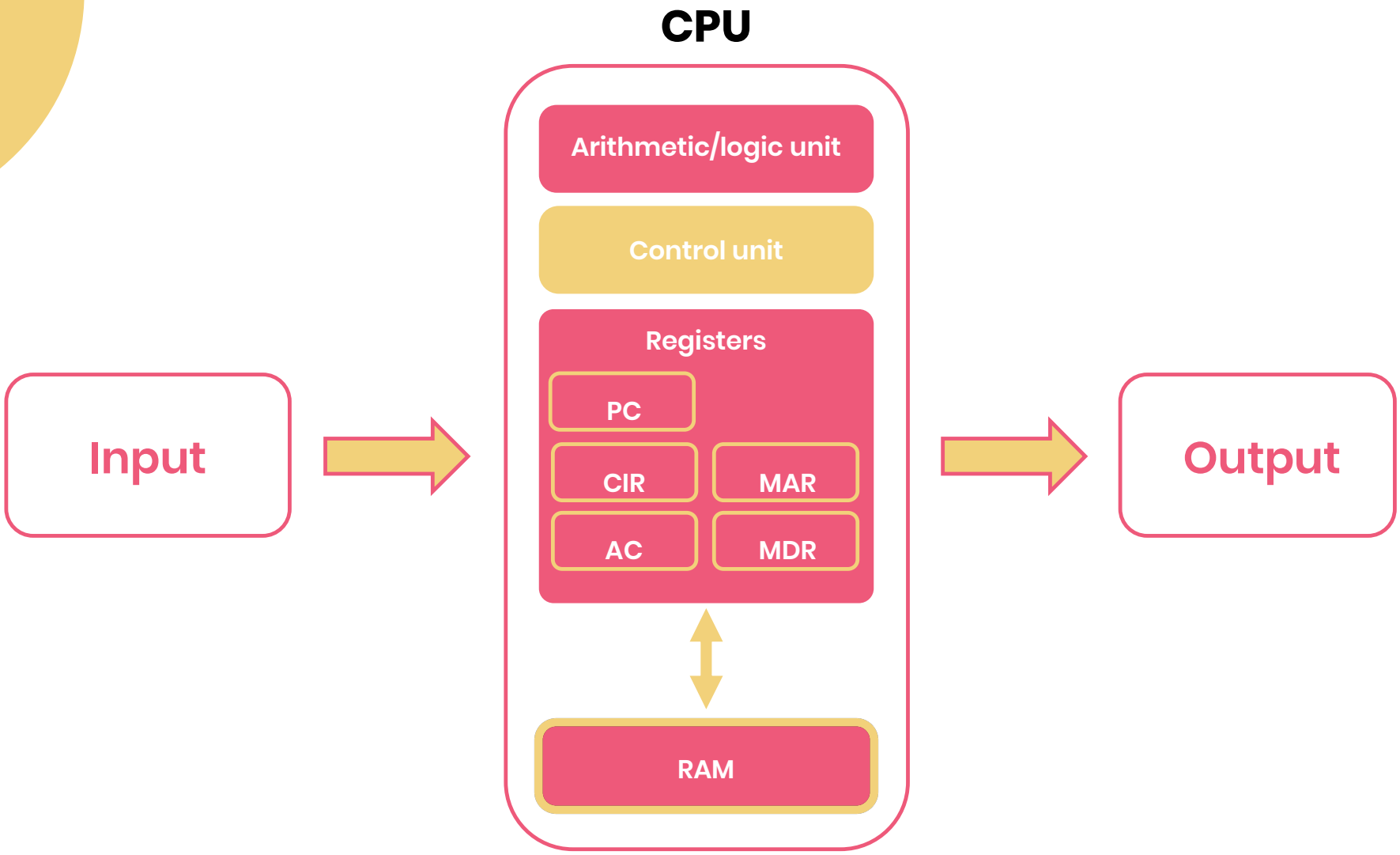
- Learn computing systems
- Understand the binary system
- Explore the weaknesses of computers



Computing systems

Structure of computers

- Just like a house, a computer is built using a plan
- Computer systems have a number of basic components
- Input devices feed raw data into the computer, output devices show results


CPU
Arithmetic/logic unit
Control unit
Registers
PC
CIR
MAR
AC
MDR
RAM
Input
Output

Computer architecture

- Computers are built in pretty much the same way nowadays
- Known as the Von Neumann architecture
- Built on the premise of storing program instructions in memory along with the instructions that operate on the data

The Von Neumann architecture

Five special registers

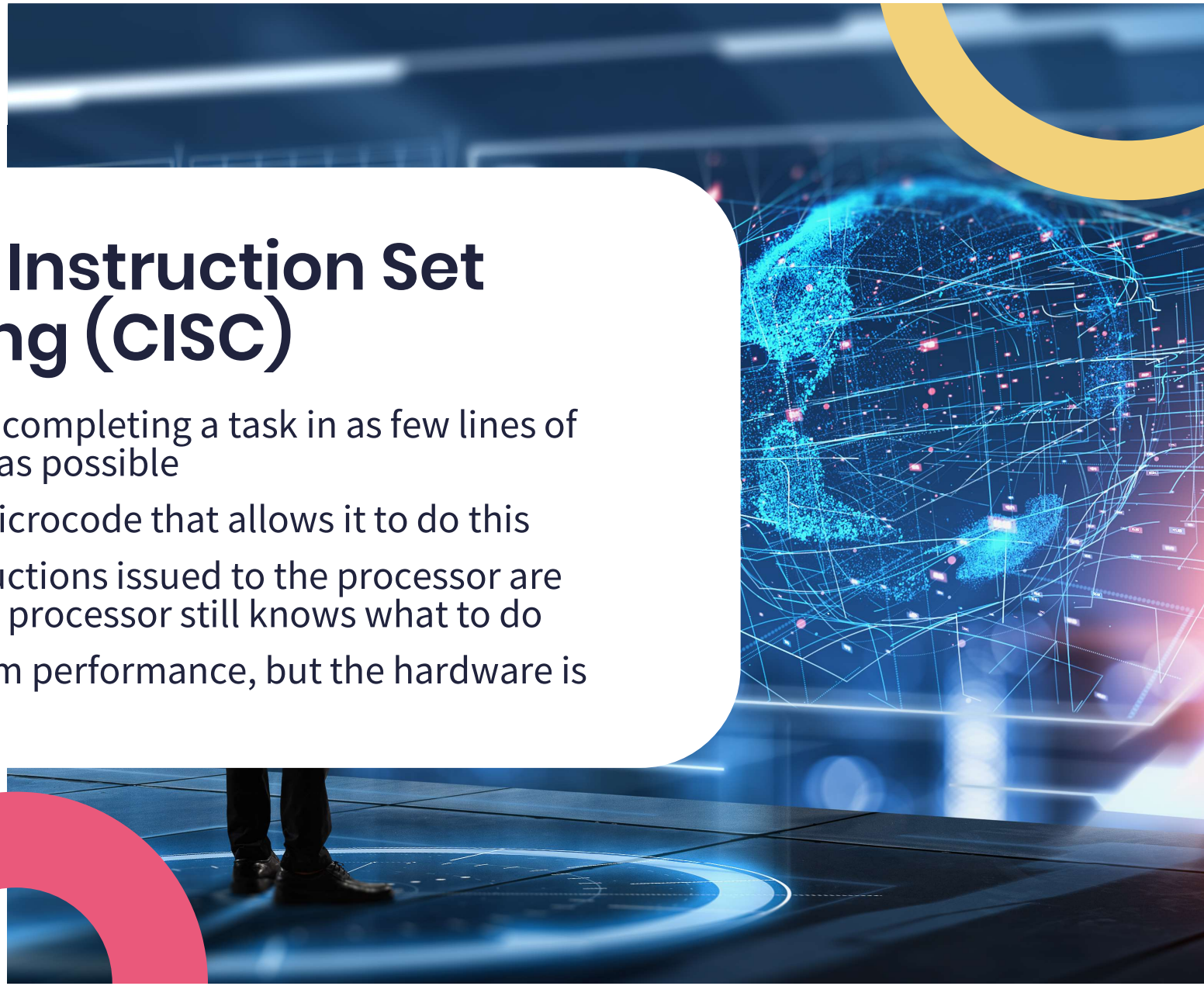
1. The program counter (PC)
2. The current instruction register (CIR)
3. The memory address register (MAR)
4. The memory data register (MDR)
5. The accumulator (ACC)

The Von Neumann architecture

- The Von Neumann architecture led to programmable computers
- An instruction set is the set of all possible commands
- Two main categories, CISC and RISC

Complex Instruction Set Computing (CISC)

- Primary goal of completing a task in as few lines of assembly code as possible
- Typically has microcode that allows it to do this
- Low-level instructions issued to the processor are shorter, but the processor still knows what to do
- Improves system performance, but the hardware is complex



Reduced Instruction Set Computing (RISC)

- Aims at simple instructions that can be completed in one clock cycle
- The programmer needs to code each individual step
- RISC systems need less transistors to carry out the same task
- Instructions can be staggered using a process called pipelining

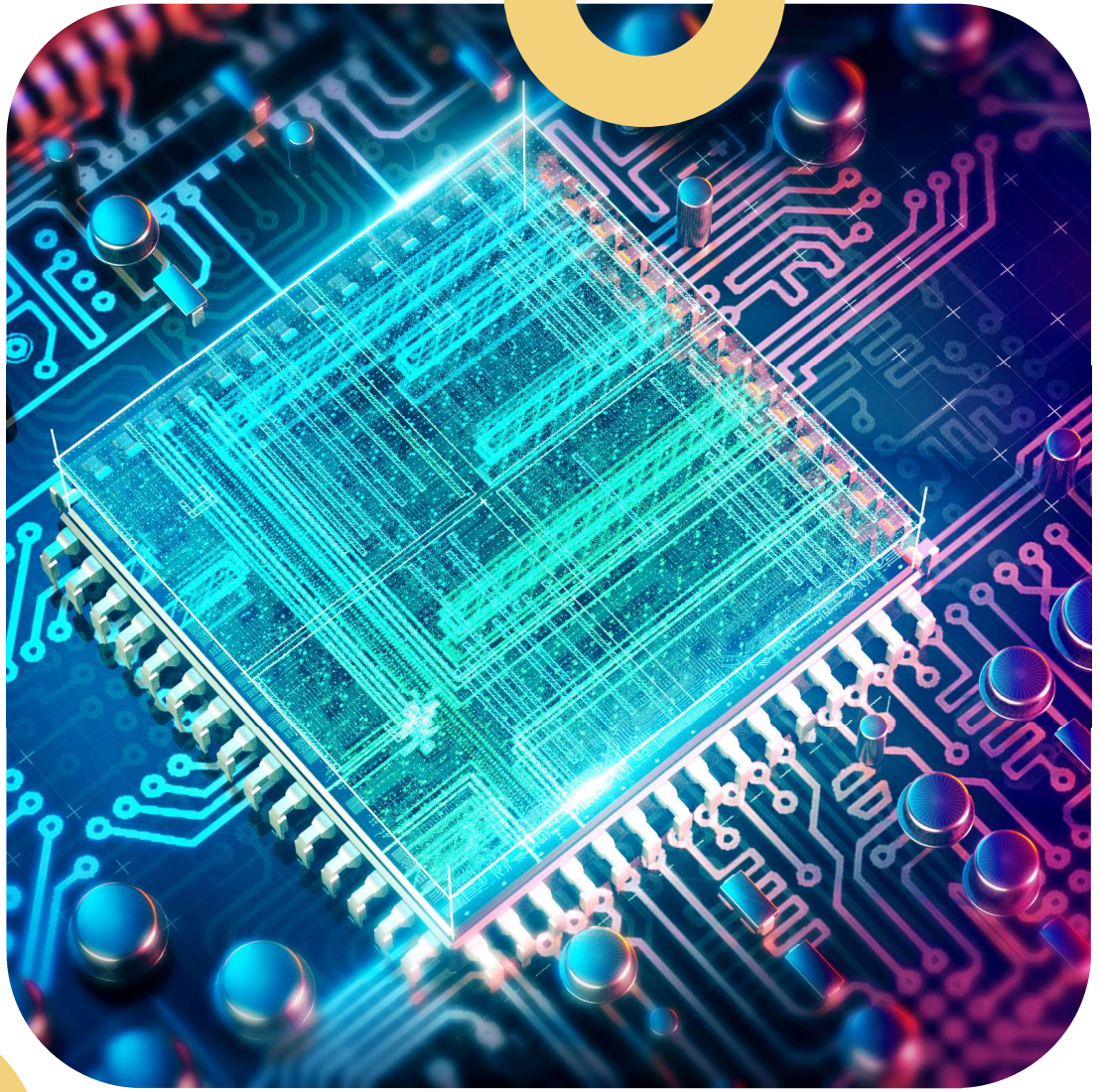
RISC vs CISC

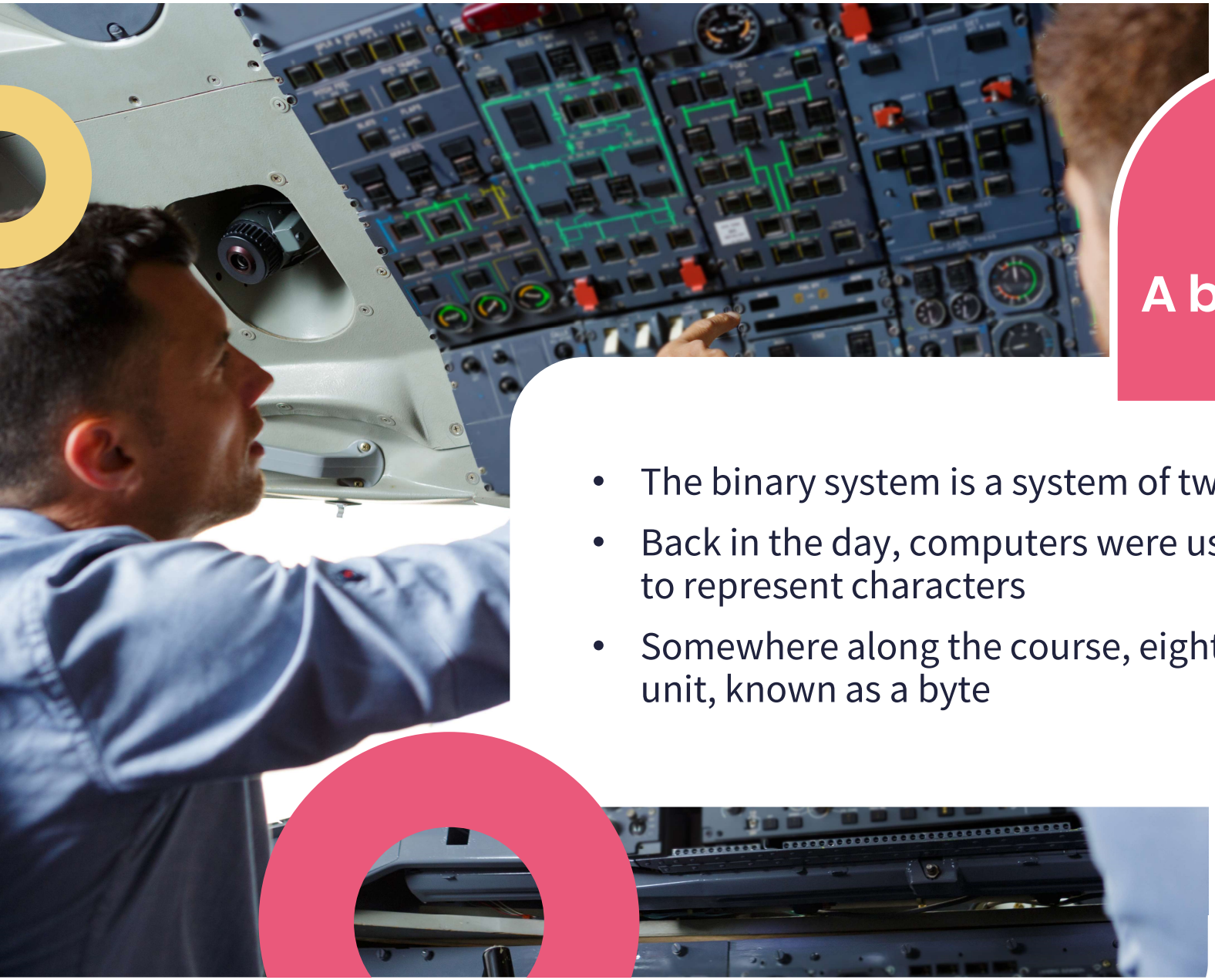
Example

- CISC would be the adult, and the child would be RISC
- RISC has simple, standardised instructions
- CISC uses less ram, and has the ability to add more instruction sets, which makes it more flexible

Writing device drivers

- Digital computing is just a bunch of switches
- “ON” = 1 and “OFF” = 0
- Forms the basis of all modern computing
- Called a “bit”
- System of numbering is called the binary system





A bit?

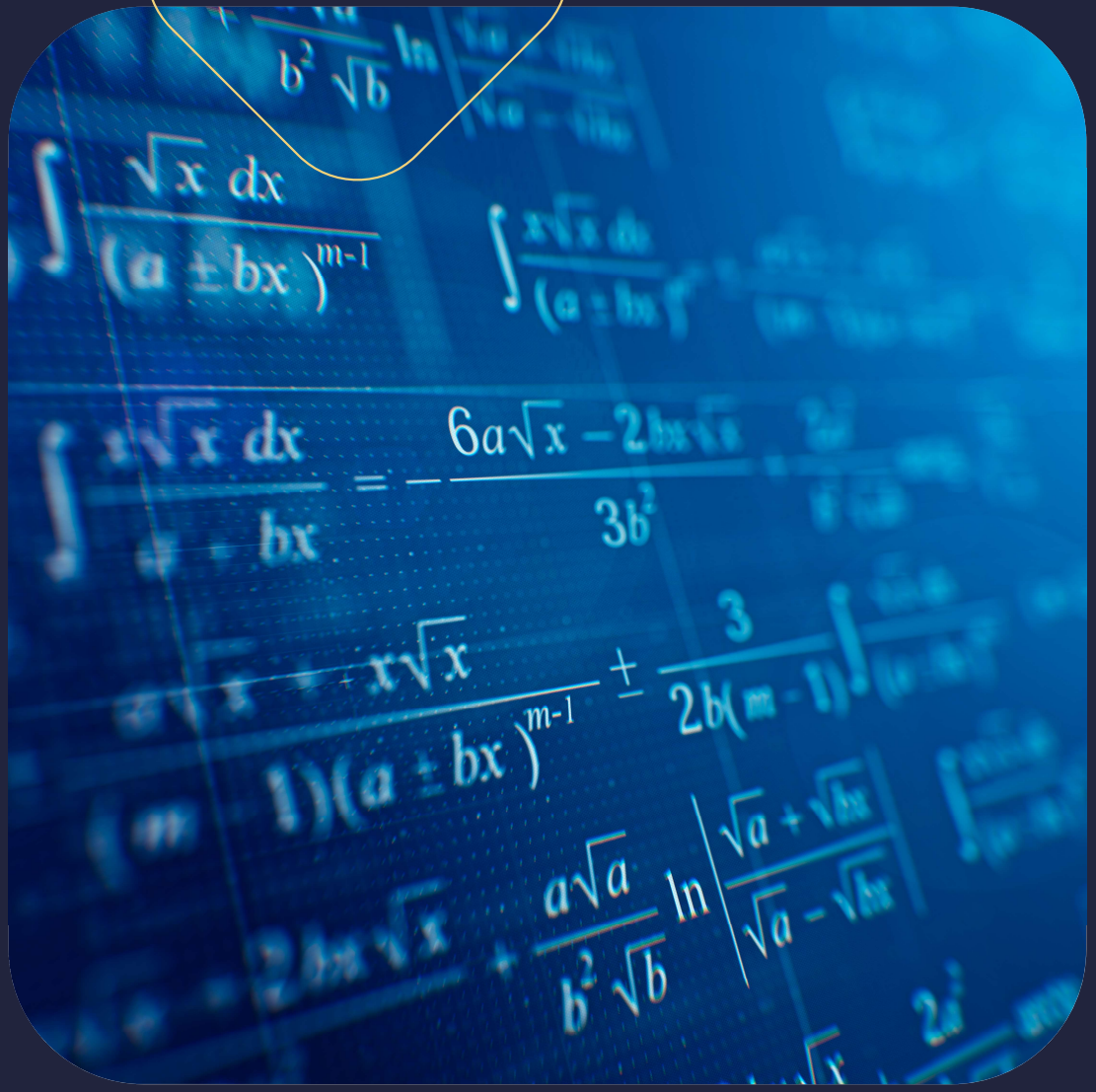
- The binary system is a system of two digits; never go above two
- Back in the day, computers were using varied numbers of bits to represent characters
- Somewhere along the course, eight bits became a standard unit, known as a byte

Standardised units

- In the 1950s, the term “byte” initially meant the addressable blocks of memory
- “byte” could mean 6, 7, 8 or even 9 bits
- 8 bits eventually became the standard and represents 1 byte of data to this day

Bite or byte?

“Byte” is a metaphor for what a computer chews on and is a deliberate misspelling of “bite” in order to avoid accidental confusion.



More units

- By today’s standards, a byte is a very small unit of data
- We need a way to represent this in a readable manner
- A byte is an addressable area, and these come in powers of 2
- Other units; a nibble, which is 4 bits and a word, which is 16 bits

Storing data

You need to tell the storage device what memory location to put it in.

Addresses are also provided in binary.

Every time you increase the number of address bits, you double the number of possible storage locations.

Generally, new storage devices must be at least 2x larger.

Example

- 4 address lines = data in 16 different locations
- If you add one address line, it can now store data in 32 different locations
- Making a storage device that could only hold 25 different pieces of data = 7 unusable addresses
- Complexity must be added to the controller

Storing data

- Because of natural progression, people rarely made storage devices that didn't work in powers of 2
- Has become a de-facto standard now

Exceptions

- DVDs - information that is actually written to the disk may not be a power of 2
- Compensated for by the fact that the drive controllers are fairly complex
- Things are confined to powers of 2 for most other controllers

Computing isn't all rosy!

Weaknesses of computers

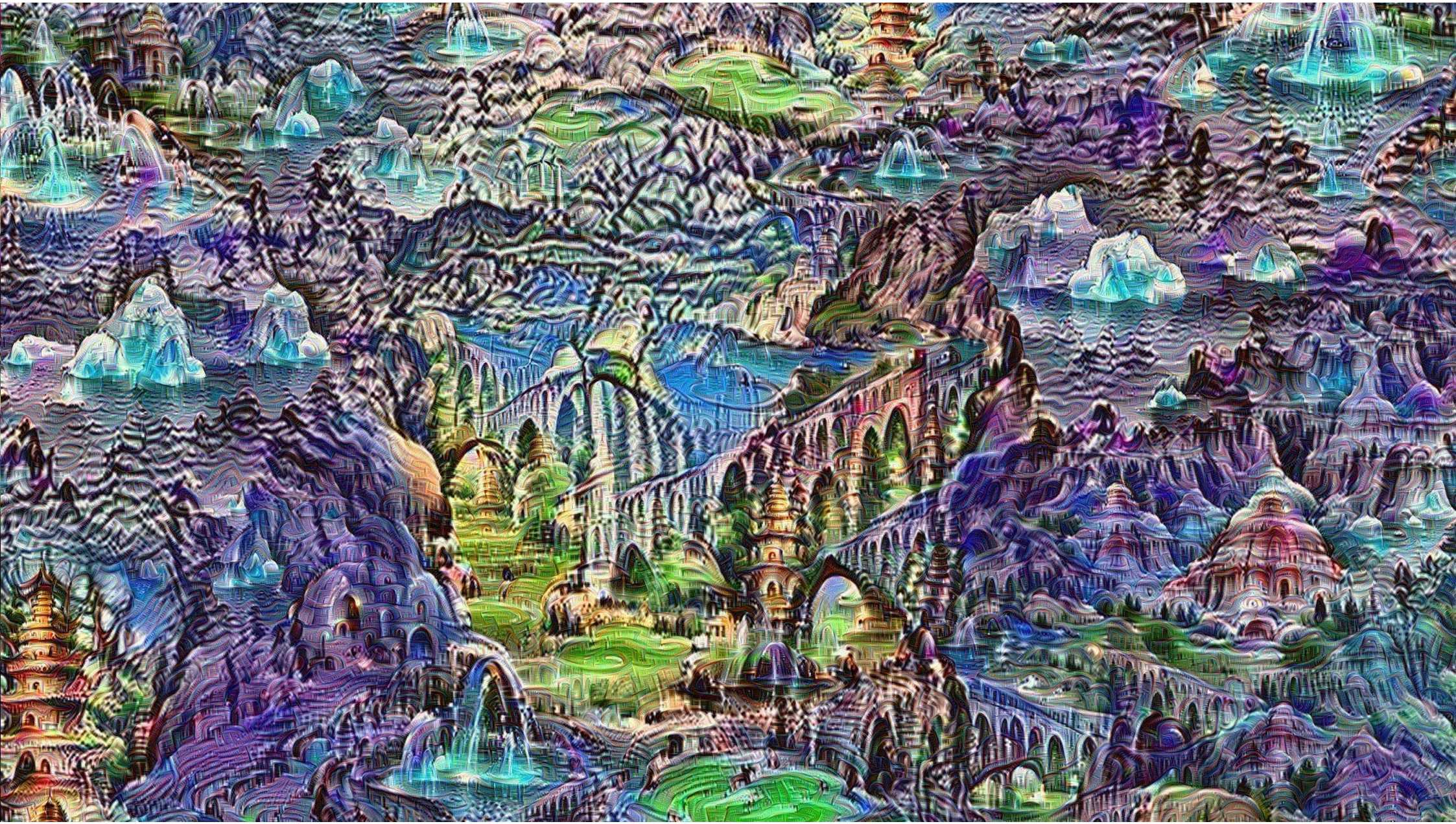
- In some instances, humans are actually a lot better at performing tasks than computers are
- Computers grew phenomenally, and can now do things that were unimaginable only 20 years ago!

Emotions

- Showing emotion still hasn’t been cracked
- This is a branch of artificial intelligence known as affective computing
- Humans, from a very early age, can make out facial expressions intuitively
- Humans can make decisions based on emotion, which is very hard for a computer

Creativity

- Computers also have a hard time creating something completely new
- Google created an AI that can “dream”, the machine was given a “blank slate” of white noise
- This process of creating images from nowhere is called inceptionism



Growth

- Computers have a hard time improving themselves
- As of now, the only way for a computer to improve is through the hard work of engineers and scientists
- There is progress in artificial intelligence

Decision making

- Computers are, so far, only as good as the information they're given
- All that processing is based on the programmer's decisions
- When it comes to independent thought and decision making, computers instantly appear dumb

Comparison to human thought

Human thought looks like a simple process from outside, but for a computer, this is near impossible.

Phones nowadays come with voice assistants.

Deeper conversational traits such as continuing from the previous sentence, topic changes, opinions and figurative language are very challenging for computers.

Judgement

- Some real-world decisions can only rely on human judgement
- Computers are particularly challenged by situations that have too many random variables, like driving

Judgement

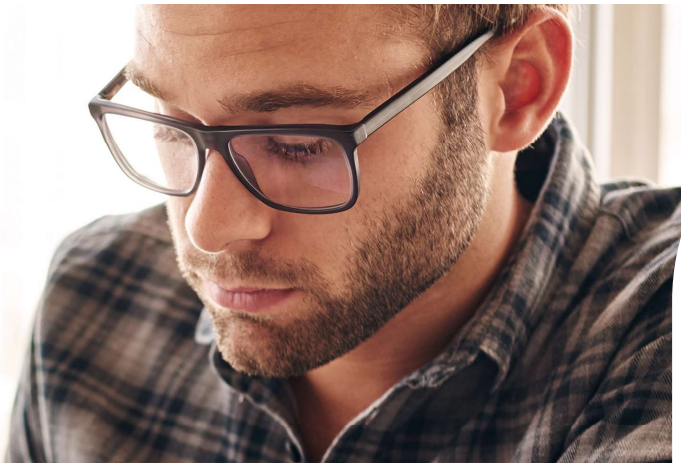
- In natural language processing, people pronounce words differently
- Fuzzy logic allows computers to reason without fitting into exact categories

The processing cycle

- Computers use the fetch-decode-execute cycle
- A complete computer cycle includes all three stages
- The cycles are perfectly timed according to the clock

The processing cycle

A computer’s speed is measured by the number of cycles that can be completed in a second.

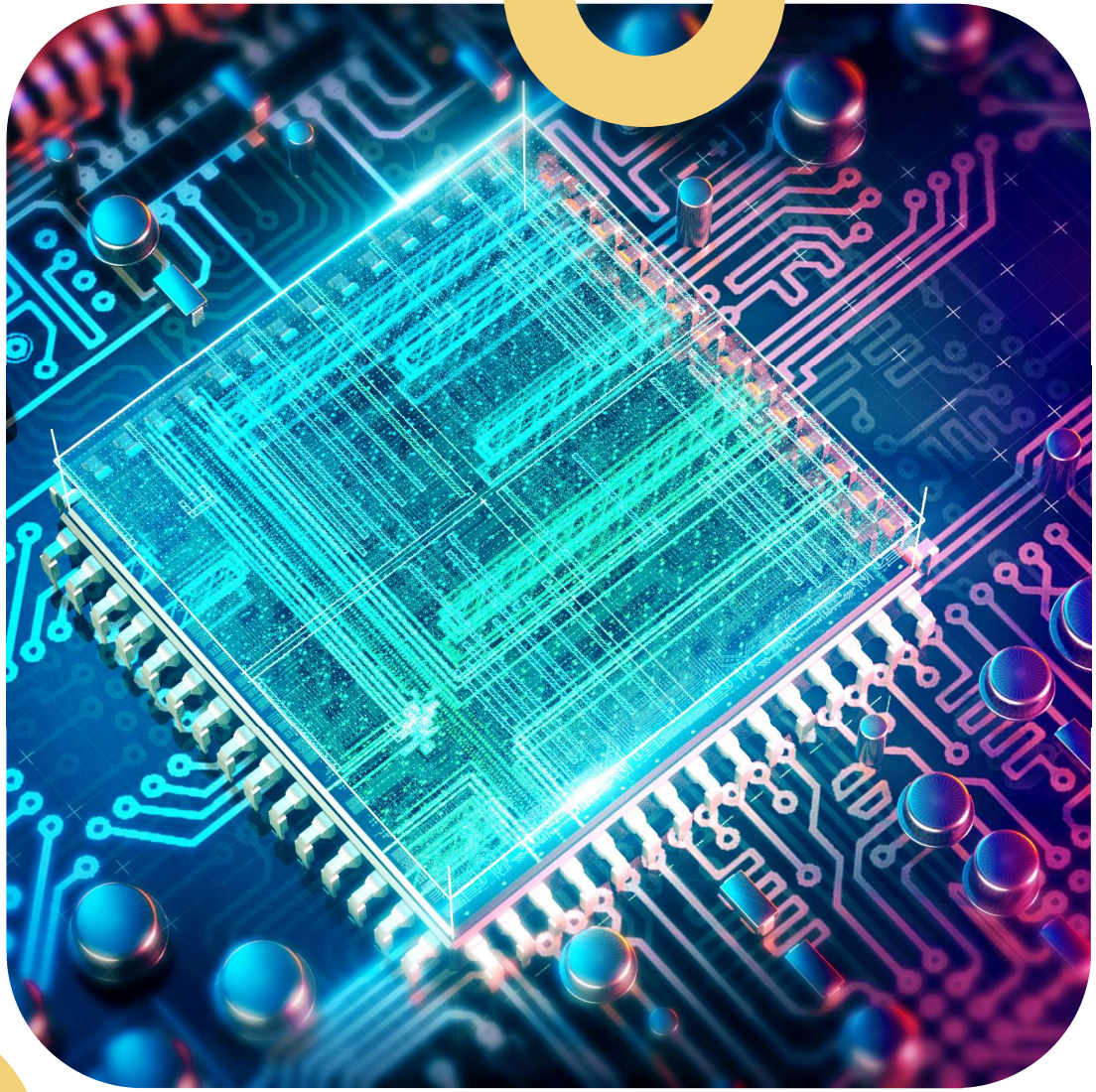


Did you know?

Modern computers can complete billions of these cycles in a second!

CPU Performance

- Determined by clock speed, cache size, the number of cores and more
- The more pulses the clock produces, the faster the CPU



CPU Performance

- Cache is close to the CPU
- The larger the cache, the faster the CPU
- The more cores a CPU has, the better
- Cores come in multiples of 2