GRADE 7
COMPUTING NOTES
TOPIC 4.3 DATA REPRESENTATION

Binary representation of characters

The text we read and write is made up of lots of different characters.
All the letters in the words in this sentence are characters. In order to code text characters in binary, computers use character sets. These are standard sets of binary codes that represent each letter or symbol.

ASCII

One example of a character set is ASCII. This set uses 7 bits (binary digits) to code each
of 128 different characters of the
Characters are made up of letters and symbols like # & @*!
English language and the number characters 0 to 9.

Did you know? ASCII was invented in the 1960s for early computers and for machines called teleprinters. Those wore a bit like typewriters- each character was printed by a little metal stamp that pressed ink onto paper. For this reason, they could only print a very limited sot of characters. This is why ASCII only includes 128 different character codes.
ASCII is only useful for writing in English, so Extended ASCII was created. This character set uses 8 bits per character to represent 256 different characters. These

extra characters include ones used in European languages such as French, German and Spanish.

Unicode

Unicode is the character set most websites use to encode text. It uses between 8 and 32 bits per character to represent over a million characters. Because it can encode so many characters, it can be used for text in a lot of different languages. The characters that use more bits take up more file space, but the advantage of Unicode is that many more characters can be encoded, even emojis!

Binary representation of images

Converting numbers and text into binary code is relatively simple , only a few bits are needed for each number or character. So how do computers encode images, which are much more complex? How is a photograph that you take with a smartphone stored just using binary digits?

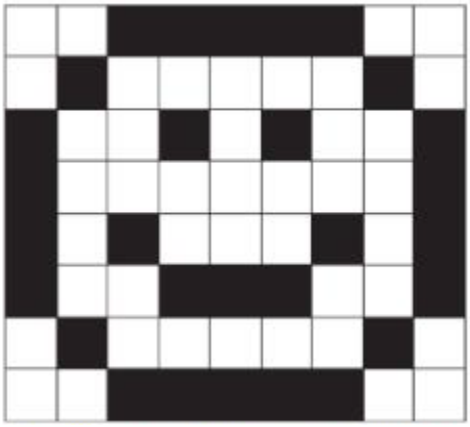
Once a digital camera captures the analogue image data, the computer (inside the camera or phone) breaks the image down into a lot of tiny little units of data called pixels.

Pixels

A pixel is the smallest possible part of an image. Each tiny little pixel has a single colour, and this colour has a matching binary value. Images are made up of thousands of pixels that are laid out in a grid.

Each image also has data that tells the computer how many pixels wide and how many pixels high the image is. The data about the size and quality of the image is also known as the resolution. The more pixels an image has for its size, the higher the resolution will be and the clearer it will look. The resolution and the colour of each pixel is all encoded in binary data that a computer can process. Using this binary data, the computer can recreate the image on a screen for you to see.

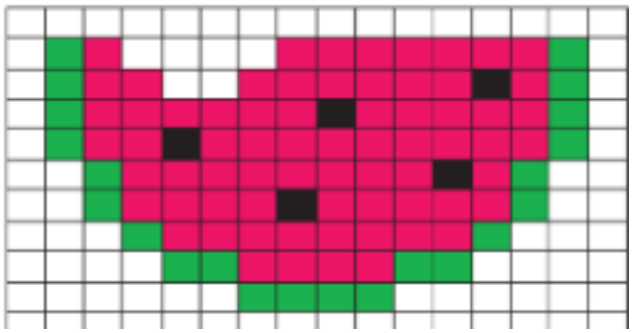
A simple example of this process is to use an image that just has the colours black and white. In this image, the colour black has the binary value I and white has the binary value 0. The size of the image is
9 pixels wide by 8 pixels high. The binary data for the image is:
001111100 010000010 100101001 100000001 101000101 100111001 010000010 001111100
The pixels need to be laid out in a grid that is 9 pixels wide and 8 pixels high. The computer then makes each pixel black or white depending on whether the colour value for the pixel is 1 or 0.
If we complete this process in the same way that the computer would, starting with the top left pixel, we get this image:



Coloured images

We have seen that if an image has just two colours (black and white), we only need one bit to code for each colour. If we want more colours, we need to use more bits per colour. The number of bits used to encode each colour is called the bit depth or colour depth. The higher the colour depth of an image, the more colours that can be used to create the image.

Bit depth	Possible combinations	Number of colours
1	0, 1	2
2	00, 01, 10, 11	4
3	000, 001, 010, 011, 100, 101, 110, 111	8



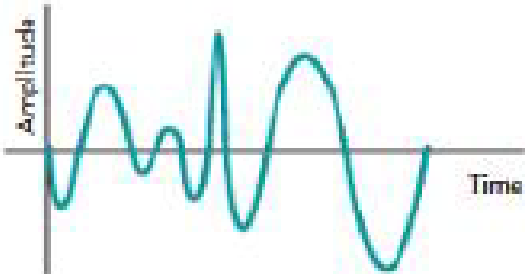
Most images have a lot more than eight different colours in them. A bit depth of 8 is needed to create a reasonably realistic colour photograph. 8-bit depth images can use up to 256 different colours. Bit depths for high-quality photographs can go up to 24 or even 32, providing over 16000 000 colours.

As you can see in the above image, the higher the bit depth, the higher the file size.

Binary representation of sounds

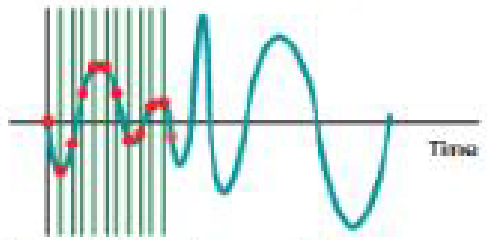
Sounds are another type of analogue data that can be encoded into binary and stored in digital form. Sound is created when something vibrates and pushes and pulls the air around it. The thing vibrating could be a loudspeaker, a human voice or two hard objects knocking together. These vibrations create waves of air going up and down, back and forth, again and again, which reach our ears.

We can draw sound waves like this:

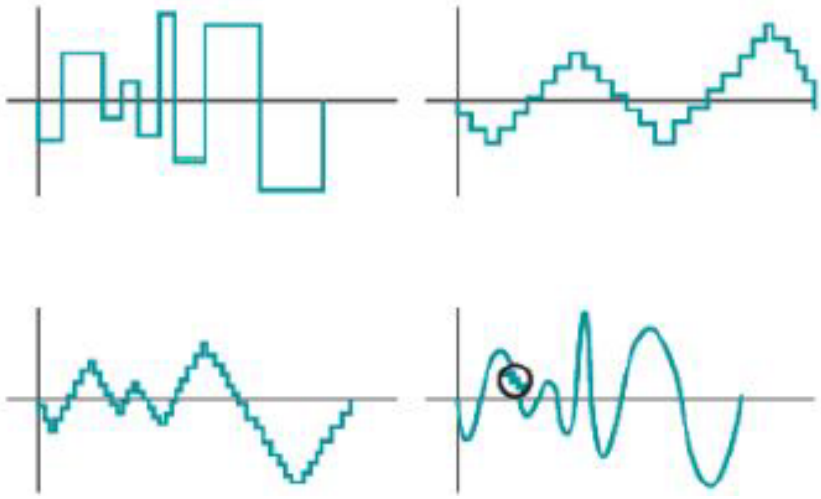


The height of each wave shows how loud the sound is. This is called the **amplitude**. A high curve means a louder sound, a lower one means a quieter sound. The width of the waves shows how high or low the **pitch** of the sound is. This is the **frequency**. If the curves look squashed together, the pitch is high. If the curves are wide and spaced out, the pitch is low.

To convert analogue sound into digital data, you need to capture it with a microphone and an **analogue to digital converter (ADC).**
The microphone converts the amplitude to electrical voltage. The ADC samples the voltage of the signal at regular points in time. This means measuring the voltage and recording the reading in binary.



Sample rate
Samples need to be taken thousands of times per second for the digital version of the sound to be close to the original. Whenever a binary value is recorded, that value will represent the amplitude of the sound ware until the next value. The more often samples are taken (the higher the sample rate), the more detail of the original sound will be represented in the digital file.



Different sample rates are used for different types of sounds. For music, a higher sample rate is often used. Sample rate is measured in **hertz (Hz)** (This is the same as the unit for the frequency of radio waves, which you learnt about in Topic 3.2.) 44 100 hertz is 44.1 kilohertz (kHz). For other types of sound, much lower sample rates of around 8 kHz can be used. Voice calls made over the internet can use sample rates this low.

Bit depth

Remember that with images, the bit depth (the number of bits used per pixel) affects how many colours can be represented. With sounds, the bit depth (the number of bits used per sample) affects how many different voltage values can be represented. The standard bit depth for CD-quality digital recordings is 16, giving 65 536 possible values. DVD recordings have a bit depth of 24, which gives over 16 million possible values.