Representing Data

Learning Intentions

- Describe the rationale for using the binary number system in digital computing.
- Describe how to convert between binary, hexadecimal and decimal.
- Use ASCII and Unicode character sets to encode/decode a message and consider the importance of having such standard.
- Collect, store and sort both continuous and discrete data

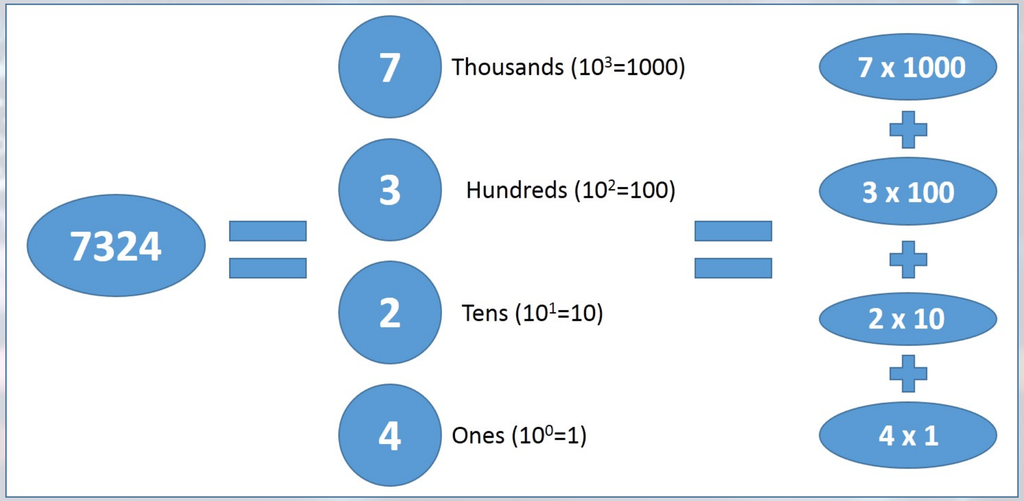
New Learning Intentions

- Describe the different components within a computer and the function of those components
- Describe the different types of logic gates **and explain how they can be arranged into larger units to perform more complex tasks.**

Revisited Learning Intentions

Decimal system

- In school we learn to deal with numbers with the base-10 number system.
- This means we have 10 different numbers available to represent different numbers, 0 - 9.



- A single digit is called a unit, the second digit is a ten, third digit is a hundred etc.
- Each digit we add to a number is a multiple of 10.

Describe the rationale for using the binary number system in digital computing.

Binary system

- Computer systems use a binary system or base-2 system.
- Instead of ten different numbers there are two, 0 and 1.
- Computers uses voltages which change regularly and no specific voltage is set for each number in the decimal system.
- Binary systems can be represented by just two electrical signals, on and off.
- Values are stored in binary using switches (transistors) by setting them on (1) or off (0).
- One switch is equivalent to one bit, so a bit represent the smaller amount of information it is possible to configure.
- Eight switches, i.e 8 bits, make up a byte which can represent any value between 0 and 256.
- Instructions are made up of these bits which the relevant hardware can read.

Describe the rationale for using the binary number system in digital computing.

Comparing number systems

Decimal	Binary	Octal	Hexadecimal
0	0000	000	0000
1	0001	001	0001
2	0010	002	0002
3	0011	003	0003
4	0100	004	0004
5	0101	005	0005
6	0110	006	0006
7	0111	007	0007
8	1000	010	0008
9	1001	011	0009
10	1010	012	A
11	1011	013	B
12	1100	014	C
13	1101	015	D
14	1110	016	E
15	1111	017	F

Describe the rationale for using the binary number system in digital computing.

Place values of decimal vs binary systems

Binary Values

10^4	10^3	10^2	10^1	10^0
10000	1000	100	10	1

Denary place values

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Binary place values

- Binary place values use multiples of 2 compared to the denary system which uses multiples of 10.

Describe the rationale for using the binary number system in digital computing.

Convert Decimal to Binary

2^5	2^4	2^3	2^2	2^1	2^0
32	16	8	4	2	1

Binary place values

- Lets convert the decimal number 20 into binary format.

Describe how to convert between binary, hexadecimal and decimal.

Homework solutions p163

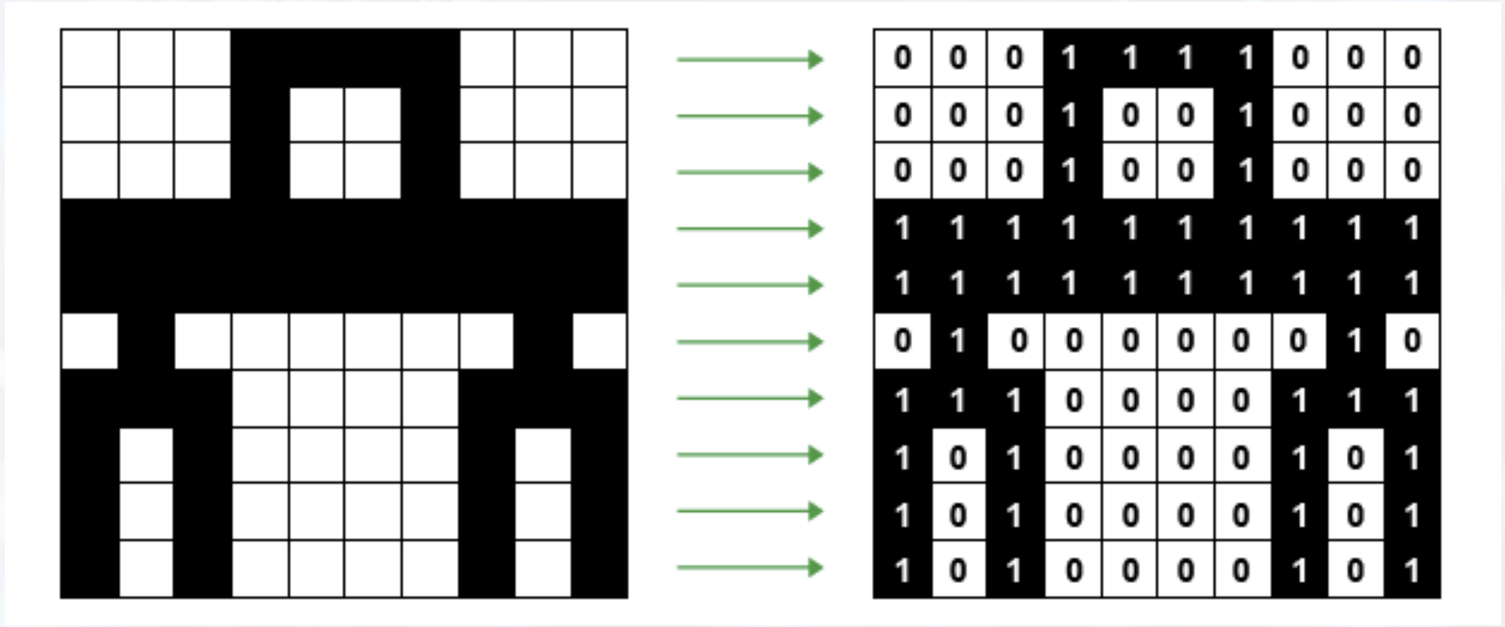
5. 8 bits in a byte
6. Binary - 1111 1111 Decimal - 255
7. 256
8. 1024 Megabytes in 1 Gigabyte
9. Answer on p159

2^5	2^4	2^3	2^2	2^1	2^0
32	16	8	4	2	1
0	1	1	0	0	0

Describe how to convert between binary, hexadecimal and decimal.

Representing Images with Binary

- An image is represented as a series of pixels.
- Each pixel in the image is made up of binary numbers.

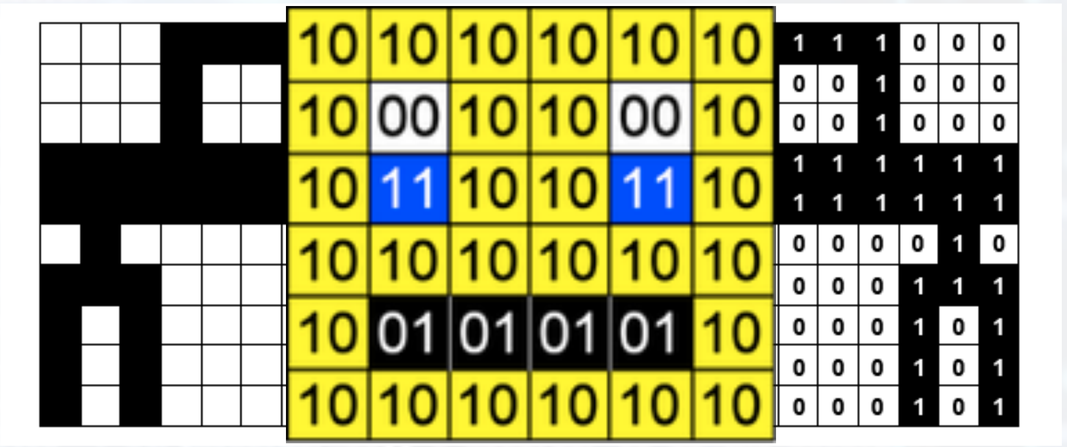


How many colours could an 8 bit binary number represent?

Think!

Describe the rationale for using the binary number system in digital computing.

Representing Images with Binary



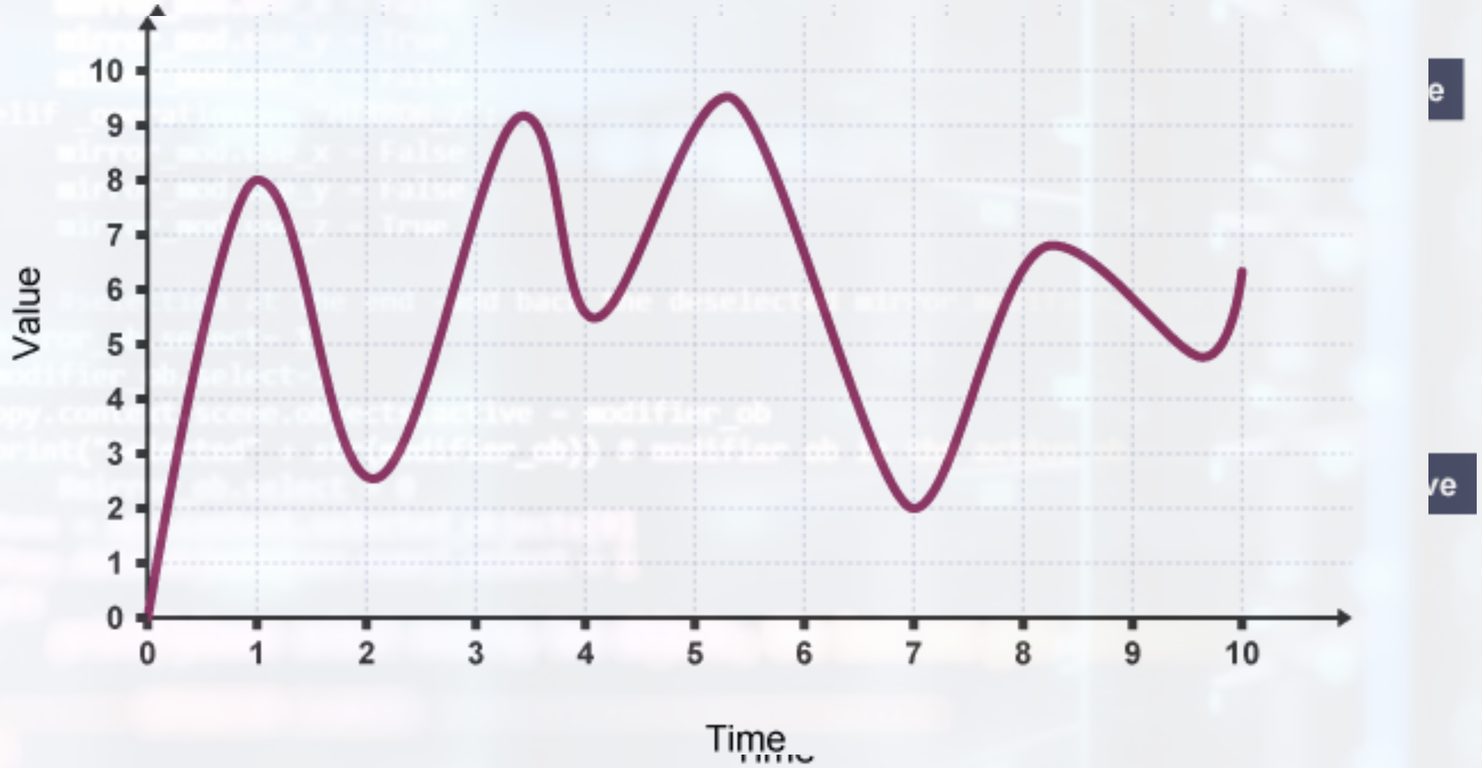
How many bits are used to represent each pixel in the image shown?

- If you used two bits per pixel then each pixel could represent four colours.

Binary Value	Colour
0	White
1	Black
10	Yellow
11	Blue

Describe the rationale for using the binary number system in digital computing.

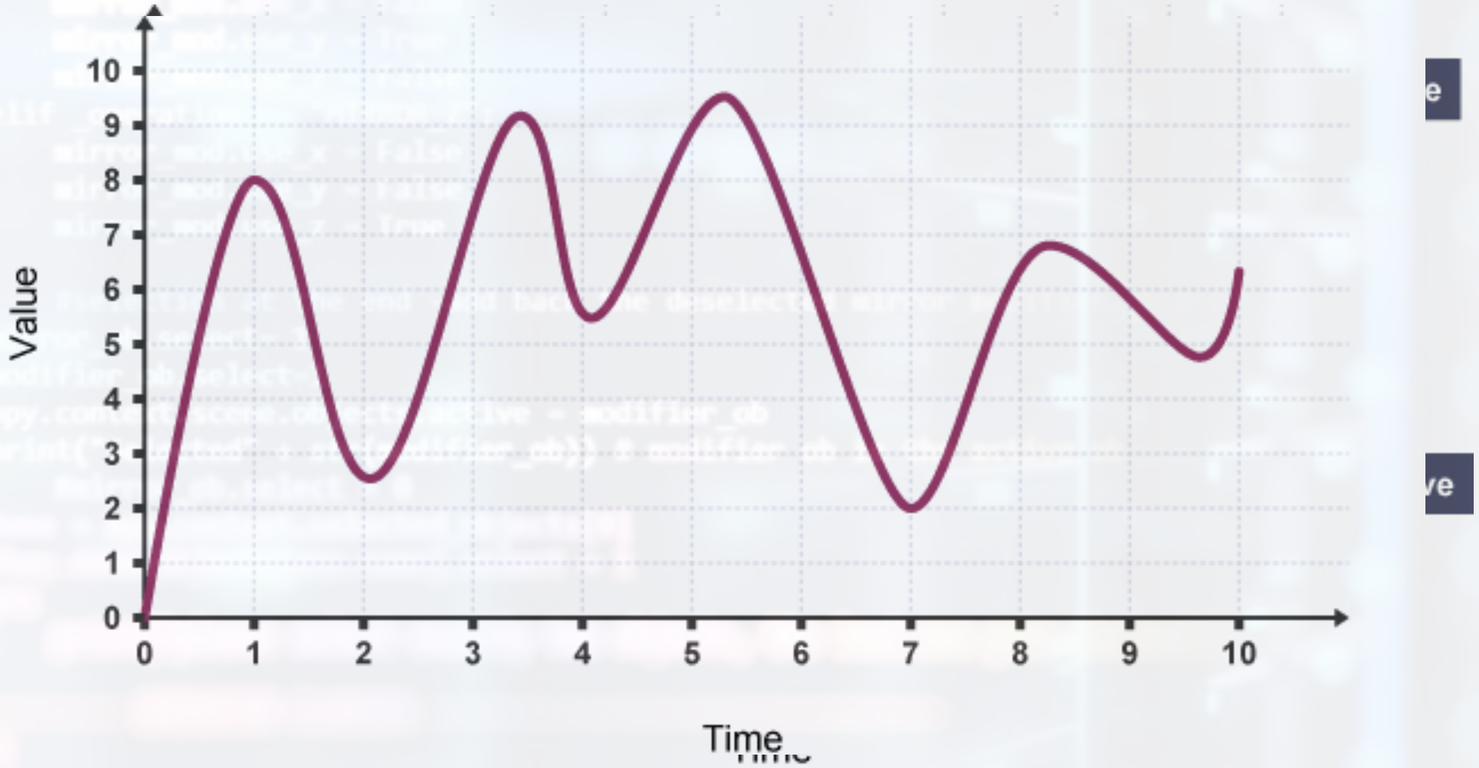
Representing Sound with Binary



- Sound needs to be converted from analogue to digital so it can be understood by a computer
- A time sample point samples the sound and produces an analogue wave.
- When the time samples are then plotted back as binary values the sound wave looks different.

Describe the rationale for using the binary number system in digital computing.

Converting decimal to binary



- Sound needs to be converted from analogue to digital so it can be understood by a computer
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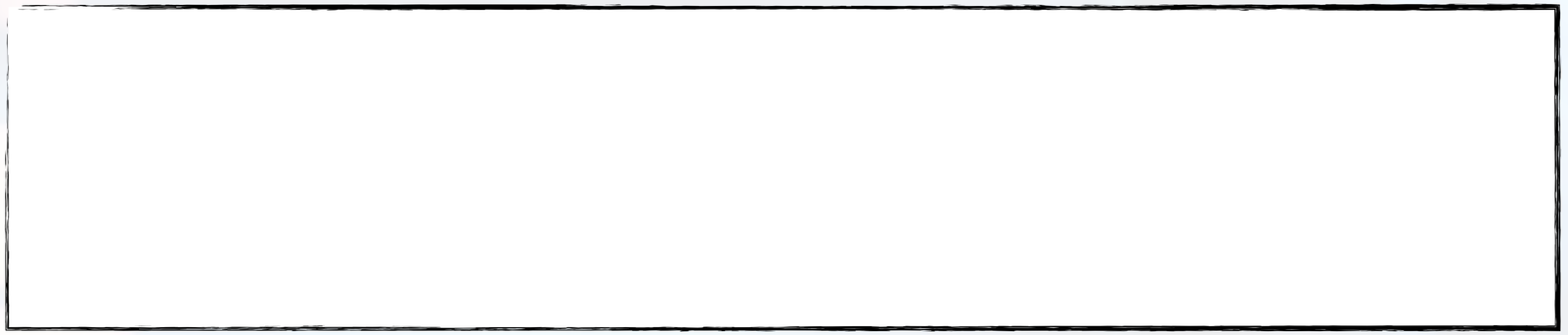
Describe the rationale for using the binary number system in digital computing.

Using logic circuits for binary addition

- Binary addition is similar to decimal addition and has a number of rules.

	Sum value	Carry value
0 + 0	0	
1 + 0	1	
0 + 1	1	
1 + 1	0	1

Rules of addition



Using logic circuits for binary addition

Carry	1		1				
Binary Number	0	1	0	1	0	0	1	41
Binary Number	0	1	0	1	1	0	0	44
Sum	1	0	1	0	1	0	1	85

Carry	1			1	1	1		
Binary Number	0	1	1	0	0	1	1	51
Binary Number	0	1	0	0	1	0	1	37
Sum	1	0	1	1	0	0	0	88

Binary addition overflow

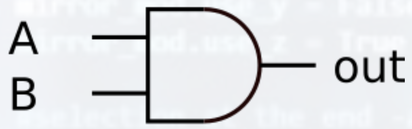
Carry		1	1				1			
Binary Numb		1	1	1	0	0	0	1	0	226
Binary Numb		1	0	1	1	1	0	1	0	186
Sum		?	0	0	1	1	1	0	0	412

- Overflow occurs when you have a carry value when you get to the highest bit value. (furthest left)
- The result of the addition is greater than 255 and an overflow error occurs where a ninth bit is needed.
- Most CPUs use a much bigger word size than 8 bits. Many have a 64-bit CPU. A 64-bit CPU can handle numbers larger than 18 quintillion (18,446,744,073,709,551,615 to be precise).

Logic circuits for binary addition

AND:

A	B	out
0	0	0
0	1	0
1	0	0
1	1	1

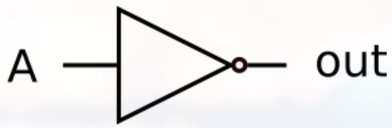


OR:

A	B	out
0	0	0
0	1	1
1	0	1
1	1	1

NOT:

A	out
0	1
1	0



- In a computer, binary numbers are added together using logic circuits called half adders or full adders.
- A half adder can take two bit inputs and gives a two-bit output.
- A full adder is made up of two half adders to add three bits.
- To add more and more bits you increase the number of full adders.

Research the layout of a half adder and full adder and draw each circuit into your notes.

Create a truth table for both adder logic circuits

Identify the logic gates used in both adder gates

Hexadecimal number system

Colour picker

- Hexadecimal numbers are base 16 and use 0-9 and A-F to represent all numbers.
- 0 ,1 ,2 ,3 ,4 ,5 ,6 ,7 ,8 ,9 ,A ,B ,C ,D ,E , F
- Similar to binary the number on the right is the least significant

16^5	16^4	16^3	16^2	16^1	16^0
1048576	65536	4096	256	16	1

- Hexadecimal numbers allow us represent long complex binary values in fewer digits.
- Computers do not use hexadecimal numbers, they are generally used as shorthand by technicians and computer users. For example representing RGB values.

Describe how to convert between binary, hexadecimal and decimal.

Hexadecimal to decimal $36B_{16}$

16^5	16^4	16^3	16^2	16^1	16^0	
1048576	65536	4096	256	16	1	Place values
			3	6	B	Hex value

- Draw a table with the place values in the top row.
- Place hex value in the bottom row, starting from the right.
- Multiply each hex value by the place value above it. (3*256) + (6*16) + (11*1)
- Add each value to get the decimal value. 875_{10}

Describe how to convert between binary, hexadecimal and decimal.

Decimal to Hexadecimal 318_{10}

- The fastest way is similar to the modulus division method used to convert decimal to binary value.

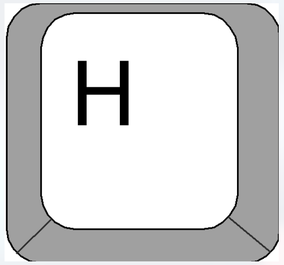
Decimal value to convert 318			
	Divide by 16	Remainder	
318	19	14	
19	1	3	
1	0	1	

- Most significant value is your last remainder value and least significant value is your first remainder value.
- 14 in hex is E
- So 318_{10} is 13E

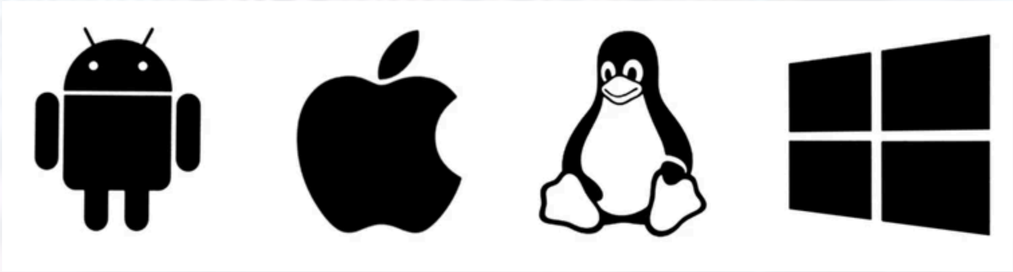
Describe how to convert between binary, hexadecimal and decimal.

ASCII and UNICODE

- ASCII stands for American Standard Code for Information Interchange.
- ASCII is a mapping of binary numbers that correspond to characters on a keyboard.
- ASCII uses 1 byte or 8 bits to represent 255 characters



User presses letter H on keyboard and an input signal is sent to the computer.



The OS knows the ASCII value for H is 72 which it can convert to binary 01001000

ASCII is only designed for the English language, other languages use other characters so a new character set had to be developed. This new character set is called Unicode which also allows us to make images such as ¯_(ツ)_/¯ or emojis such as 🐻

Use ASCII and Unicode character sets to encode/decode a message and consider the importance of having such standard.

ASCII and UNICODE

- Unicode is favoured over ASCII for a number of reasons.
- Unicode uses up to 64 bits to represent each character such as emojis and smathemaical symbols
- Unicode can support languages with alphabet sets greater than 26

Use ASCII and Unicode character sets to encode/decode a message and consider the importance of having such standard.

UTF-8

- UTF stands for Unicode Transformation Format

What do you think the 8 stands for?

- UTF-8 is used to encode Unicode characters and is the main encoding method used on the internet

Unicode Values	Description	Contents	Bytes in UTF-8
U+0000 – U+007F	ASCII	Everything on a standard English keyboard	1
U+0080 – U+07FF	Basic Multilingual Plane (BMP)	Latin languages, Greek, Cyrillic and some Aramaic	2
U+0800 – U+FFFF	BMP *continued...*	Remaining *modern* languages	3
U+010000 – U+10FFFF	Supplemental Planes	Archaic languages, Emoji	4

Use ASCII and Unicode character sets to encode/decode a message and consider the importance of having such standard.