Binary – *A number system made up of 0 and 1 used by computers to store and represent data such as numbers, sound, and graphics*

- Also known as Base 2
- Computers use binary because the CPU contains transistors, which are either on or /off

Hexadecimal – *A number system made up of 16 symbols, 0-9 and the letters A-F.*

- Also known as Base 16
- Useful because large numbers can be represented using fewer digits.
- Easier to understand, write and check than binary.
- Commonly used for colour values and MAC addresses.

Binary States – *The number of states which can be represented in a given number of bits using binary*

- To calculate the number of states use the formula 2^n where n is the length of the pattern
- Limits on the number of bits available affect how much data can be stored

Measuring Storage

Size	Unit
8 bits	1 byte
1,024 bytes	1 kilobyte - KB
1,024 kilobytes - 1,024 KB	1 megabyte - MB
1,024 megabytes - 1,024 MB	1 gigabyte - GB
1,024 gigabytes - 1,024 GB	1 terabyte - TB
1,024 terabytes - 1,024 TB	1 petabyte - PB

ASCII – *American Standard Code for Information Interchange*

- A 7 bit method to represent characters using binary
- 7 bits allows 128 characters.
- The characters are represented in a table, called the ASCII table.
- ASCII characters include control codes, punctuation, upper and lower case letters, numbers.
- Upper and lower case characters have different codes.

Character	Denary	Binary	Hexadecimal
A	65	1000001	41
Z	90	1011010	5A
a	97	1100001	61
z	122	1111010	7A
0	48	110000	30
9	57	111001	39

Topic 2 – Data

Bitmap Images

Allow computers to represent images in binary.
Images are broken down using a grid.
Each square in the grid is known as a pixel

Colour Depth

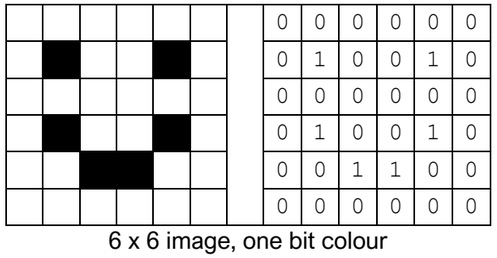
- The more colours an image needs, the more bits per pixel are used.
- The greater the colour depth, the larger the image file will be.
- one bit per pixel (0 or 1) - two possible colours
- two bits per pixel (00 to 11) - four possible colours
- three bits per pixel (000 to 111) - eight possible colours

Resolution

- Higher quality image = higher resolution = more pixels in the same space = smaller pixels.
- Higher resolution = more space needed.
- Calculated by multiplying the width in pixels by the height in pixels.

File Size

The file size of an image can be calculated using the formula :
height in pixels X width in pixels X colour depth per pixel



6 x 6 image, one bit colour
12 pixel resolution, 12 bit file size

Sounds in Binary

Amplitude - The height of the sound wave at the time it was sampled. The higher the amplitude the louder the sound.
Sample Interval – How often (in milliseconds) the sound is sampled
Small sample interval = better quality sound file = larger file.
Sample Rate –we often use the term sample rate instead of sample interval.
The sample rate (in Hz) is the number of samples in one second.

Sample Rate = 1 / Sampling Interval

Small sampling interval = high sample rate = better quality sound file = larger file.
Bit Depth - the number of bits used to record each sample.
Higher bit depth = higher quality audio = larger file size.
Usually 16 bits on a CD and 24 bits on a DVD.

Unsigned and Two's Compliment Integers

Unsigned integers must be positive
Signed integers can be positive or negative

- Both are as accurate
- Both can have overflow errors
- Unsigned integers store more positive values (unsigned is 0 to 255, signed is -127 to 127)

Two's complement

- Used by computers to show negative numbers.
- More effective when performing mathematical operations.
- The bit at the far left of the bit pattern - the most significant bit or MSB - is used to indicate positive or negative and the remaining bits are used to store the size of the number.

Using two's complement for negative numbers

- Find the positive binary value for the negative number.
- Add a 0 to the front of the number, to indicate that it is positive.
- Invert or find the complement of each bit in the number.
- Add 1 to this number.

Converting Between Bases

Binary to Denary

1) Draw your conversion table.

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

2) Write the binary number in the conversion table.
3) Add together all numbers with a 1 beneath them

128 + 64 + 8 + 4 = 204

11001100 in binary is 204 in denary

Denary to Binary

1) Draw your conversion table.
2) Is the number higher than the first column in the table?
   a) If so, put a 1 in that column and work out the difference.
   b) If not, put a 0 in that column.
3) Repeat the step above with the difference.
4) Keep going until the difference is 0, put a 0 in any empty columns.
5) Read the number from the bottom row of the table.

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

200 – 128 = **72**
72 – 64 = **8**
8 – 8 = **0**

200 in denary is 11001000 in binary

Denary to Hexadecimal

1) Divide the denary number by 16 and write down both the answer and the remainder.
2) Divide the answer by 16 again. Write down both the answer and the remainder.
3) Keep going until you reach an answer of 0.
4) Read the remainders from bottom to top.
5) Convert each remainder to hex.

62 ÷ 16 = 3 R 14
3 ÷ 16 = 0 R 3
3 14
3E

62 in binary is 3E in hexadecimal

Binary to Hexadecimal

1) Draw two separate conversion tables.
2) Write the binary number across both tables.
3) For each table, add up the numbers which have a 1 beneath them.
4) Convert each number to hexadecimal.

8	4	2	1
0	1	1	0

4 + 2 = 6 → 6

8	4	2	1
1	1	0	1

8 + 4 + 1 = 13 → D

01101101 in binary is 6D in hexadecimal

Binary Maths

Addition

- 0 + 0 = 0
- 1 + 0 = 1
- 1 + 1 = 10 (binary for denary 2)
- 1 + 1 + 1 = 11 (binary for denary 3)

Multiplication (using binary shifts)

Move the digits to the left and fill the gaps after the shift with 0.
Move 1 place for X2, 2 places for X4 etc.

Division (using binary shifts)

Move the digits to the right and fill the gaps after the shift with 0.
Move 1 place for X2, 2 places for X4 etc.

Compression

Lossy Compression

- Some data is removed, reducing the amount of data and the size of the file.
- There is a balance to be struck between reducing file size and maintaining quality.
- Images can be compressed by reducing colour depth.
- Audio files can be compressed by reducing the bit depth of the samples.
- Lossy standards include:
  - JPEG file format for images
  - MPEG file format for video and audio
  - MP3 file format for audio

Lossless compression

- Files are reduced in size without the loss of data.
- Lossless compression results in a smaller reduction in file size than lossy compression.
- Lossless compression gives a better file quality that lossy compression
- Lossless standards include:
  - PDF file format for documents
  - GIF file format for images