

Unit 6 - Data Representation Knowledge Organiser

Summary:

All data (e.g. names, numbers, colours in a photograph or notes in a piece of music) inside a computer is transmitted as a series of electrical signals that are either **on** or **off**. This data is represented as a sequence of 1s and 0s (on and off). **All data that we want a computer to process needs to be converted into this binary (base 2) format.**

When any key on a keyboard is pressed, it is converted using a character map, either **ASCII** or **Unicode**. A code is used to represent each letter or symbol and this can be used to convert text into binary.

Colours in photographs and images also need to be converted into binary in order for a computer to process them so that they can be seen on our screen. Digital images are made up of **pixels**. Each pixel in an image is made up of binary numbers. The size of the file depends on the number of bits (**bit/colour depth**) used.

Key Vocabulary:

Binary	Binary is a number system that only uses two digits: 1 and 0. All information that is processed by a computer is in the form of a sequence of 1s and 0s. Therefore, all data that we want a computer to process needs to be converted into binary. The binary system is known as a ' base 2 ' system.																																		
Decimal/Denary	Our number system that we use to count in. It used 10 digits (0 - 9). It is also known as a ' base 10 ' system.																																		
Overflow Error	An overflow error occurs when the largest number that a CPU register can hold is exceeded (e.g. if 9 bits are needed to represent the number and there are only 8 bits available).																																		
Hexadecimal	Hexadecimal (or hex) is a base 16 system used to simplify how binary is represented. A hex digit can be any of the following 16 digits:- 0 1 2 3 4 5 6 7 8 9 A B C D E F <table><tr><th>Hexadecimal</th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr><tr><th>Denary</th><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td></tr></table>	Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	Denary	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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ASCII	ASCII stands for American Standard Code for Information Interchange . There are 128 standard ASCII codes that represent letters and symbols, each of which can be represented by a binary number.																																		
Pixel	A single point in an image. Pixel stands for P icture E lement.																																		
Resolution	The number of pixels that make up an image (e.g. 800 x 600).																																		
Bit Depth\Colour Depth	The number of bits used to store each pixel (e.g. each colour - e.g. 8 bit colour and 24 bit 'True Colour'). Images with more colours need more pixels to store each available colour. This means that images that use lots of colours have larger file sizes.																																		
Metadata	Metadata is data about data. It is information other than the image data that is store in a file. This will include information about colour depth, resolution, data created, author.																																		
Frequency	Sound waves are measured in 'Hertz'. This is the frequency of sound, which you sense as the pitch of the sound.																																		
Amplitude	The loudness of a sound is called the ' amplitude ' of the sound and is the height of the sound wave.																																		
Sampling	Sampling is a method of converting an analogue sound signal into a digital file containing binary numbers.																																		
Bit\Sample Rate	Sample rate is the number of samples (or measurements taken) per second of a sound.																																		

Binary Units:

1 Bit	= 1 or 0 (1 binary digit)
1 Nibble	= 4 bits
1 Byte	= 8 bits
1 Kilobyte (KB)	= 1024 bytes
1 Megabyte (MB)	= 1024 Kilobytes
1 Gigabyte (GB)	= 1024 Megabytes
1 Terrabyte (TB)	= 1024 Gigabytes

ASCII vs Unicode:

	Advantages	Disadvantages
ASCII	Only uses 7 bits to store a character, meaning less memory is used.	Limited to 128 different characters.

Converting to 8-bit binary:

Converting the denary number 214 to binary:

- Using the binary place values, work out the combination of numbers that add up to equal 214

$$128 + 64 + 16 + 4 + 2$$

- Put a 1 in each of these columns

128	64	32	16	8	4	2	1
1	1		1		1	1	

- Put a 0 in any blank columns

128	64	32	16	8	4	2	1
1	1	0	1	0	1	1	0

Converting to denary:

Converting the number 10011101 to denary:

- Put the binary number under the binary place value headings
- Take the place value heading for any column that has a 1 in it

128	64	32	16	8	4	2	1
1	0	0	1	1	1	0	1

- Add these numbers together

$$128 + 16 + 8 + 4 + 1$$

The denary number for 10011101 is 157.

Unicode	Uses up to 32 bits per character meaning it can store a wider range of language characters.	More bits per character means more memory is used.
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Binary Addition

There are **4 rules** that need to be followed when adding 2 binary numbers together.

Rules:

- 0 + 0 = 0
- 1 + 0 = 1 (also 0 + 1 = 1)
- 1 + 1 = 0 carry 1 (binary for 2)
- 1 + 1 + 1 = 1 carry 1 (binary for 3)

$$\begin{array}{r} 10 \\ + 01 \\ \hline 11 \end{array}$$

$$\begin{array}{r} 1011 \\ + 0110 \\ \hline 10001 \end{array}$$

$$\begin{array}{r} 01011 \\ + 10111 \\ \hline 10001 \end{array}$$

Binary Subtraction

There are **3 rules** that need to be followed when subtracting 2 binary numbers.

Rules:

- 0 - 0 = 0
- 1 - 0 = 1
- 0 - 1 = 1 (borrow 1 from the left - the most significant bit)

$$\begin{array}{r} 11 \\ - 10 \\ \hline 01 \end{array}$$

$$\begin{array}{r} 1011 \\ - 0101 \\ \hline 0110 \end{array}$$

$$\begin{array}{r} 10001 \\ - 00011 \\ \hline 01110 \end{array}$$

Converting Denary to Hexadecimal

Example: Convert the denary number **165** into hexadecimal.

1) Create a binary table and place the number 1 under each number you need to make up 165 and a 0 under those not used.

128	64	32	16	8	4	2	1	Answer
1	0	1	0	0	1	0	1	165

2) Split the number into two nibbles.

8	4	2	1	8	4	2	1	Answer
128	64	32	16	8	4	2	1	165
1	0	1	0	0	1	0	1	

3) Add up the nibbles separately. In this example, the 1st nibble adds to 10, which in Hex is represented by the character **A** and the 2nd nibble adds up to **5** which means that **165 in Hex is A5**.

8	4	2	1	8	4	2	1	Answer
128	64	32	16	8	4	2	1	165
1	0	1	0	0	1	0	1	
A				5				A5

Converting Hexadecimal to Denary

Example: convert the hexadecimal number **9A** into denary.

1) Split the number in half

9 | A

2) Convert these separate numbers into denary

Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Denary	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

So hexadecimal **9** is **9** in denary and hexadecimal **A** is **10** in denary.

3) Take the separate digits and represent them as nibbles.

8	4	2	1	8	4	2	1
9				10			
1	0	0	1	1	0	1	0

4) Push the two nibbles together to make an 8-bit binary number and then convert the 8-bit binary number into denary.

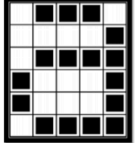
8	4	2	1	8	4	2	1	Answer
128	64	32	16	8	4	2	1	154
1	0	0	1	1	0	1	0	

Image Representation

Sound Representation

How images are represented

A computer breaks down an image into tiny elements called pixels (picture element). Each element of the image is represented in binary. Metadata is also stored with the image.



1,0
1,1
1,0
0,1
0,1
1,0

Bit/Colour Depth

The number of binary digits used to represent each pixel depends on the bit/colour depth.

Bit Depth	Number of colours
1	$2 = 2^1$
2	$4 = 2^2$
3	$8 = 2^3$
4	$16 = 2^4$
5	$32 = 2^5$
6	$64 = 2^6$
7	$128 = 2^7$
8	$256 = 2^8$
24	16 million = 2^{24}

Sound must be converted into binary for it to be stored and processed by the computer. Digital sounds are usually captured by a microphone and will either play or not play, which is why DAB radios will not play anything when they lose reception. The computer converts the analogue sound wave to digital by taking samples of the wave at certain points, (called **sampling**) and is represented by the bars (in the 2nd image). The **sample rate** is the number of times the sound is sampled over the period of time. Increasing the sample rate improves the quality of the sound.

