Learning Aims

- Explain why computers use binary to represent data and program instructions
- Determine the max number of states that can be represented by a binary pattern of a given length
- Describe how computers represent and manipulate unsigned integers (positive numbers)
- Convery between denary and 8 bit binary numbers (0-255)

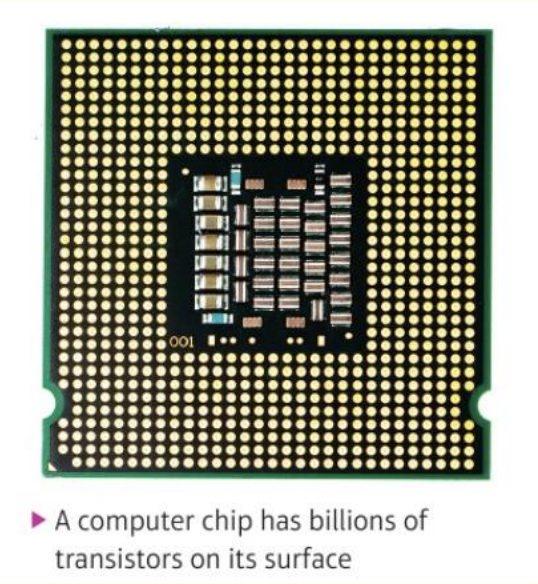
Why binary?

- **Binary** is a sequence of 0's and 1's, it can read by a computer processor, decoded and executed (BASE 2)

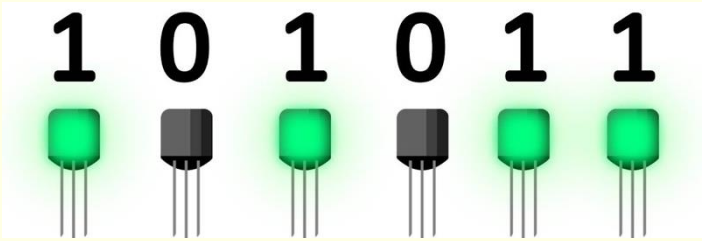
- Computers can store a sequence of 0 and 1's using tiny switches (on and off) known as **micro transistors** built into an **integrated circuit**.

- The circuits in a computer's processor are made up of billions of **transistors**.

- **A bit is a single binary digit. (0 or 1)**



A computer chip has billions of transistors on its surface



Binary Patterns

A single bit has only one state 1 or 0

2 bits produces 4 different binary patterns 00 01 10 11

3 bits = 8 binary patterns 000 001 011 111 011 101 110 111

The number of bit patterns can be expressed as:

$$2^{numberofbits}$$

Bytes & Nibbles

Byte is 8 bits

With 8 bits = 256 binary pattens = 2^8

Nibble is 4 bits

With 4 bits = 16 binary patterns = 2^4

Number of bits	2^n	Number of binary patterns	Bit patterns
1	2^1	2	0 1
2	2^2	4	00 01 10 11
3	2^3	8	000 001 010 011 100 101 110 111
4	2^4	16	0000 0001 0010 0011 0100 0101 0110 0111 1000 1001 1010 1011 1100 1101 1110 1111

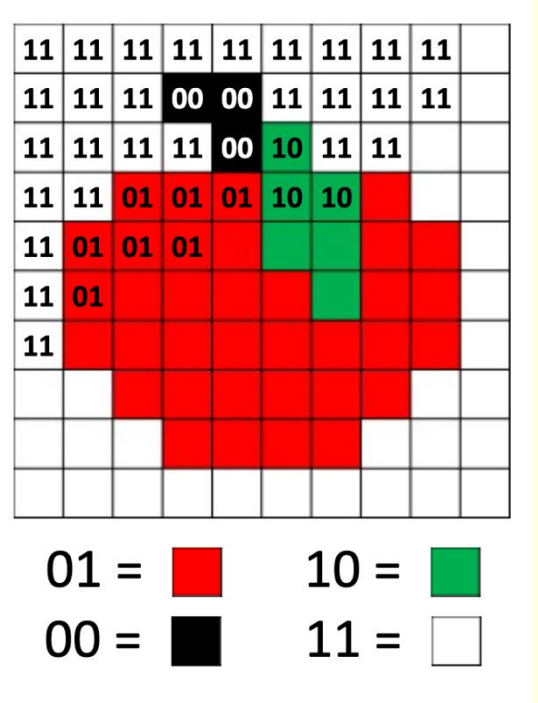
Using binary to represent data and program instructions

- Numbers, letters, images, sound and instructions have to encoded in binary
- For example, ASCII encoding system for representing text as binary numbers:

Letter	Binary
8	0011 1000
<space>	0010 0000
b	0110 0010
i	0110 1001
t	0111 0100
s	0111 0011

When we display a binary pattern as characters on the screen, it looks up the graphic representation for it in the font definition and sends it to the screen

To encode an image, each tiny picture element (pixel) is allocated its own binary pattern, for example 2 bits per pixel can generate 4 different possible colours.



Number Systems

- Computers can handle different formats of numbers
- Positive, negative numbers and decimal numbers
- GCSE Level: Only how positive and negative numbers are represented
- Unsigned numbers = only positive numbers

  For example: 1 byte can represent 0-255

- Signed numbers = range of numbers that include negative and positive

  For example: 1 byte can represent -128 to 127

Binary system

- The bit at the leftmost position is known as the Most Significant Bit (MSB)
- The bit at the rightmost position is known as the Least Significant Bit (LSB)

Place Values	2^8	2^7	2^6	2^5	2^4	2^2	2^1	2^0
	128	64	32	16	8	4	2	1
	0	**0**	**0**	**1**	**0**	**1**	**0**	**1**

Adding these together gives **21**

Alternative way of converting Denary to Binary

Worked example

Convert the denary number 213 to binary.

Denary number	÷ 2	Remainder	
213	106	1	LSB
106	53	0	
53	26	1	
26	13	0	
13	6	1	
6	3	0	
3	1	1	
1	0	1	MSB

read this way

The denary number 213 = 1101 0101 in binary.

Worked example

Convert the denary number 13 to an 8-bit binary number.

Denary number	÷ 2	Remainder	
13	6	1	LSB
6	3	0	
3	1	1	
1	0	1	
	0		
	0		
	0		
	0		MSB

read this way

The denary number 13 = 0000 1101 in 8-bit binary.